NASA Tech Briefs

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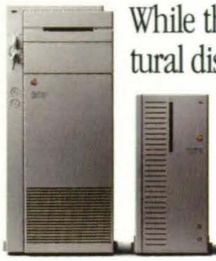
National Aeronautics and
Space Administration
Volume 15 Number 11

Transferring Technology
to Industry and
Government
November 1991

Aerospace Technology Drives Auto Advances

Attila t



While the engineering and architectural disciplines have always prized the elegant solution, there are times when brute strength is imperative.

Introducing the Apple® Macintosh® Quadra™ 700 and Quadra 900 computers.

Awesomely powerful. Ferociously fast. But each is still very much a Macintosh.

So much power in so little space. The Quadra 900 is just 18.6" high and fits comfortably next to your desk. The Quadra 700 fits comfortably on top of it.

Up to twice as swift as any of their forebears, they're the first Macintosh computers to be built around the Motorola 68040, rated at 20 MIPS and running at 25 MHz. A highly integrated design, the 040 combines the processor, math coprocessor, memory controller, and cache memory all onto one chip.

More important than merely technical measurements, the Macintosh Quadra computers are totally harmonized systems. The hardware architecture, operating system, interface, peripherals, and networking were all designed from the start to optimize the 040's power and work together smoothly as a single integrated system.

Anyone using compute-intensive applications — like 3-D modeling and stress analysis — will immediately appreciate the difference.

Popular software packages like Infini-D, MicroStation Mac, and Virtus WalkThrough perform more nimbly and

Big just got bigger. The new Macintosh 21" Color Display gives you more drawing board to work on. Colors are vivid, focus is crisp, brightness and contrast are high.

*24-bit video support for up to 16" monitors; 8-bit video support for up to 21" monitors. **There are two easy ways to do it. Simply add an application called SoftPC, or one of two cards from Orange Micro, the Mac286 or Orange386. Apple, the Virtus Corp. Camera 1 image was created in Infini-D; Infini-D is a trademark of Specular International, Ltd. Orbiter image was created with MicroStation Mac; MicroStation is a registered trademark of Bentley Systems Inc., an Intergraph affiliate. ORACLE is a registered Instruments. Lotus and 1-2-3 are registered trademarks of Lotus Development Corporation. SoftPC is a registered trademark of Insignia Solutions Inc. WordPerfect is a registered trademark of WordPerfect Corp. By the way, this ad was designed, typeset, and otherwise*

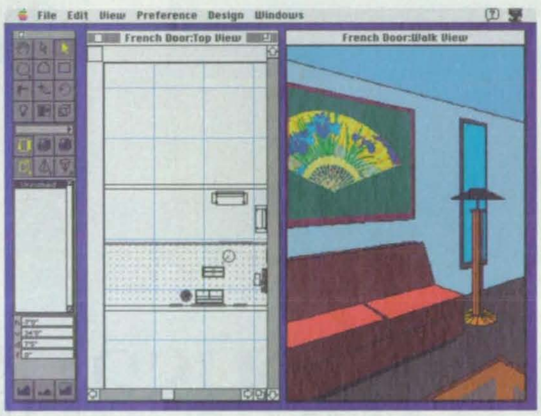
he Mac.

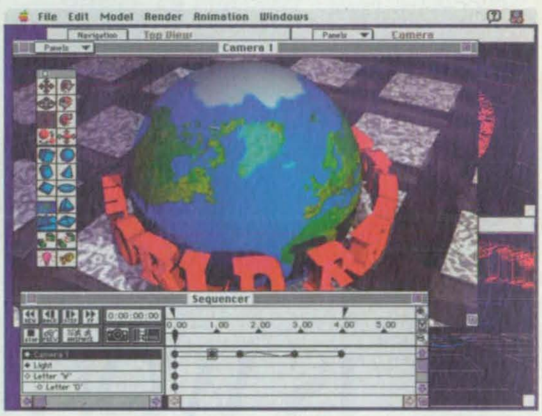
responsively than they ever did before.

And because you do more than design and engineering, these computers also run thousands of Macintosh productivity programs like Lotus 1-2-3 and WordPerfect. Accounting programs like Great Plains. Database programs like ORACLE and FoxBASE+/Mac. And presentation programs like PowerPoint.

In addition, RAM is expandable up to 20MB.

The Quadra 900 is a standing tower of immense capacity with five NuBus expansion slots, SuperDrive, plus three additional half-height expansion bays for CD-ROM drives, magneto-optical disk drives, tape backups, or hard disk storage of over 1 gigabyte. RAM can be added up to 64MB. It also features a key lock, not only





Because it's a Macintosh, extremely sophisticated programs for interior spatial emulation, 3-D modeling, and CAD/CAM are easy to use. Because it's a Macintosh Quadra, they've got the muscle to run nimbly and quickly. Pictured in action, Virtus WalkThrough and Infini-D.

Both Mac® Quadra models offer a generous array of expansion slots. Which you may never need since so much is already on board.

That includes sound input and output ports. And high-performance 24-bit color video controllers built onto the logic boards which will run any Apple and many third-party monitors.* Saving both a slot and the cost of a video card. And both come with Ethernet. So you can move large CAD files around the office at warp speed.

The Macintosh Quadra 700 is the same compact size as the popular Macintosh IIci.

It also comes with a SuperDrive™ disk drive, two NuBus™ slots, and a hard drive of up to 400MB.

for security, but to protect against interruption of your long, compute-intensive jobs.

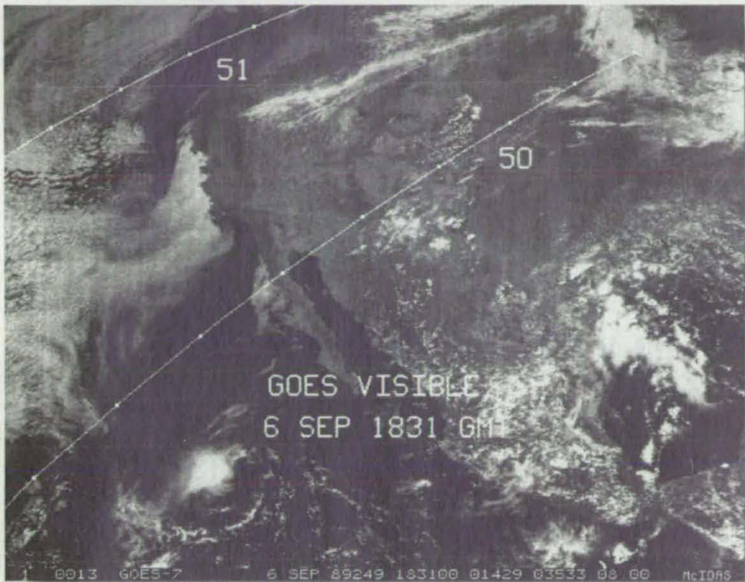
Despite their unprecedented abilities, the Quadra computers are as easy to set up and use as every Macintosh and are capable of running not only thousands of Macintosh applications, but MS-DOS** programs as well.

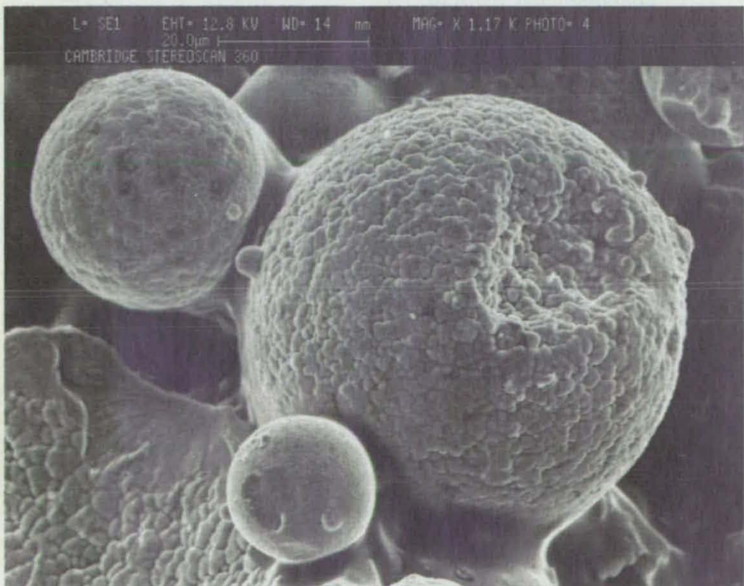
For the name of your nearest authorized Apple reseller, call 800-538-9696, extension 320.

They'll be pleased to demonstrate a power that has vaulted once again to new heights. The power to be your best.®

Introducing Macintosh Quadra.

One thing NASA and modern medicine have in common: Seikosha video printers.





The high-resolution Seikosha VP-3500.

It was Seikosha, a Seiko Group company, that invented the first video printer in 1979.

And it was Seikosha that understood the importance of making a video printer with a line rate high enough for applications ranging from MRI to electron microscopy to industrial QC/QA.

The hard copy images NASA produced on the VP-3500 from geostationary satellite transmissions were used by the last four Space Shuttle crews.

Our 1280-line, multi-format video printer can make things perfectly clear.

The bottom line for any application is picture quality. And the VP-3500's bottom line is very impressive.

The Seikosha VP-3500 gives you 1280 x 1240 resolution with full 64-tone gray-scale prints from any video source: NTSC, PAL, SECAM and RS-170. Plus you can choose multi-format prints.

Let us introduce you to the video printer with the resolution good enough for modern medicine and NASA.

For a demonstration, or additional information on the Seikosha VP-3500, call 1 800-338-2609 or 1 201-327-7227.

SEIKOSHA

A SEIKO GROUP COMPANY

Serious printers for serious business.

Circle Reader Action No. 462

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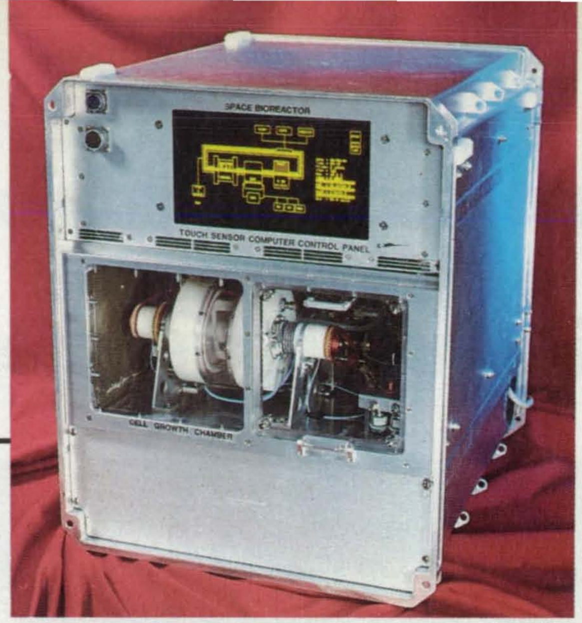

Photo courtesy Johnson Space Center

The Johnson Space Center has produced and patented a cell culturing system (page 17) that achieves previously unobtainable levels of three-dimensional growth and differentiation.

SPECIAL FEATURES

Mission Accomplished 10
Technology 2001 Exhibitor Directory 14

TECHNICAL SECTION

New Product Ideas 24
NASA TU Services 26
Electronic Components and Circuits 28
Electronic Systems 36
Physical Sciences 52
Materials 62
Computer Programs 65
Mechanics 71
Machinery 82
Fabrication Technology 91
Mathematics and Information Sciences 96
Subject Index 107

DEPARTMENTS

On The Cover: The marriage of aerospace and automotive technology has produced a remarkable offspring: the Vector TwinTurbo V-8, a US-built "supercar" that reaches speeds in excess of 200 mph. Turn to Mission Accomplished, page 10.
(Photo courtesy Vector Aeromotive Corp.)

New on the Market 103
New Literature 104
Advertisers Index 110

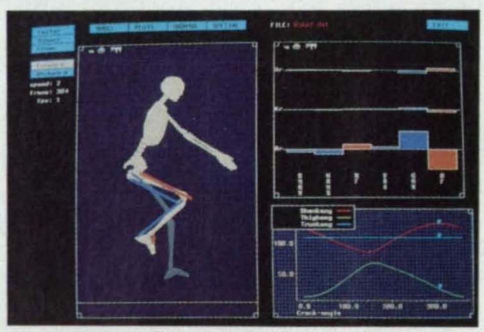

Photo courtesy Department of Veterans Affairs

At the NASA-sponsored Technology 2001 conference this December, the Department of Veterans Affairs' Rehabilitation R&D Center will demonstrate a software program that displays animated pictures of computer-simulated, experimental human motion data. See page 14.

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"It's the automotive equivalent of an F/A -18," said Gerald Wiegert, pointing to his prize creation, the Vector W8 supercar, a high-tech sports car that "flies" from 0-to-60 mph in 3.7 seconds. Wiegert, chairman and CEO of Vector Aeromotive Corp., the California-based manufacturer of the exotic automobile, has adopted technology customarily reserved for spacecraft and fighter jets to make the Vector the quickest accelerating production car ever built in the US.

"If you took the wheels off the Vector and hung it from the ceiling, you would think it was a novel flight design," said Wiegert. "Incorporating everything reasonable and practical from aerospace technology sets the Vector apart from sports cars built in Europe."

The Vector's engine features aircraft-specification twin turbochargers.

Aerospace principles have guided Wiegert's designs from his earliest conception of the Vector in 1971, to a working prototype in 1978, and continuing steadfastly to the first delivery of a W8 TwinTurbo in 1990. David Kostka, Vector Aeromotive's vice president of engineering, cites the space program as a source of such primary design concepts as system redundancy, modularity of components, reusable and quick-release fittings, and the use of bonding in construction.

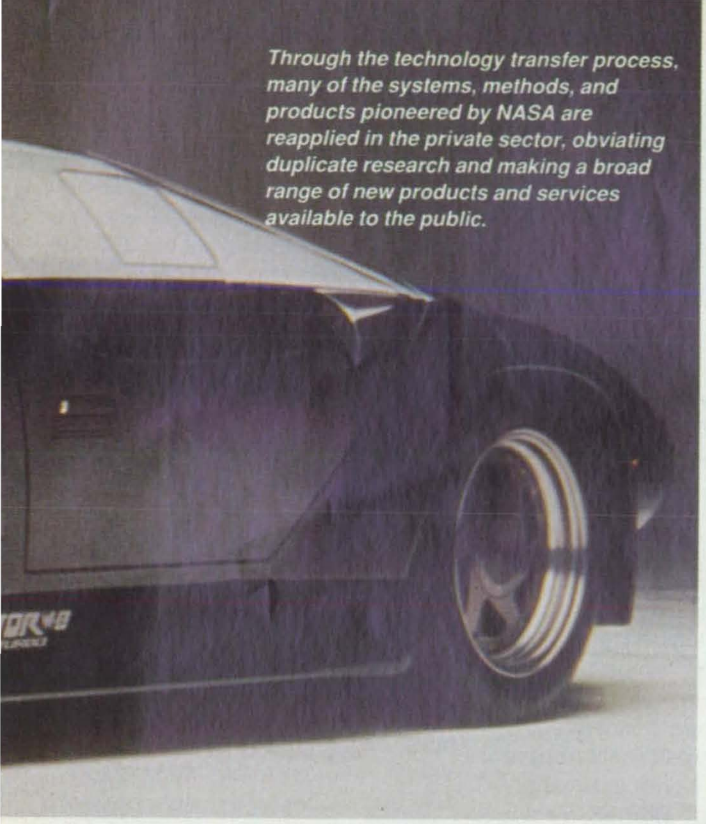
Wiegert's reliance on aerospace technology extends to the automobile's parts and materials, conferring advantages in strength, performance, durability, and safety. Instead of a chassis welded from steel, the Vector's semi-monocoque chassis comprises an aluminum honeycomb floorpan, aluminum panels that are epoxy-bonded and riveted to the frame, and a chrome moly tube steel roll cage. The honeycomb panels provide monocoque crush zones for progressive impact protection, absorbing stress while the passenger remains safely within the roll cage.

Honeycomb aluminum, originally manufactured and patented by Hexcell in 1948, is found in virtually every modern aerospace vehicle. NASA played a key role in the early application and refinement of aluminum honeycomb, according to Michael Bandak, manager of special lab projects at Hexcell. "NASA provided the incentive for companies like ours to develop materials with light weight-to-strength ratios," he said. "All of the current applications owe a debt to the Apollo Lunar Excursion Module, which was the first major application of aluminum honeycomb as an energy absorber."

The Vector's lightweight body, made of a hybrid composite of carbon, Kevlar®, and S-glass unidirectional fibers in an epoxy resin matrix, is resistant to abrasion and corrosion. Kevlar, a material also used widely in the aerospace industry, contributes exceptional toughness, compression strength, and vibration damping.

Housed within this rugged structure is a 6.0-liter, fuel-injected aluminum V8 powerplant that offers 600+ horsepower and 600+ ft./lbs. of torque. Twin aircraft-specification turbochargers propel the Vector to a quarter-mile speed of 124 mph in 12 seconds and a top speed in excess of 200 mph. The engine is designed, like all of the car, for ease of maintenance and repair. Components such as its intercooler package can be dropped out without interfering with other parts by unclasping quick-release aerospace clamps.

The Vector also features military-specification switches, rivets, and circuit breakers; the same high-sheer-strength fasteners used on the space shuttle; and high-tolerance aircraft fuel, brake, trans-



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

Aerospace materials and components set the Vector W8 TwinTurbo apart from other sports cars.

mission, and water-coolant lines. Heat treating enhances, as it does many aerospace parts, the strength of various steel components.

Space-based Protectant

An aluminum-impregnated ceramic coating used on the Vector's exhaust system was originally developed by NASA in the 1960s as a corrosion protectant for blades and heat shields. Improved significantly in the intervening years and now manufactured commercially to military specification for aerospace applications, the coating is temperature-resistant to 704°C and guards against oxidation and corrosion.

Similarly, a thermal barrier coating typically used on aircraft and rocket engines is applied on the exhaust manifold. It reduces temperatures inside the engine compartment, protects the manifold from corrosion, and helps both the catalytic converter and turbochargers to work more efficiently.

The Vector's "cockpit" also manifests Wiegert's commitment to aerospace innovation. The electroluminescent instrument display, analogous to advanced tactical displays found in various military aircraft, is reconfigurable and menu-driven, with a viewing angle exceeding 160 degrees, and has over

Panels of aluminum honeycomb, also used on the space shuttle, provide monocoque crush zones for impact protection.

The Vector is hand-built of primarily American-made parts in Wilmington, CA.

Photos courtesy of Vector Aeromotive Corp.

125,000 pixels for high-resolution graphics and text. It scrolls automatically through four screens, providing data on pressures and temperatures in both digital and analog formats.

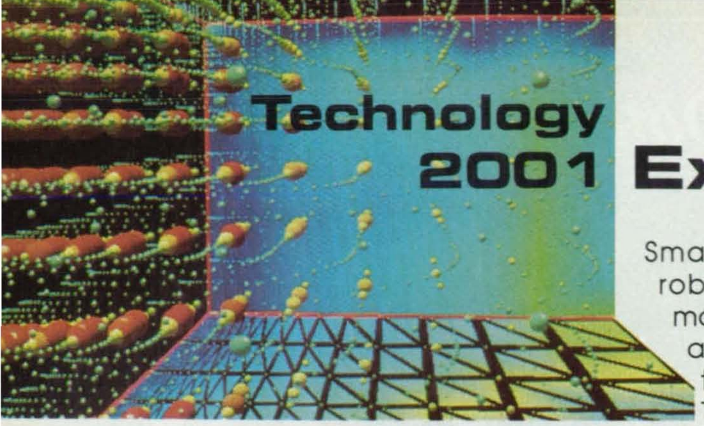
The advanced materials that contribute to the car's high performance also conspire to lower its weight, permitting a luxurious interior. "Not only are many exotics much more fragile than the Vector," said Kostka, "but they also lack creature comforts that would make them much heavier." The Vector sports fully-articulating leather seats with powered back support and a 180-watt tri-amplified sound system with in-dash loading capacity for ten compact disks.

The same technology that makes the Vector one of the world's most powerful production cars also makes it one of the safest. The auto has passed every NHTSA test for safety certification on the first try and with a significant margin, according to Robert Braner, Vector Aeromotive's director of sales and marketing. Standard safety features include air bags, heavy-duty shock-absorbing bumper mounts, and an impact-resistant aircraft-type fuel tank with explosion-suppressing foam. Braided steel hoses reduce collision fire hazard, and manual and automatic fire extinguishing systems are also available.

The Vector is hand-built in Wilmington, CA, at the rate of approximately two per month and has a list price of $398,000. According to Wiegert, the car is "built to last the lifetime of the person who buys it." Sales to international clientele have included numerous European deliveries and the first shipment to Japan in September. The company has fulfilled two US orders since EPA certification in July, and has five more domestic orders currently in production.

Wiegert continues to monitor developments in the aerospace industry with an eye toward the next-generation Vector. "We intend to parallel the state of the art in aerospace materials and techniques," he said. A heads-up display and an optional global positioning system hover on the horizon. The craftsmen at Vector Aeromotive are working to ensure that the best of aerospace takes to the road as well as the air. ❑

Editor's note: *The Vector will be on display at Technology 2001, the second national technology transfer conference and exposition, December 3-5 in the San Jose Convention Center.*



Technology 2001 Exhibitor Directory

Smart sensors...super-strong composites...roving robots...rapid prototyping systems...virtual reality machines...high-tech aids for the disabled. These are just a few of the innovative inventions government laboratories, universities, and private firms will demonstrate at Technology 2001, the second national technology transfer conference and exhibition, December 3-5 in the San Jose Convention Center. Following is a preview of the more than 200 exhibits and diverse technologies to be featured at this NASA-sponsored event.

BOOTH

AECL — 801
Pinawa, Manitoba
Company literature will describe the use of an electron beam to cure, cross-link, and graft polymers and to improve the physical properties of advanced composites.

Aerospace Lubricants Inc. — 231
Columbus, OH,
will exhibit synthetic lubricants for oxygen and vacuum systems, gear boxes, and gas, diesel, and two-cycle engines.

Aerospatiale — 317, 416
Les Mureaux Cedex, France
The firm's Spinoff and Space Products Department will exhibit high-temperature composite materials, fire and thermal protection materials, composite material applications, magnetic bearings, and various space products.

AGEMA Infrared Systems — 824
Secaucus, NJ,
will display advanced infrared thermal imaging systems, including the new Thermovision 800 series, which features an integrated thermal processor, CPU, display and keyboard, and analytical software.

Air Force Systems Command — 217
Andrews Air Force Base, Washington, DC,
will showcase new technologies available for commercial license in the fields of electronics, photonics, AI, avionics, propulsion, space science, and geophysics.

Alsys Inc. — 801
Burlington, MA
Literature will highlight the advantages of using Ada for large, real-time applications, and will describe Alsys' cross-compilers and tools.

Ambassador Marketing — 912
National City, CA,
will display bacteriostatic water treatment units for home and travel usage. The units utilize water filtration technology originally developed for the space shuttle.

American Ceramic Society — 136
Westerville, OH,
will display photopanels of ACS meetings and expos, and offer books and other information about continuing education programs.

American Welding Society — 1034
Miami, FL,
will spotlight the society's annual convention, as well as its educational seminars and conferences. Available literature will include the society's Welding Journal, and AWS codes and standards.

Ames Research Center — 707
Moffett Field, CA
This exhibit will focus on the center's research in information sciences, life sciences, advanced life support, human factors, Earth sciences, civil aeronautics/flight testing, and computational fluid dynamics.

Ames Spatial Auditory Display Laboratory — 225
Moffett Field, CA,
will demonstrate the Convolvotron, a real-time, interactive simulation of a reverberant room. Using headphones, users can manipulate the room's acoustics by expanding and contracting virtual walls, and move four virtual sound sources to affect sound quality.

Ampex — 417
Redwood City, CA,
will display high-performance mass storage systems for space exploration, including the TeraStore™ digital cassette recorder and the TeraAccess™ automated cassette library.

Analytical Graphics — 838
King of Prussia, PA,
will present the Satellite Tool Kit, an interactive graphical tool for 2D display and analysis of satellite, aircraft, ship, and terrestrial vehicle paths; and the Interactive Aerospace Modeling System, a 4D modeler capable of complete satellite constellation display, including Earth model, star fields, and solar plane.

Applied Science and Technology Inc. — 801
Woburn, MA
Literature will describe a wide range of microwave products including power generators, plasma sources, and plasma deposition systems for diamond and other hard surfaces.

Arthur D. Little Inc. — 801
Cambridge, MA
Literature will highlight the company's Solar Power Satellite Project and discuss various space station technologies, such as refrigerator-freezer and laundry systems and a portable contamination and leak detector.

Association of American Railroads/ US Department of Transportation — 1040
Pueblo, CO,
will spotlight a variety of R&D programs for rail transportation conducted at the Transportation Test Center in Pueblo.

Astro-Med Inc. — 1028
West Warwick, RI,
will feature advanced chart recorders ranging from two-channel portable to 16-channel analog/digital programmable, including the Dash 8, a rugged eight-channel field recorder that captures real-time data from DC to 25 kHz at speeds up to 200 mm/sec.

Bateman Manufacturing Company Inc. — 441
Hayward, CA,
will exhibit its precision, short-run CNC machining and large-diameter CNC turning. Bateman specializes in high-energy, stainless steel and aluminum parts.

Bend Research Inc. — 901
Bend, OR,
develops separation systems for industrial and commercial applications in such areas as waste treatment, bioprocesses, gas separations, water purification, and pharmaceuticals.

Bendix/King Air Transport Avionics Div. — 801
Ft. Lauderdale, FL
Literature will describe the Traffic Alert and Collision Avoidance System and SATCOM.

BF Goodrich Aerospace Super-Temp — 406
Sante Fe Springs, CA,
will present high-temperature composite aerospace components, including airframe engine, space, missile, nuclear, and electronic parts.

Bimillennium Corp. — 216
Los Gatos, CA,
will feature HiQ, the first completely integrated software environment for solving real-world engineering and scientific problems, combining over 500 built-in functions, a 4GL programming language, and an interactive graphical editor.

The Bionetics Corp. — 937
Hampton, VA,
will discuss Space Commerce '92, the fourth international space symposium, to be held March 23-26 in Montreux, Switzerland.

Bit 3 Computer Corp. — 410
Minneapolis, MN,
will display adaptors for high-speed, direct, point-to-point interconnection between many popular buses and platforms, including IBM (AT, PS/2, RS/6000), DEC (QBus), Sun (Sbus), Apple (NuBus), VMEBus, MULTIBus, and EISA Bus.

The Boeing Company — 909
Huntsville, AL
This display will spotlight Boeing Defense & Space Group's role in designing, building, and testing laboratory and living modules for space station Freedom, where astronauts will live and work in space for three- to six-month periods. Boeing also will build supply modules and the connecting structures, called nodes, plus on-board systems.

Brookhaven National Laboratory — 533
Upton, NY
This booth will highlight technology transfer opportunities derived from Brookhaven's basic and applied research in the physical, biomedical, and environmental sciences, and in selected energy technologies.

BOOTH

California Institute of Technology 434
Pasadena, CA,
will display posters and provide literature describing research at the Caltech Concurrent Supercomputing Facilities, including data obtained with the Intel Touchstone DELTA system operated by the Concurrent Supercomputing Consortium.

Canadian Space Agency 801
Greater Montreal Area, Quebec
Literature will spotlight the Mobile Servicing System, a remote manipulator for space station assembly and maintenance; RADARSAT, a remote-sensing satellite to be launched in 1994; the Canadian Astronaut Program; and the David Florida Laboratory, the agency's aerospace environmental test facility.

Carnegie Mellon University Robotics Institute 307
Pittsburgh, PA,
will display space-related robotic systems such as the Ambler planetary exploration robot and the Kennedy Space Center tile inspection robot for shuttle ground servicing.

Center for Aerospace Information 617
Baltimore, MD,
will demonstrate how NASA-generated technology has found its way into the private sector via commercial spinoffs. Technology utilization specialists will explain how the professional community can tap into NASA's vast storehouse of available technology.

Ceracon Inc. 839
Sacramento, CA,
will demonstrate a method for consolidating metallic, plastic, and ceramic powders into fully dense, near-net-shape parts in seconds. The process can fully densify ferrous and nonferrous metals, superconductors, superalloys, glassy aluminums, intermetallics, refractory carbides, MMCs, and heavy metals.

CI Systems 724
North Billerica, MA,
will display its mid-size portable collimator system for testing the image quality of infrared cameras in the laboratory or field, as well as its closed-loop automatic FLIR tester.

Computer Sciences Corp. 1041
Lompoc, CA,
developed, with NASA Dryden, the Integrated Test Facility (ITF) Test Bay Computer System, which enables safe and efficient flight testing of advanced research aircraft. It utilizes a network of distributed systems that communicate real-time data through a shared reflective memory.

Corning Inc. 306
Corning, NY
Corning's Technology Sales and Licensing Group will describe the company's analytical and engineering services and its patented technologies available for sale or license.

Creative Designs & Inventions 117
Houston, TX,
will exhibit the Electronik Dipstik, an instrument that electronically determines crankcase or transmission fluid levels.

Cybernet Systems Corp. 129
Ann Arbor, MI,
will showcase a six-axis force-reflecting hand controller; CyberSight®, a 3D vision system; and CyberView®, a multimedia educational astronomy package.

BOOTH

Datatape Inc. 424, 425
Pasadena, CA,
will display high-environment rotary digital and analog magnetic tape recording systems used in aerospace and commercial applications.

Design & Evaluation Inc. 801
Laurel Springs, NJ
Literature will describe a training seminar on "worst case circuit analysis" developed with NASA's Jet Propulsion Laboratory, as well as reliability engineering consulting services.

Diamonex Inc. 520
Allentown, PA,
will display diamonds and diamond coatings for optical and thermal applications, and chemical- and abrasion-resistant coatings for metal, glass, ceramic, and plaster substrates.

Digiray Corp. 311
San Ramon, CA,
will present an electronic, real-time x-ray system based on reverse geometry. It uses a scanning beam of electrons to produce film-quality x-ray images that are displayed on a video monitor in 2D or 3D stereo.

Digital Instruments 801
Santa Barbara, CA
Literature will describe the company's scanning probe microscopes (STM and AFM) with a variety of interchangeable scan heads and scanners for scans ranging from a few nanometers to over 125 microns.

Dimension Technologies Inc. 935
Rochester, NY,
will exhibit the DTI-100M monochrome autostereoscopic 3D display and a full-color (4096) real-time autostereoscopic 3D display.

Earth Observation Satellite Co. 837
Lanham, MD,
will demonstrate with NASA the combined use of remote sensing and digital information processing in resource management.

Eastman Kodak Co. 424, 425
Rochester, NY,
will display high-performance solid-state image sensors and demonstrate the new digital camera system, an infrared imaging system, and the XL7700 digital continuous tone printer.

European Space Agency 416
Paris, France,
will feature the TEST catalog, which presents a range of technologies developed by European firms for space programs and compiled by a group of companies called Space Link Europe.

Fabric Development Inc. 801
Quakertown, PA,
develops and manufactures custom fabrics for industrial, aerospace, and aircraft applications from a variety of yarns including Kevlar, graphite, Nicalon, Nextel, quartz, Spectra, Teflon, Gore-tex, and Nomex.

Fermi National Accelerator Laboratory 634
Batavia, IL
Fermilab's research employing the superconducting Tevatron, the world's most powerful particle accelerator, has led to technological developments in cryogenics and superconductivity, accelerators for medical applications, advanced computers and software, fast electronics, and controls.

BOOTH

FLIR Systems Inc. 1033
Portland, OR,
will present infrared systems for industrial and aerospace applications, including the Probeye models TVS-7300 and TVS-200, and the Thermal Image Management System.

Francis Bitter National Magnet Laboratory
Cambridge, MA 801
Literature will detail the capabilities of the nation's High-Magnetic Field Facility, where the world's highest magnetic fields are offered free of charge to qualified scientists and engineers.

General Sciences Corp. 801
Laurel, MD
Brochure will describe METPRO, a fully-integrated weather information ingest and processing system supporting operational forecast and atmospheric research on a UNIX-based SGI workstation.

Georgia Power Co. 234
Atlanta, GA,
This exhibit will spotlight the Clifton Corridor Council, a not-for-profit foundation dedicated to developing Georgia's biomedical technology industry through a program of technology transfer, resource marketing, and education involving its member research institutions and businesses.

Goddard Space Flight Center 506
Greenbelt, MD,
will display innovative biomedical devices such as a temperature pill for measuring and relaying deep body temperature, a programmable implantable medication system, and a directional hearing aid. The center also will exhibit a climbing robot, a two-hundred-pound compliant joint, a spine-locking screen end effector for space, and a capacIflector sensor.

Government of Israel Trade Center 120
New York, NY

Government of Ontario, Canada 801
California Office
Los Angeles, CA
Government of Ontario offices in Europe, Asia, the Pacific Rim, and throughout the US provide information and advice on trade, licensing, technology transfer, joint venture, and investment opportunities.

Hamilton Technologies Inc. 801
Cambridge, MA
Literature will spotlight a high-productivity system and software life-cycle development tool that generates reliable, production-quality code from graphical object-oriented network specifications.

Hardigg Industries 1000
South Deerfield, MA
Hardigg's rotationally-molded and durable cases provide shipping protection for delicate payloads and are available in 221 sizes, including 19" rack cases.

Heimann Infrared Division/ Pyrotechnics Corp. 801
Millington, NJ
Literature will describe Heimann's versatile, microprocessor-based infrared thermometer, the model KT19, which makes extremely repeatable measurements and is available with laser sighting.

BOOTH

HEMCO Corp. 941
Independence, MO,
will present Unilab, a modular self-contained room enclosure that can be designed to meet clean room, environmental control room, and laboratory work area requirements. Fume hoods and related equipment also will be displayed.

Hewlett-Packard Co. 1032
Orlando, FL,
will demonstrate visualization software running on series 700 workstations. Application will run on VUE, the HP graphical user interface.

Hitachi Denshi America Ltd. 524
Woodbury, NY,
will show its ultra-high-resolution, self-contained rear projectors for use in command center, HDTV, simulation, and other applications.

BOOTH

Hi-Techniques 439
Madison, WI,
will exhibit data acquisition systems ranging from 1 Hz to 200 MHz, featuring thorough data analysis and outputs and including computers, printers, and plotters.

Horstmann Software Design Corp. 931
San Jose, CA,
will demonstrate ChiWriter, a scientific/multilingual word processor featuring a WYSIWYG screen display, easy math editing, and automatic formatting.

HTS Inc. 235
Troy, NY,
will display polyimide resins and compounds, prepregs, adhesives, and composites, as well as polyimide foam products.

BOOTH

Hyperspeed Technologies Inc. 801
San Diego, CA
Hyperspeed's line of i860-based single and dual processor supercomputer add-on boards and software for IBM PC/AT bus-compatible computers will be detailed in company literature.

Idaho National Engineering Laboratory
Idaho Falls, ID, 631
will spotlight research in nuclear reactors, information technology, waste treatment, materials, biotechnology, chemical sciences, applied engineering, and rapid prototyping.

Ideas Inc. 801
Columbia, MD
Literature will highlight the company's space-flight hardware design, development, and fabrication, space station robotics, system engineering, and system integration capabilities.

Industrial Materials Technology Inc. 801
Andover, MA,
will illustrate the hot isostatic pressing (HIP) of powder metals to make net-shape copper-alloy rocket thrust chambers.

Information Handling Services 310
Englewood, CO,
will demonstrate its technical databases on CD-ROM, including military specifications and standards and parameters on more than one million IC/discrete devices.

Inframetrics Inc. 724
North Billerica, MA
Inframetrics will feature the new convenient and portable 700 series thermal imaging radiometer for infrared inspection and analysis.

Institute of Environmental Sciences 801
Mount Prospect, IL
The *Journal of the IES* discusses the institute's role as a technical society serving in the interests of contamination control, product reliability, energy and environment, testing, and computer applications.

Integral Systems Inc. 936
Lanham, MD,
will exhibit EPOCH 2000, a workstation-based system for satellite command, control, and analysis. This database-driven, open-architecture solution supports distributed processing.

Integrated Engineering Software 435
Winnipeg, Manitoba,
will demonstrate interactive 2D/3D CAE electromagnetic field analysis software based on the boundary element method and used in the design and analysis of magnetic, electrical, and electronic components.

Integrated Systems Inc. 122
Santa Clara, CA,
develops numerical analysis and simulation tools such as Xmath, which features 2D and 3D graphs, object-oriented algorithm development, and high-level numerical programming.

InterFinance Corp. 801
Minneapolis, MN,
will offer *High-Technology SuperConnections*, a journal for technology industry leaders covering strategic alliances, technology transfer, financing, and international expansion.

Inventive Machine Laboratory 237
Minsk, USSR,
will display the Inventive Machine, a family of expert systems for solving complex engineering problems.

	BOOTH
IXYS Corp.	801

San Jose, CA,
and its German subsidiary, ABB-IXYS Semiconductor GMBH, specialize in high-performance discrete power semiconductors, power modules, and ICs for devices used in industrial automation, commercial, medical, and automotive applications.

James Grunder & Associates Inc. — 834
Mission, KS,
will show its video scan converters, including the YEM CVS 980, which converts computer signals to broadcast video signals, and the Video International DTC 1504, a broadcast-quality standards converter.

Jet Propulsion Laboratory — 713
Pasadena, CA,
will highlight examples of commercialized technologies, including infrared sensors for medical thermometers, neural networks for robotics application, materials characterization, and mobile satellite communications.

Johnson Space Center — 508
Houston, TX,
will feature a cell culturing system that achieves previously unobtainable levels of three-dimensional growth and differentiation.

JP Technologies Inc. — 332
Upland, CA,
will exhibit sensors for measuring strain, temperature, electromagnetic fields, and radiation.

Keane Controls Corp. — 340
Anaheim, CA,
will highlight its high-performance solenoid valves, pressure regulators, and pilot valves. The products are explosion-proof, function from vacuum to 10,000 psi, and feature zero leak.

Kennedy Space Center — 711
Florida,
will showcase the Knowledge-Based Autonomous Test Engineer (KATE), a computerized expert system that performs control and redundancy management of process control systems. Also featured will be electrically conducting polymers for corrosion protection, fiber/optic TV camera direct, a global positioning system, and a neuromuscular stimulator.

Kevex X-Ray Inc. — 421
Scotts Valley, CA,
will display microfocus and portable x-ray sources, and its new XC series of x-ray sensitive cameras.

Langley Research Center — 808
Hampton, VA,
will display spinoff technologies including an induction heating gun, a fetal heart rate monitor, an x-ray fluorescence spectrometer, a pressure-sensitive surgical knife, a flowrate logging seepage meter, a bladder distension sensor, and a hyperthermia temperature monitor.

Lawrence Livermore National Laboratory — 530
Livermore, CA,
will feature technologies, patent licensing opportunities, and potential collaborative arrangements with the laboratory.

Lazerus — 801
Berkeley, CA
Literature will describe Express Windows, a high-performance, Windows-driven software package that allows Windows applications to run on the entire line of Expressway modular i860 graphics boards for PCs.

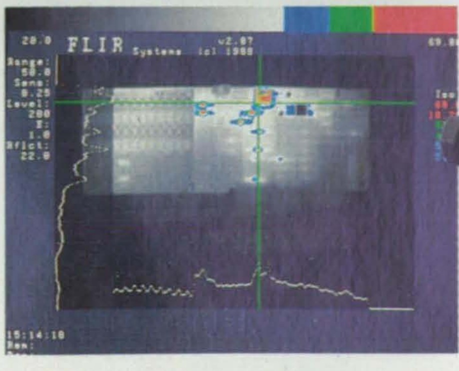
Lewis Research Center — 510
Cleveland, OH,
will feature solid-state electronic circuits fabricated from high-temperature superconductors that could increase the message-handling capacity of COMSATs by a factor of five. The center also will show extruded PS212 high-temperature dry bearing materials, applications of the TAZ-8A alloy, and research to optimize the fit of orthopedic implants and reduce artificial joint failures.

Lockheed Missiles and Space Company — 413
Sunnyvale, CA,
will offer free transportation to their nearby visitor's center, which features Hydromod 7 (a lunar hydroponic greenhouse) and a space station Freedom mockup.

Los Alamos National Laboratory — 639
Los Alamos, NM,
will present licensable technology in computing and communications, materials science, sensors, advanced energy, and environmental science.

Luxtron Corp. — 801
Beaverton, OR
OFT products from Luxtron's Accufiber Division enable scientists and engineers to measure high temperatures with greater range, resolution, and repeatability, and at a faster rate than possible with either thermocouples or conventional optical pyrometers.

Mantech/NSI — 801
Sunnyvale, CA
Literature will describe Mantech's capabilities in aeronautical engineering, space operations, aircraft maintenance, and flight simulation.



BOOTH

Marshall Space Flight Center — 512
Alabama,
will demonstrate spinoff products including an automatic weld joint tracking system; a lightweight, portable, powered seat lift; a thermal curtain for food delivery carts; a lunch box insulation unit; and below-the-elbow prosthesis end effectors for unilateral amputees.

Martin Marietta Energy Systems Inc. — 730
Oak Ridge, TN
The Department of Energy's Oak Ridge National Laboratory, a government-owned contractor-operated facility, has licensed over 50 technologies to industry. The exhibit will focus on high-temperature materials.

Martin Marietta Manned Space Systems — 409
New Orleans, LA,
will display advanced insulation materials and welding technology developed for NASA's space shuttle external tank project and now available for commercial use.

Martin Marietta Paducah Gaseous Diffusion Plant — 117
Murray, KY,
will exhibit the Integrated Automated Emergency Management Information System developed on NASA software for industry and government applications.

MathWorks Inc. — 228
Natick, MA,
will demonstrate the latest release of MATLAB™ an interactive software system for high-performance numeric computation and data analysis. Combined with SIMULAB™ software for block diagram modeling and simulation, the system can be applied to digital signal processing, control system design, and optimization.

BOOTH

Maxwell Laboratories Inc. — 801
San Diego, CA
Literature will describe power supplies in voltages from 10-50 kv for use as constant current sources for efficient charging of high-voltage capacitors.

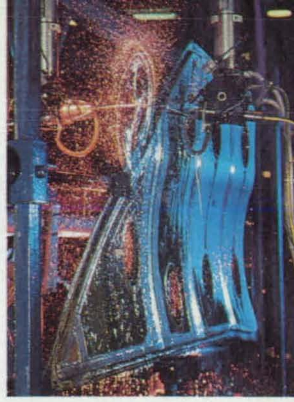
McClellan Air Force Base — 316
California,
will display an electroglass automatic wafer handler and prober that tests up to 4000 chips per wafer; very-high-speed integrated circuit (VHSIC) chips; and several nondestructive inspection processes, such as ultrasonic bond testing and neutron radiography.

MCNC, Center for Microelectronics — 938
Research Triangle Park, NC,
provides R&D support for microstructural processing services, novel device development and prototyping, circuit design, and VLSI process development.

Med Tech International — 801
London, Ontario,
is a nonprofit national forum for the dissemination of information on medical device technology. Literature will highlight Med Tech's 1992 conference and exhibition.

BOOTH

Meridian Laboratory Inc. — 318
Middleton, WI,
will exhibit a high-friction elastomeric material for precision-molded friction feed rollers; high-performance rotary electrical contacts that transfer power, measurement, and control signals into rotating machinery; and sealed mercury wetted contacts that eliminate electrical slipring noise and mechanical wear.



A nondestructive inspection package the Air Force will demonstrate at Technology 2001 uses sound waves traveling through water to detect flaws and delamination in bonded material.

Metalworking Technology Inc. — 725
Johnstown, PA,
provides a wide range of high-quality, cost-efficient technical services to improve productivity and manufacturing performance in the metalworking industry.

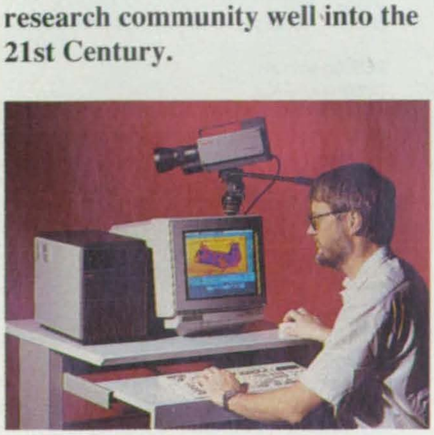
Mikron Instrument Co. — 835
Wyckoff, NJ,
will display infrared thermometers for non-contact temperature measurement, blackbody sources, thermal imaging, and fiber optic sensors.

Mitsubishi International Corp. — 801
White Plains, NY
Brochure will spotlight the Shinko CHC-S445 A-size 300 dpi dye sublimation printer, which produces brilliant, photo-realistic images with laser-sharp text.

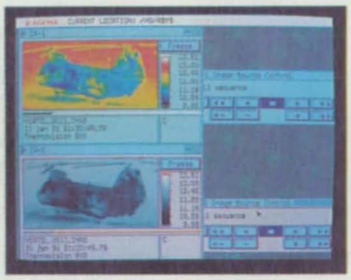
Molectron Detector Inc. — 801
Portland, OR
Literature will feature laser power meters, pyroelectric energy meters, hybrid pyroelectric detectors and amplifiers, and wire grid polarizers.

All existing infrared imaging systems just joined yesterday's technology.

Introducing Thermovision®900: a high definition thermal measurement and analysis system, designed to meet the highly specialized and constantly evolving needs of the advanced research community well into the 21st Century.



Superior image resolution. Absolute measurement accuracy. Unlimited processing capability. Finally there's an infrared thermal measurement and analysis system that provides all three - and it's integrated into an easy to operate desktop total workstation.



To begin with, the advanced optical design of the Thermovision®900's new, multifaceted scanning module is nearly three times more efficient than conventional scanning systems and more than twice as efficient as a focal plane array. So the 900's long and short wave scanners capture the details of a thermal event with incredible resolution and accuracy.

The thermal image data is digitized at 12 bits, prior to transmission, ensuring that the full, 4,096 level dynamic signal range is downloaded for processing and storage by the Thermovision control unit.

Today's PC's couldn't handle the 900 scanners' high data rates, so we've designed a powerful, dedicated system controller whose two, parallel channels allow simultaneous, real time presentation and analysis of two images from either one single scanner or two separate scanners on the same display, or direct comparison of current and stored image data.

VME bus architecture, OS-9 operating system and the X-Windows graphic user interface combine to provide a multi-tasking IR workstation, with all scanner operations, including focus, aperture and filter selection, controlled from the mouse or keyboard. Built-in Ethernet allows two-way communication and control from a remote computer.

Best of all, the 900 is designed with your future in mind. State of the art now, it has the built-in modularity to stay that way, even as your requirements change and expand.

If the Thermovision 900 sounds like a system you'd like to see more of, just contact AGEMA Infrared Systems, 550 County Avenue, Secaucus, NJ 07094. Tel 201-867-5390 Fax 201-867-2191.

And get a jump on the 21st Century

AGEMA
Infrared Systems

Circle Reader Action No. 603

BOOTH

Morgantown Energy Technology Center 534
Morgantown, WV,
will discuss its laboratory and engineering facilities and expertise in fossil-energy-related research and development.

NASA 507
Washington, DC
NASA's "theater island" will highlight technologies developed for industrial use in such fields as materials, microsensors, and life sciences. The exhibit will feature a 20-foot video wall and models of the National Aero-Space Plane, the space shuttle, and space station Freedom.

NASA Industrial Applications Center/ University of Pittsburgh 133
Pittsburgh, PA
NIAC specializes in the transfer of technology from federal agencies and other domestic and international organizations. Its services include information retrieval, technical analyses and assessments, market intelligence, product enhancement, and applications development.

NASA Regional Technology Transfer Centers 811
This exhibit will spotlight six new regional centers and the National Technology Transfer Center, which work with federal and state technology transfer activities and over 600 federal laboratories to form a comprehensive network for the rapid transfer of federal technologies to US business and industry.

NASA Small Business Innovation Research Program 806
Bethesda, MD
The SBIR program advances aerospace science and engineering by funding innovative R&D projects to meet NASA's technical requirements.

NASA Tech Briefs 112
New York, NY

National Center for Manufacturing Sciences 210
Ann Arbor, MI
NCMS, a not-for-profit corporation with 115 member corporations, promotes manufacturing technology R&D by building cofunded consortia of its member corporations.

National Institute of Standards & Technology 1024
Gaithersburg, MD,
will showcase its technology services which provide technical support and, in some cases, financial assistance to US industry, especially to small and medium-size businesses.

National Institutes of Health 1035
Bethesda, MD,
will present inventions available for license and CRADA opportunities, and will distribute an outreach package.

National Instruments Corp. 330
Austin, TX,
will exhibit LabVIEW® 2 and LabWindows® software and acquisition hardware products used by scientists and engineers to build integrated PC-based instrumentation systems.

National Renewable Energy Laboratory 539
Golden, CO,
The NREL exhibit will focus on technology in the areas of solar detoxification, solar thermal, energy efficiency in buildings, photovoltaics, wind, and biofuels.

BOOTH

National Space Society 236
Washington, DC,
is a nonprofit organization promoting space research, exploration, development, and habitation.

Naval Air Warfare Center 830
Point Magu, CA,
will exhibit computer hardware, test instrumentation, building materials, electronics, composites, microwave applications, and propellants.

Naval Research Laboratory 625
Washington, DC,
will display current research developments available for licensing, such as an antifoulant coating, drug detection sensors, silicon-on-insulators, and fluorinated resins.

NERAC Inc. 1029
Tolland, CT
A technology transfer center, NERAC works in cooperation with NASA to promote American industry by providing technological assistance and problem-solving services.

Novespace 416
Paris, France,
will describe European technology transfer networks established around Novespace, and will feature various technology catalogs.

Numerical Algorithms Group 841
Downers Grove, IL,
will exhibit its scientific and numerical subroutine library software for user-callable applications in research and engineering.

NYMA Inc. 925
Greenbelt, MD
NYMA manufactures a line of 386 and 486 PCs and provides systems integration, systems engineering, and programmatic support to the aerospace industry.

Ohio Aerospace Institute 411
Brook Park, OH,
is a university industry government consortium organized to promote collaborative research, graduate and continuing education, and technology transfer in aerospace-related science and engineering.

Olympus Corp. 335
Lake Success, NY,
will display industrial high-magnification borescopes and fiberscopes with video for use in vacuum and high-temperature inspection applications.

Optical Society of America 1038
Washington, DC
OSA, a not-for-profit professional organization of over 11,000 optical scientists and engineers, will display publications, digests, and journals, as well as information on optics careers, OSA meetings, and membership services.

Oracle Corp. 407
Bethesda, MD,
will exhibit its integrated line of software products for database management, computer-aided systems engineering, application development, and office automation.

Pacific Northwest Laboratory 638
Richland, WA,
will show an electro-optic liquid sensor that provides highly accurate readings of water and liquid contaminant levels in soil and other porous materials, and a software package that provides summary information on over 100 environmental remediation technologies.

BOOTH

Pasha Publications 801
Arlington, VA,
will display a catalog of aerospace books and newsletters, including the *Space Station Directory and Program Guide*, the *World Guide to Commercial Launch Vehicles*, and *Space Business News*.

Patton & Patton Software 933
Morgan Hill, CA,
will demonstrate Flow Charting 3, a software package that automates the development and revision of flowcharts, process control diagrams, data flow diagrams, and organizational charts.

Pittsburgh Energy Technology Center 535
Pittsburgh, PA,
will feature a scale model of the Coal Preparation Advanced Fine-Coal Cleaning integrated circuit, designed for CRADA partners to test individual modules (100 lbs/hr feed).

PMS Electro-Optics 334
Boulder, CO,
will exhibit tunable helium-neon lasers, including orange (612nm), yellow (594nm), and green (543nm).

Princeton Plasma Physics Laboratory 538
Princeton, NJ,
will highlight recent developments in plasma processing, vacuum and magnetic systems, mechanical and electrical controls, and neutral beams.

Proto Manufacturing Ltd. 114
Oldcastle, Ontario,
will display nondestructive, residual stress measurement systems and services, including portable x-ray diffraction systems offering the smallest available diffraction heads.

Quantum Devices Inc. 801
Barneveld, WI
Literature will feature wavelength-specific, high-power GaAlAs LEDs and detail applications in controlled environment agriculture, molecular biology, and photobiological research.

Raytheon Company, M & PT Division 125
Waltham, MA,
will display space-qualified custom hybrid microcircuits and high-density power supplies.

Rehab R&D Center, VA Medical Center 131
Palo Alto, CA,
This exhibit will focus on devices and techniques to increase the independence of disabled individuals. Relevant research fields include automation, robotics, surgery simulation, interface design, communication and control systems, patient handling, and joint replacement.

RGB Spectrum 900
Berkeley, CA,
will showcase the RGB/Videolink™ scan converters, which transform computer graphics to television format in real time; the RGB/View™ video windowing system, which displays live video on computer monitors; and the High-Resolution Video Mixer (HRVM), for combining the video outputs from two or more computer displays in real time with resolution up to 1600 x 1200 pixels.

RG Hansen & Associates 138
Santa Barbara, CA,
will exhibit cryogenic systems and components for use in spectroscopy sample cooling, materials research, and detector cooling, as well as custom cryogenic systems for R&D.

WE JUST CUT YOUR MASS STORAGE PROBLEMS DOWN TO SIZE.

Imagine taking all the data from 412 industry-standard 3490E written cartridges and putting them on just one cartridge.

That's like shrinking the entire red area above into the little gray box in the corner.

But that's the extraordinary increase in data density you can achieve with the new Ampex TeraStore™ system.

With it, you can store a full terabyte of data in just six cartridges a little larger than this page.

Or, with our new TeraAccess™ Automated Cartridge Library, you can store 6.4 terabytes in just 21 square feet—a volumetric efficiency of more than 100:1 over any other robotic system on the market today.

And both systems deliver an unprecedented transfer rate of 15 Mbytes per second sustained, 20 Mbytes per second burst.

The simple fact is, TeraStore and TeraAccess can help you cut the mass storage problems of the 90's down to size *today.*

For more information, call or write us today. Or see these revolutionary systems in person at Booth 417 at the NASA Technology 2001 Show in San Jose from December 3-5, 1991.

AMPEX

Circle Reader Action No. 595

Ampex Data Systems Corporation 401 Broadway, MS 3-23 Redwood City, CA 94063-3199 (800) 562-3621

BOOTH

Ribbon Technology Corp. 735
Blacklick, OH,
will present "Melt Overflow" direct casting technology, which can produce superalloys and intermetallics in the form of fiber, particulate, and strip or foil.

Rockwell International Commercial GPS Business 516
Richardson, TX,
will display NavCore V, a single-board, 5-channel, C/A code Global Positioning System (GPS) receiver engine designed for integration into OEM navigation products.

Salco Circuits 929
Corona, CA,
specializes in custom printed circuit boards, CAD, fabrication, and assemblies. Available board types include multilayer, flex, rigid-flex, and microwave.

Sandia National Laboratories 630
Albuquerque, NM,
will spotlight its unique technical capabilities in materials and processes, parallel processing, software, pulse power microelectronics, field testing, robotics, and manufacturing processes.

Science Applications International Corp. 801
San Diego, CA
Literature will report developments in the fields of optics, sensors, computers, systems synthesis and analysis, and manufacturing.

Simmonds Precision Aircraft Systems 406
Vergennes, VT,
will exhibit fluid and propellant measuring systems for aerospace applications such as manned space and expendable launch vehicles, strategic missiles, and orbiting satellites.

SMTEK 1030
Newbury Park, CA,
will present an integrated approach for High-Rel military and space SMT requirements. SMTEK's turnkey facility provides PWB design and fabrication, concurrent engineering analysis, and automated CCA assembly and testing.

Sorbilite Inc. 525
Virginia Beach, VA,
will feature a low-cost recycling system that converts sawdust, paper, and other waste materials into high-quality 3D articles and covers them with decorative skins in one step.

South Carolina Universities Research Education Foundation 336
Charleston, SC
The foundation's technology transfer council conceives, evaluates, and implements programs for the commercialization of technology from the Westinghouse Savannah River Company and South Carolina's major institutions.

Space News 230
Springfield, VA,
is a weekly newspaper dedicated to the politics, business, and technology of space, offering concise and timely coverage of space community developments.

Specialty Steel & Forge 1001
Leonia, NJ,
is a service center and open die forge facility specializing in stainless steel, nickel, titanium, aluminum, and exotic alloys in all mill forms.

BOOTH

SRI International 624
Menlo Park, CA,
a nonprofit R&D consulting organization and the evaluator of NASA technology for *NASA Tech Briefs*, will demonstrate FRASTA, a new approach to failure analysis, and discuss diamagnetic levitation and telepresence research.

SR Taylor & Associates 801
Bartlesville, OK,
develops new ultrasonic processing technologies including sonocatalysis, coalescence, flow promotion, and atomization.

Stardent Computer Inc. 1031
Milpitas, CA,
will exhibit the Vistra 800 series desktop visualization system based on Intel's i860; application visualization system (AVS) software; and the Titan 3000 and 750 visualization system departmental supercomputers.

Statistical Sciences Inc. 117
Seattle, WA,
will demonstrate S-PLUS, data analysis software featuring interactive graphics, exploratory data analysis, modern statistical methods, and an advanced programming language.

Stennis Space Center 709
Mississippi,
will present various technologies available for commercialization including a gamma ray collimator for NDTE of thick-walled pressure vessels; cryogenic spill and fire protection coveralls; smart hydrogen sensor technology; and engine plume diagnostic testing.

Stephens Analytical 737
Montreal, Quebec,
will exhibit MCM hygrometers (trace moisture analyzers) for air and noncorrosive gases. They feature reliable response from saturation to 0.5 ppm(v) in less than 15 seconds.

StereoGraphics Corp. 836
San Rafael, CA,
will demonstrate the CrystalEyes stereoptic 3D viewing system. The lightweight, tetherless, all electronic eyeware allows users to see lifelike, real-time images.

Strategic Defense Initiative Organization 241
Washington, DC,
will exhibit successful spinoff technologies from the SDI to the marketplace and other government applications.

Sun Microsystems Inc. 124
Mountain View, CA,
will demonstrate its latest family of networking UNIX workstations, highlighting video and multimedia capabilities.

Symbolics Inc./MACSYMA Division 739
Burlington, MA,
will demonstrate MACSYMA® symbolic math software, which applies 2D and 3D graphics to problems in algebra, calculus, trigonometry, and other branches of higher mathematics.

Systems Control Technology Inc. 216
Palo Alto, CA,
will feature Model-C, an interactive software package for modeling and simulation of nonlinear dynamic systems.

BOOTH

TechLaw Group 801
Pittsburgh, PA
Brochure describes this law firm network serving businesses, agencies, institutions, and individuals involved in technology.

Technical Insights Inc. 801
Fort Lee, NJ,
will display *Inside R&D*, a weekly publication focusing on new and significant developments that will generate products and markets in the near term.

Technology Access Report 137
San Rafael, CA,
is a leading source of news, analysis, and advice on technology transfer, commercialization, management, policy, and deployment across all technological industries and fields.

Technology Targeting Inc. 801
Salt Lake City, UT
The Technology Targeting DataBase™ is a computerized system for matching publicly-funded technologies produced at universities and federal laboratories to private corporations seeking such technologies.

Technology Transfer Society 134
Indianapolis, IN,
will exhibit technology transfer journals/newsletters, and provide membership and society activities information.

Tennessee Technology Foundation 736
Knoxville, TN,
is a not-for-profit corporation promoting technology-based economic growth in Tennessee. Various companies will be exhibiting products in the fields of image analysis, computational fluid dynamics, neural networks and expert systems, advanced materials, and aerospace design and fabrication.

Thin Film Technology Inc. 840
Buellton, CA,
will showcase its vacuum coating service, which employs both evaporation and RF/DC magnetron sputtering techniques to produce conductive, resistive, dielectric, wear-resistant, or optical coatings; and its substrate patterning services, which use etchback, liftoff, and plating techniques to generate high-resolution patterns.

Tiodize Company Inc. 325
Huntington Beach, CA,
will display all-graphite composite products, self-lubricating graphite composites, titanium anodizing, hard anodize with Teflon, anti-corrosion coatings, dry film PTFE lubricants, Teflon coatings, and mold releases.

Triodyne Inc. 430
Niles, IL,
will highlight work with the Department of Energy's Office of Technology Development in the fields of environmental restoration and waste management.

Ultramet 940
Pacoima, CA,
will display advanced materials for high-temperature aerospace applications, including refractory metals and ceramics fabricated by chemical vapor deposition and infiltration.

United Magnet Technologies 939
Oakland, CA,
will feature accelerator-beam handling electromagnets, plasma (fusion) containment coils, pulse transformers, chokes, inductors, and solenoids.

BOOTH

University of Dayton Research Institute 741
Dayton, OH
The UDRI exhibit will feature advanced phase-change thermal energy storage materials for heating and cooling applications, an oil life measurement technique, rigid-rod molecular composites, fire-extinguishing materials, and ceramic devices for sustained, long-term delivery of chemicals.

University of Georgia/COSMIC 807
Athens, GA
NASA's Computer Software Management and Information Center (COSMIC) will provide information on more than 1200 software programs developed or funded by NASA and available for use in industry, education, and government.

USAF Manufacturing Technology Directorate 320
Wright Patterson Air Force Base, OH,
will provide information on more than 100 ManTech programs with technology commercialization and transfer potential.

US Army Laboratory Command 930
Adelphi, MD
LABCOM will feature technologies from the US Army Technology Base including advanced electronics, signal processors, polymers, superconductors, advanced computing software, artificial intelligence, ballistics, and materials.

USBI Corp. 107
Huntsville, AL,
United Technologies Corporation's USBI is the prime contractor for the nonmotor segments of the space shuttle's solid rocket boosters. USBI's Automated Robotic Maintenance System (ARMS) is spinoff technology from the shuttle program. It features high-pressure waterjet to strip aircraft paint and remove coatings from turbine engines.

USDA Agricultural Research Service 540
Beltsville, MD,
will show computer-controlled equipment, expert systems, and bioprocess engineering systems for manufacturing value-added industrial and food products.

US Geological Survey Water Resources Division 906
Reston, VA,
will present information on water resources from computer-oriented systems including CD-ROM and GIS, and on applications of water data to land use in California's Central Valley.

Vector Aeromotive Corp. 916
Wilmington, CA,
will exhibit the Vector supercar, sporting advanced aerospace systems design, military specification electronics, and fighter-type instrumentation. The Vector's 600+ horsepower, all-aluminum TwinTurbo V8 powerplant has established it as the fastest American-built production automobile.

Vermont Research Corp. 801
North Springfield, VT
Literature will highlight the company's high-speed solid-state disks, designed to resolve I/O bottlenecks, reduce response times, and withstand harsh environments.

Viking Labs Metrum 902
Mountain View, CA,
will describe the capabilities of Metrum Instrumentation Services, which calibrates, maintains, and repairs electronic and dimensional instruments, and Metrum Viking Laboratories, which provides component screening and environmental testing of electronic devices and systems.

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Virginia Center for Innovative Technology 934
Herndon, VA,
a nonprofit corporation developing technology with industry at the state's universities, will display university intellectual properties available for licensing in information technology, CAE, materials science, and biotechnology.

Wisconsin Center for Space Automation and Robotics 801
Madison, WI
Literature will highlight automation and robotic technologies, automated plant growth systems for space applications, and automated lunar resource processing systems.

BOOTH

Wolfram Research Inc. 232
Champaign, IL,
will demonstrate Mathematica®, a system for performing numerical, symbolic, and graphical computation. Used as both an interactive calculation tool and a programming language, numerical capabilities include arbitrary precision arithmetic and matrix manipulation.

Editor's note: The final and complete list of exhibitors and booth locations will be contained in the official show program distributed on-site in the show registration area. *For further information about Technology 2001, see page 41.*

Circle Reader Action No. 531

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 26). NASA's patent-licensing program to encourage commercial development is described on page 26.

Magnet/Hall-Effect Random-Access Memory

A proposed random-access memory would have the nonvolatility of present magnetoresistive memories but could be read about 10 times as fast. Other desirable characteristics would include high immunity to ionizing radiation and storage densities of the order of 10^6 bits/cm^2 or more.
(See page 28)

Lockwasher Strongly Resists Disassembly

A lockwasher prevents counterrotation and loosening of machine screw once the screw is fully tightened. The features of the lockwasher and its mating screwhead are similar to those of a "childproof" cap on a pill bottle.
(See page 93)

Fluidized-Bed Silane-Decomposition Reactor

An energy-efficient pyrolysis reactor produces high-purity polycrystalline silicon from silane or halosilane. Deposition of silicon on the reactor walls is effectively eliminated. The product silicon can be used to construct solar cells and other semiconductor products.
(See page 63)

Two-Phase Hero Turbine With Curved Nozzles

A proposed Hero turbine would include curved de Laval nozzles for increased efficiency. Such turbines could compete with rotary separator turbines that have been used in geothermal powerplants. Other potential applications include heat pumps and thermal-energy conversion systems.
(See page 87)

Compensating for Movement of Eye in Laser Surgery

A conceptual system for laser surgery would include a subsystem to keep the laser aimed at the desired spot on the retina as the eye moves. The subsystem could also be modified to prevent the laser from being fired when the spot has moved off target.
(See page 46)

Magnetic Analog Random-Access Memory

A proposed integrated, solid-state, analog memory would be based on a principle of magnetic writing and magnetoresistive reading. Attributes would include fast access, low power, nonvolatility, and high storage density.
(See page 30)

HOW YOU CAN BENEFIT FROM NASA's TECHNOLOGY UTILIZATION SERVICES

If you're a regular reader of TECH BRIEFS, then you're already making use of one of the low-and no-cost services provided by NASA's Technology Utilization (TU) Network. But a TECH BRIEFS subscription represents only a fraction of the technical information and applications/engineering services offered by the TU Network as a whole. In fact, when all of the components of NASA's Technology Utilization Network are considered, TECH BRIEFS represents the proverbial tip of the iceberg.

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

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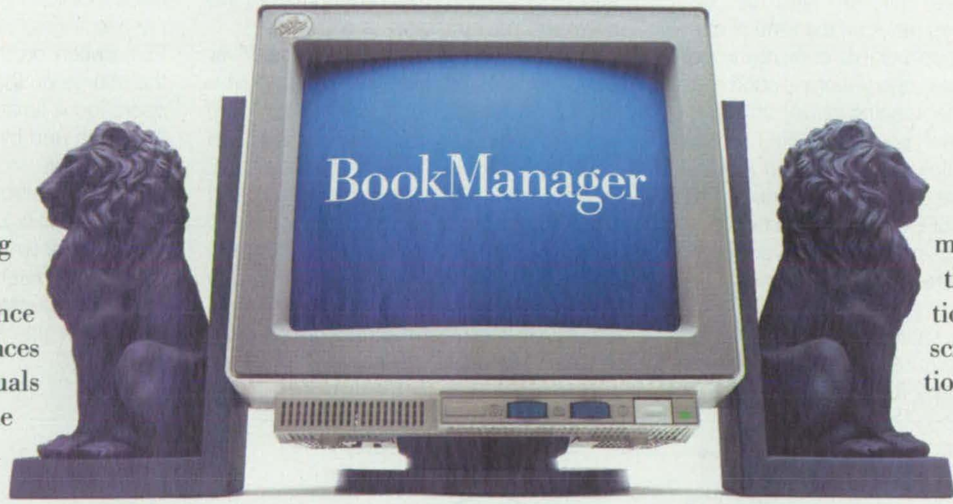

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Driver Circuit for High-Power MOSFET's

This circuit generates the fast, high-current pulses needed for efficient switching.

Lewis Research Center, Cleveland, Ohio

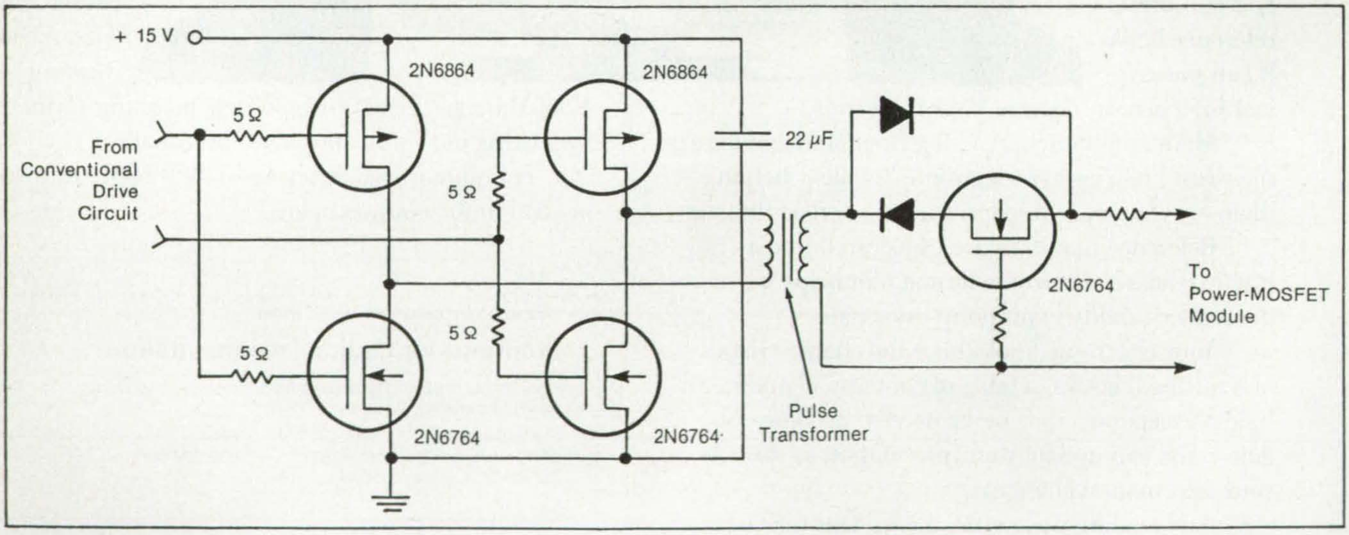
A driver circuit generates the rapid-voltage-transition pulses needed to switch high-power metal oxide/semiconductor field-effect transistor (MOSFET) modules rapidly between full "on" and full "off." Rapid switching reduces the time of overlap between appreciable current through and appreciable voltage across such modules, thereby increasing power efficiency.

Because each power MOSFET module contains multiple MOSFET's in parallel, the sum of the gate capacitances of the individual MOSFET's presents a high overall gate capacitance to the driver. To produce the required fast voltage transitions, the driver must act as a low-impedance source. More specifically it must supply the high pulse currents to charge the capacitance quickly, it must include a source of sufficient energy to keep the voltage from drooping, and its series resistance must be low enough that it does not engender excessive voltage drops. In addition, isolation of the gating signal from the switched power signal is required.

To satisfy these requirements, the driver circuit incorporates an FET switch driven by a pulse transformer (see figure). The primary side of the transformer is driven by a full-bridge FET switch that is driven, in turn, by a conventional one-shot and driver circuit timed by duration-modulated gating pulses. The inherent advantage of the full-bridge switch is that any voltage caused by the flux-reset energy of the core is shunted back to the source of switching energy via the low-impedance path of the p-channel FET's that are used as the switches on the high side of the bridge: this prevents undesired "flyback" voltages.

The loss of energy in the core of the transformer is minimized by applying a pulse that lasts just long enough to charge the overall gate capacitance. Thereafter, the FET switch on the secondary side holds the charge on the gates. The frequency of operation is limited only by the duration of the pulse and by any propagation delays. (For example, in the prototype of this circuit, these factors limit the frequency to about 500 kHz.)

This work was done by Kevin A. Letzer of Rockwell International Corp. for **Lewis Research Center**. *For further information, Circle 2 on the TSP Request Card.*
LEW-15089



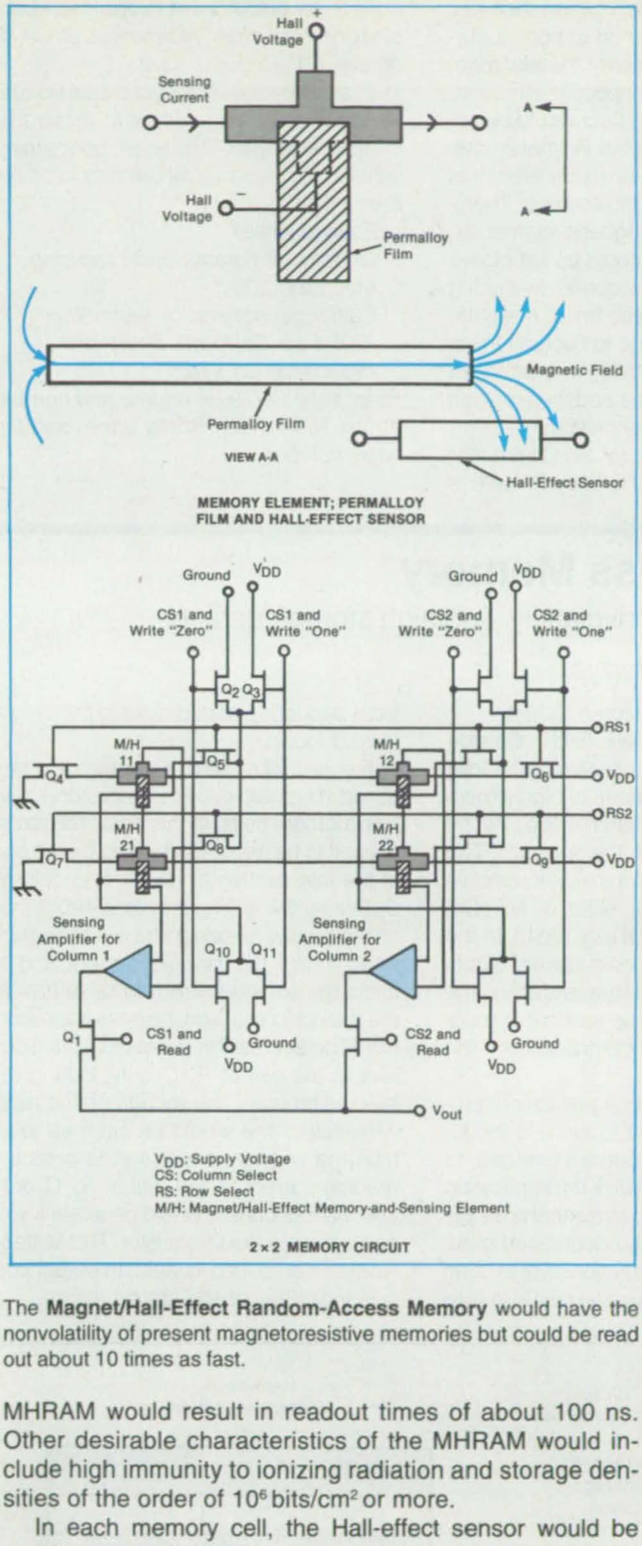
A **Full-Bridge FET Switch** drives a pulse transformer, which drives another FET switch. This circuit operates at high energy efficiency, providing the rapid pulses needed for efficient switching of a power-MOSFET module.

Magnet/Hall-Effect Random-Access Memory

Characteristics would include nonvolatility and fast readout.

NASA's Jet Propulsion Laboratory, Pasadena, California

In the proposed magnet/Hall-effect random-access memory (MHRAM), bits of data would be stored magnetically in Permalloy (or equivalent)-film memory elements and read out by using Hall-effect sensors to detect the magnetization. The value of each bit (one or zero) would be represented by the polarity of the magnetization. Like present magnetoresistive random-access memories (MRAM's), the proposed memory could retain its data for an indefinite time (or until the data are rewritten). Unlike in MRAM's, which have readout times of the order of microseconds, the speed of the Hall-effect sensors in the



The **Magnet/Hall-Effect Random-Access Memory** would have the nonvolatility of present magnetoresistive memories but could be read out about 10 times as fast.

MHRAM would result in readout times of about 100 ns. Other desirable characteristics of the MHRAM would include high immunity to ionizing radiation and storage densities of the order of 10^6 bits/cm^2 or more.

In each memory cell, the Hall-effect sensor would be positioned to detect the component of the fringing megnetic field perpendicular to the plane of the Permalloy film. In addition to the film and sensor, each memory cell would include a transistor that would serve as a switch for the writing current that would magnetize the film. Other transistors at the ends of the rows and columns of memory cells would control the selection of rows and columns for writing or reading and the polarity of the writing current (see figure).

The following example illustrates the readout operation: Suppose that the memory cell at the intersection of the first column and the second row is selected for readout. Transistors Q_7 and Q_9 are turned on, sending a current through and producing a Hall voltage in every Hall sensor in the second row. Each Hall voltage is amplified by a sensing amplifier at the bottom of the corresponding column. However, of the column-selecting readout transistors, only Q_1 is turned on, connecting the output from sensor 21 to the final output, V_{out}. Transistor Q_8, which switches the writing current for this cell, is also turned on when the second row is selected, but inasmuch as none of the transistors Q_2, Q_3, Q_{10}, and Q_{11} is turned on, no writing current flows through Q_8 during this readout condition.

The following example illustrates the writing operation: Suppose that the cell at the intersection of column 1 and row 2 is selected for writing. If the bit to be written is a "one," then Q_3, Q_8, and Q_{11} are turned on. If a "zero" is to be written, then Q_2, Q_8, and Q_{10} are turned on to pass a current of the opposite polarity, thereby magnetizing the film in the opposite direction. Because the switching field would be applied to only the selected Permalloy element, the rest of the Permalloy elements would not be subjected to any field. Therefore, unlike in prior magnetic memories, the switching current could be set higher than the maximum required switching threshold of the magnetic film to make the writing process immune to fluctuations in the threshold value. With this scheme, large operating margins and, hence, high chip yields could be achieved.

This work was done by Jiin-Chuan Wu, Henry L. Stadler, and Romney R. Katti of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 89 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

Edward Ansell
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1201 East California Boulevard
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Refer to NPO-17999, volume and number of this NASA Tech Briefs *issue, and the page number.*

Magnetic Analog Random-Access Memory

Attributes would include fast access, low power, nonvolatility, and high storage density.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed integrated, solid-state, analog random-access memory would be based on a principle of magnetic writing and magnetoresistive reading. The memory is intended to provide high storage density (equivalent to a digital-memory density of ≥ 1Mb/cm²) and rapid access (≤ 100 ns), to be nonvolatile, to consume relatively little power, and to be relatively invulnerable to ionizing radiation.

Each cell of the proposed memory (see Figure 1) would be configured so that writing and reading processes would be performed by circuits that are electrically isolated from each other and from the storage medium. The writing current would flow in an upper conductive layer (e.g., aluminum), inducing a magnetic field in a ferromagnetic or ferrimagnetic (e.g., sputtered γ Fe_2O_3) intermediate layer. When the writing current was turned off, the remanent magnetization in this magnetic layer would represent the stored datum.

The remanent magnetic field in the storage layer would be channeled into a lower readout layer by pieces of highly magnetically permeable material (e.g., Ni/Fe alloy) at the edges of these layers. The readout layer would be a magnetoresistive material (e.g., InSb, Bi, NiFe, or NiFeCo) or a Hall-effect material (e.g., InSb). In the readout process, a known current would be passed through this layer, extracting the datum in the form of the applicable magnetoresistive or Hall component of the readout voltage.

A conventional demagnetization procedure would be used to erase a datum and prepare the cell to store a new datum. Typically, this would involve the application of a sinusoidal writing current, the amplitude of which would be decreased gradually from an initial saturation level to bring the remanent magnetization nearly to zero via a sequence of diminishing minor hysteresis loops.

Figure 2 illustrates a portion of a proposed integrated-circuit version containing four memory cells. In this case, the memory cell to be addressed would be the one at the intersection of row R_i and column C_j. During the writing process, the voltage on the read/write-select line would be such as to inhibit the reading current and to allow the writing current to pass toward the memory cells, and the pass transistors would be activated to direct the writing current to the cell at R_i, C_j only. During the reading process, the voltage on the read/write-select line would be such as to inhibit the writing current and to pass the reading current to the cell at R_i, C_j only. The readout current would generate a voltage across a load transistor. This voltage would be amplified to yield an output voltage indicative of the stored datum.

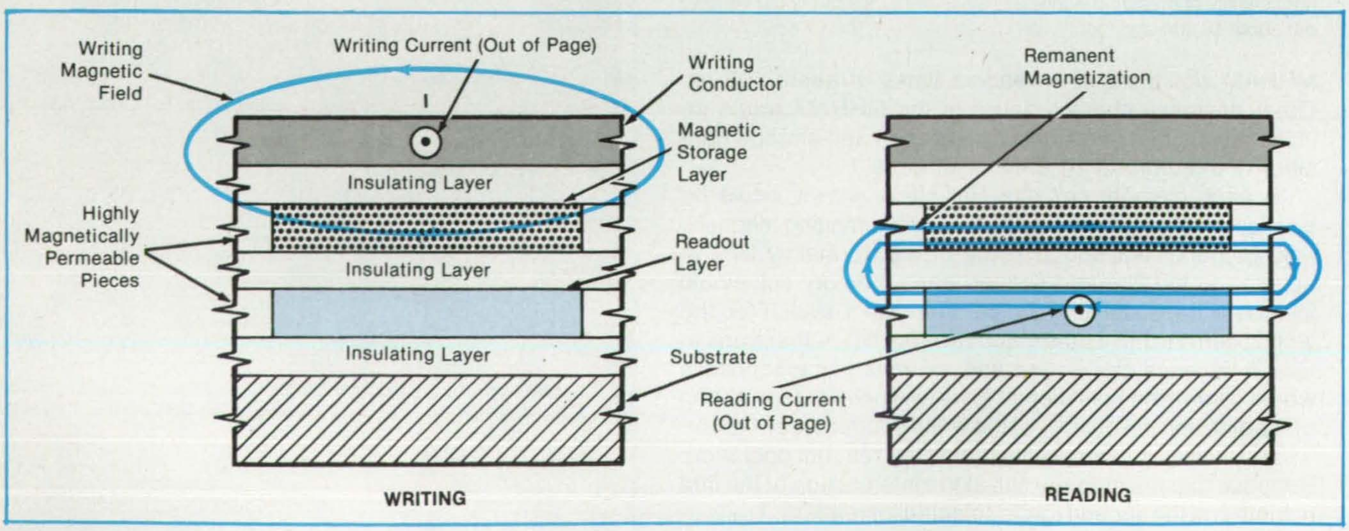
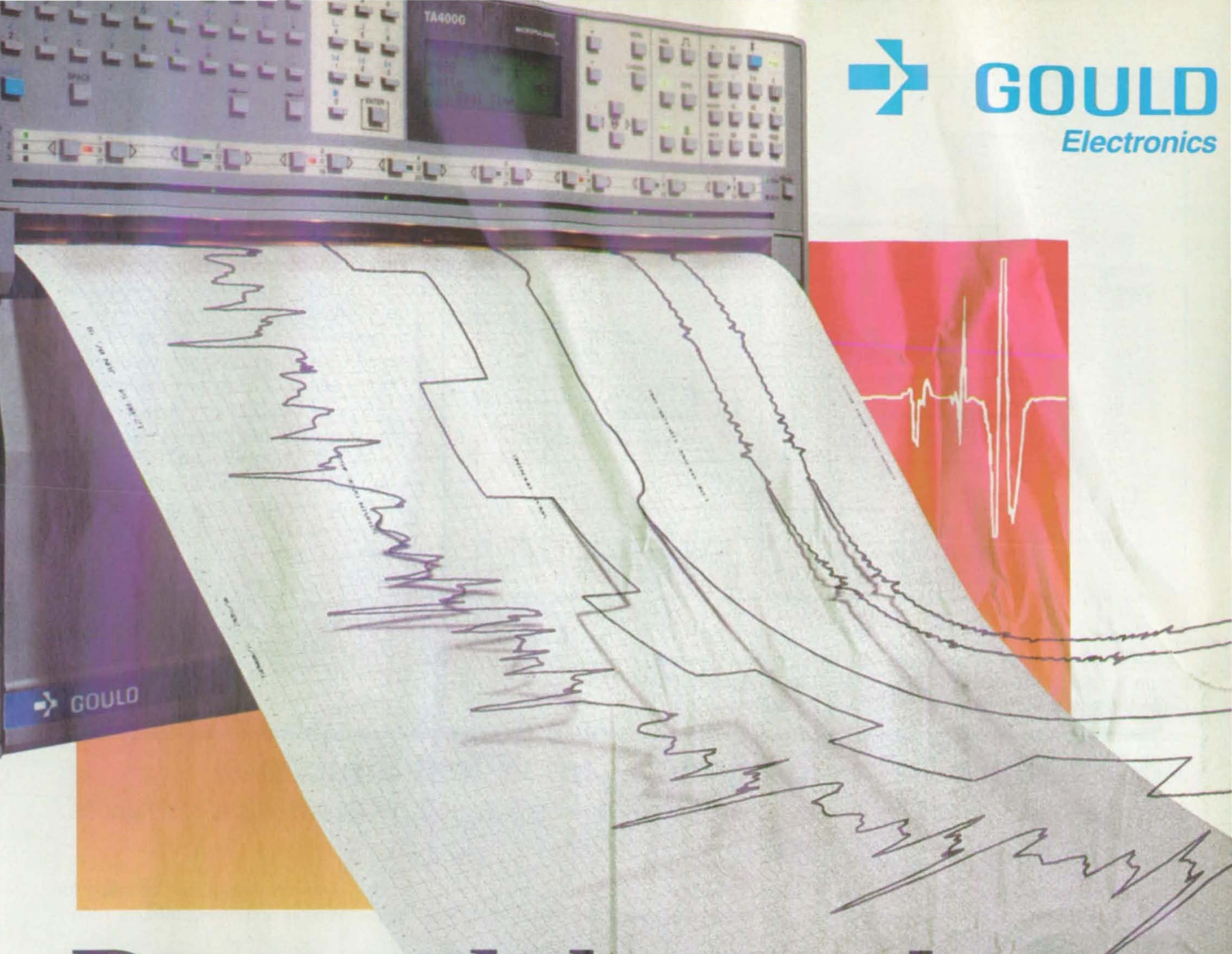


Figure 1. **Current in the Writing Conductor** would magnetize the storage layer. The remanent magnetization in the storage layer would penetrate the readout layer and be detected by the magnetoresistive effect or the Hall effect.



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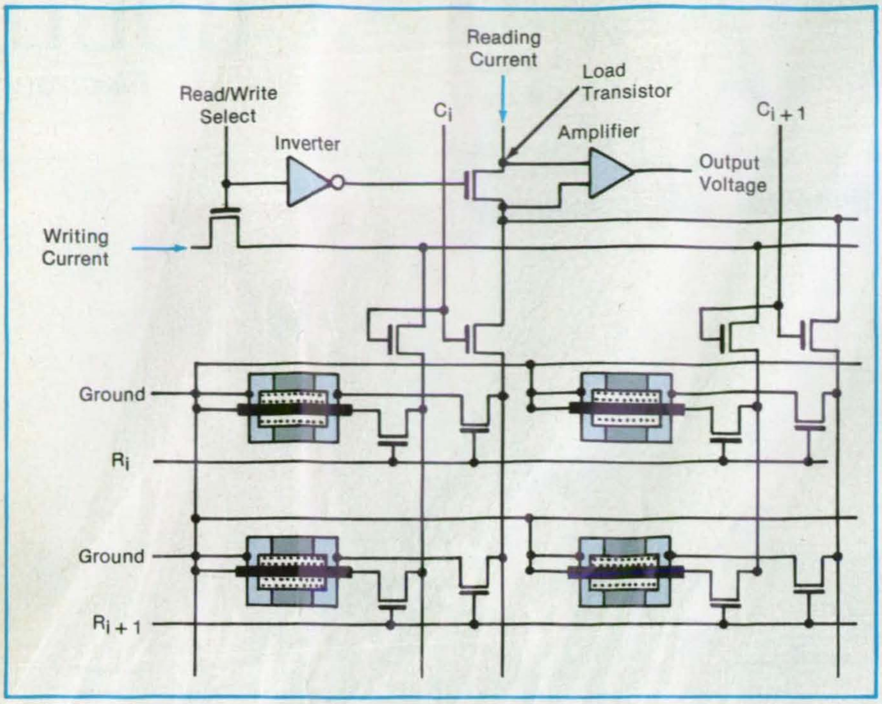

Figure 2. **Memory Cells** would be parts of an integrated circuit that would also include the associated reading and writing transistors.

Each cell should offer high sensitivity. When readback is sensed magnetoresistively, for example, an element 10 μm by 1 μm by 0.01 μm in size can produce a 200,000-μV signal excursion, assuming a sense current of 10 mA, a resistivity (ρ_o) of Ω-μm, and a magnetoresistance coeficient (Δ_ρ) of 2 percent. If a reasonable analog sensitivity of 20 μV/level is assumed, then 10,000 levels, or 13 bits, can be resolved. Higher bit resolution can be achieved by increasing sensor length, sense current, and Δ_ρ, and by decreasing the sensor's width and thickness.

This work was done by Romney R. Katti, Jiin-Chuan Wu, and Henry L. Stadler of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 82 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 26]. Refer to NPO-17998.

Addressable-Matrix Integrated-Circuit Test Structure

Step coverages and widths of lines would be determined rapidly from measurements of resistances.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of quality control based on the use of a row- and column-addressable test structure speeds the collection of data on the widths of resistor lines and coverage of the steps in integrated circuits. By use of a straightforward mathematical model, the line widths and step coverages are deduced from measurements of electrical resistances in each of the various combinations of lines, steps, and bridges that are addressable in the test structure.

The structure and model are intended especially for use in evaluating processes and equipment used in the manufacture of application-specific integrated circuits. The widths and step coverages can be determined more rapidly by this method than by optical inspection. In contrast with such prior integrated-circuit test structures as cross-bridge and serpentine resistors, this structure utilizes circuit area more efficiently. It provides many more sampling points within a small sampling area, thereby yielding data on variations among conductor lines within the small area.

The test structure (see Figure 1) includes probe pads and a step/line-width resistor matrix. The structure contains 522 bridge substructures: 18 rows, and 29 columns. The structure is of the complementary metal oxide/semiconductor (CMOS) type, with nominal 2-μm line widths. The size of each cell in the matrix is 46×60 μm: the structure is about 50 times as dense as that of an individually probed bridge resistor.

The first six rows of the matrix include bridge resistors over a pair of steps for step-coverage and line-continuity meas-

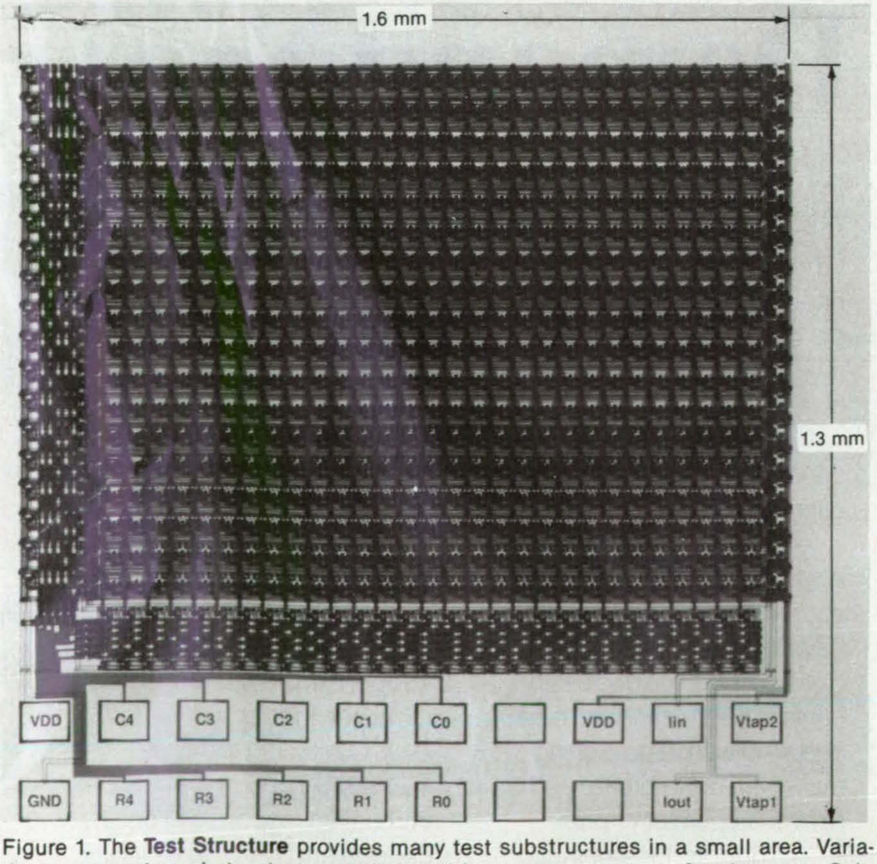

Figure 1. The **Test Structure** provides many test substructures in a small area. Variations among the substructures are deduced from measurements of resistances. Substructures are addressed individually via the rows and columns of the matrix.

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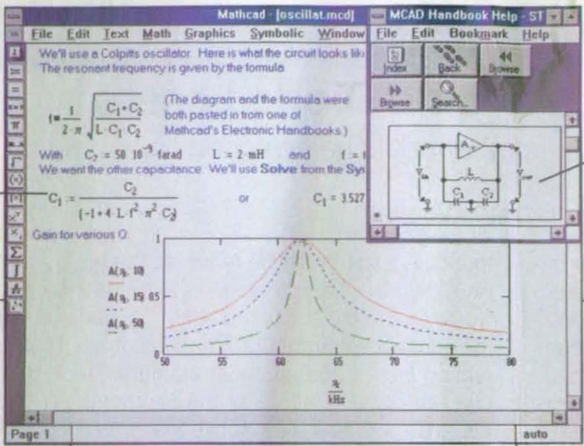

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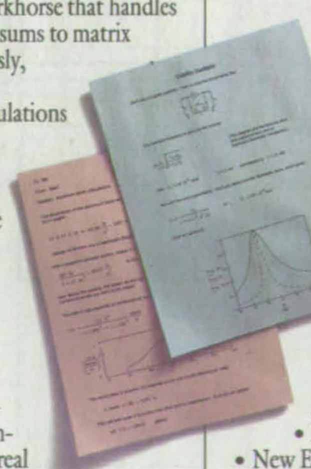

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Circle Reader Action No. 682

urements for metal-1, polycrystalline-silicon, and metal-2 layers like those shown in Figure 2. The second and third groups of rows each include bridge resistors that are used to measure variations in the widths of metal-1, polycrystalline-silicon, and metal-2 lines over lower and higher steps, respectively.

From measurements on a prototype of the test structure, it was found that the widths of the lines were normally distributed except for occasional lines. The lines in the higher layers were found to be consistently narrower than the lines in the lower layers. The resistances of the steps did not exceed 7.8 percent of the resistances of the low bridges — less than the 10-percent level, which is considered to be the maximum acceptable.

This work was done by Hoshyar R. Sayah and Martin G. Buehler of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 136 on the TSP Request Card.*
NPO-18162

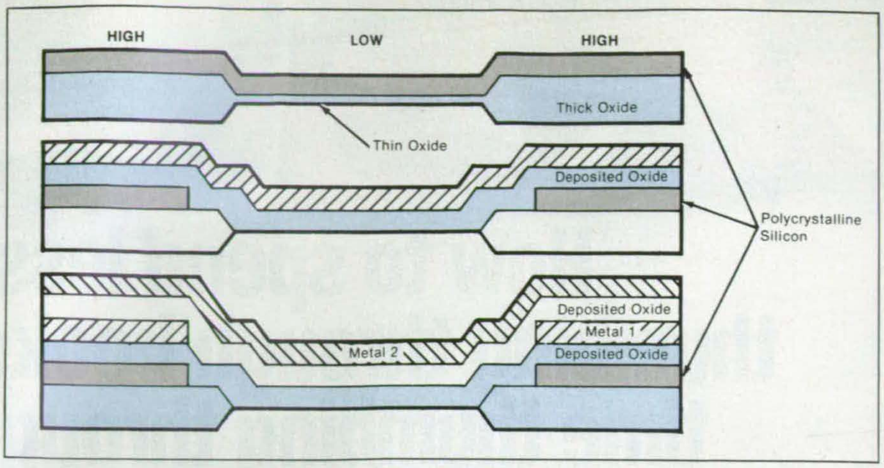


Figure 2. These **Step-Coverage Cross Sections** are included in the various substructures of the test structure illustrated in Figure 1.

Multiple Integrated In-Line Diode Lasers

When one of the devices fails, another could be switched on.

Langley Research Center, Hampton, Virginia

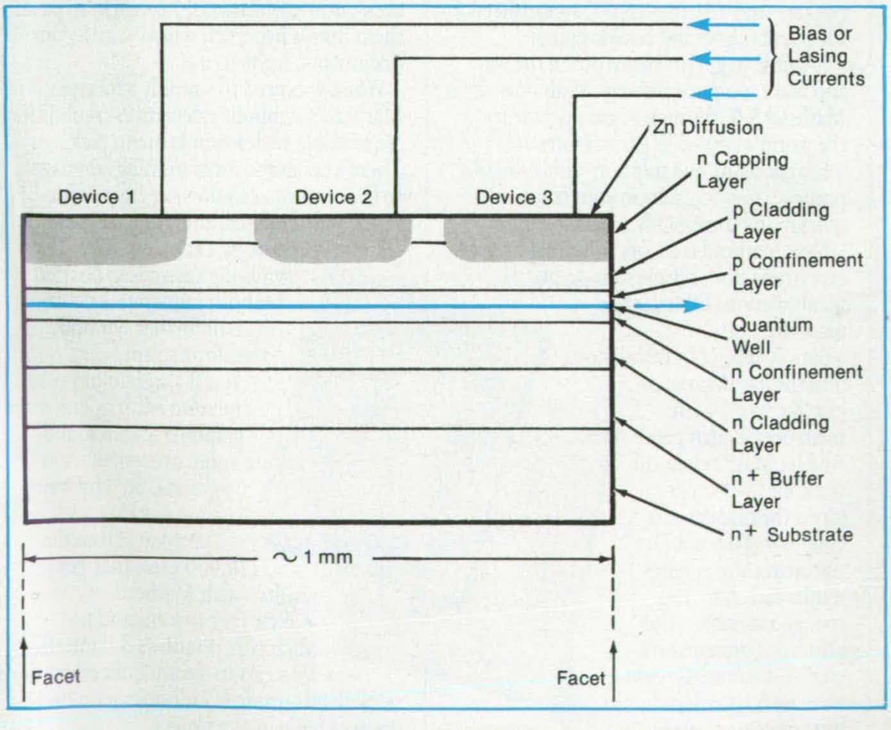
A proposed integrated in-line array of semiconductor lasers is intended to provide high reliability and/or long operating lifetime. Should one of the laser devices in the array fail or otherwise deteriorate beyond specifications, it would not be necessary to move or replace the array to enable it to continue operating. This is an important advantage in systems in which both reliability of diode lasers and alignment of those lasers with other optical components are critical.

In essence, the proposed array would be a single diode laser divided longitudinally into segments (see figure). Electrically, each segment would be a separate laser. However, all segments would share a common optical waveguide, so that the position, divergence, and frequency of the output beam of light would be the same, no matter which segment was operating at a given moment.

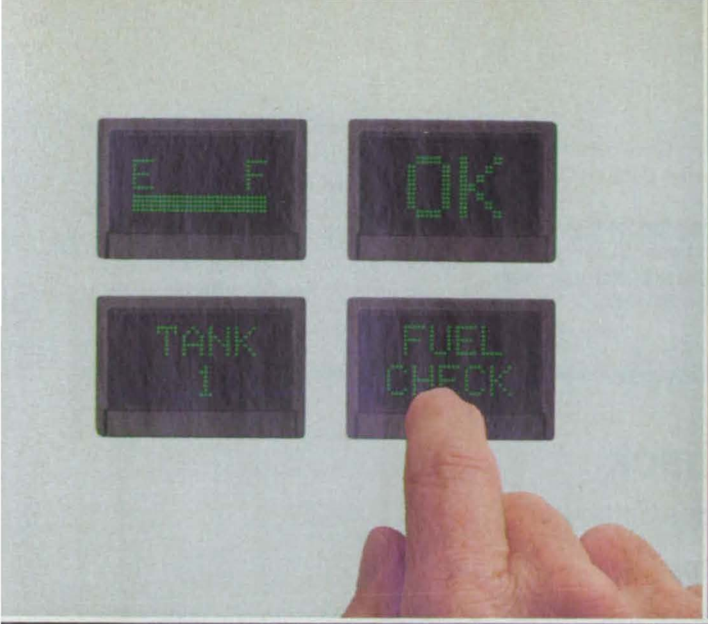
Although the figure shows only three segments, more could be used. If the number of segments were so large that the losses in the nonoperating segments would prevent effective lasing in the operating segment, then the electrical conditions for operation could be modified. The full lasing current would be applied to one segment while a bias current less than the lasing-threshold current could be applied to each of the other segments to reduce the optical losses in them.

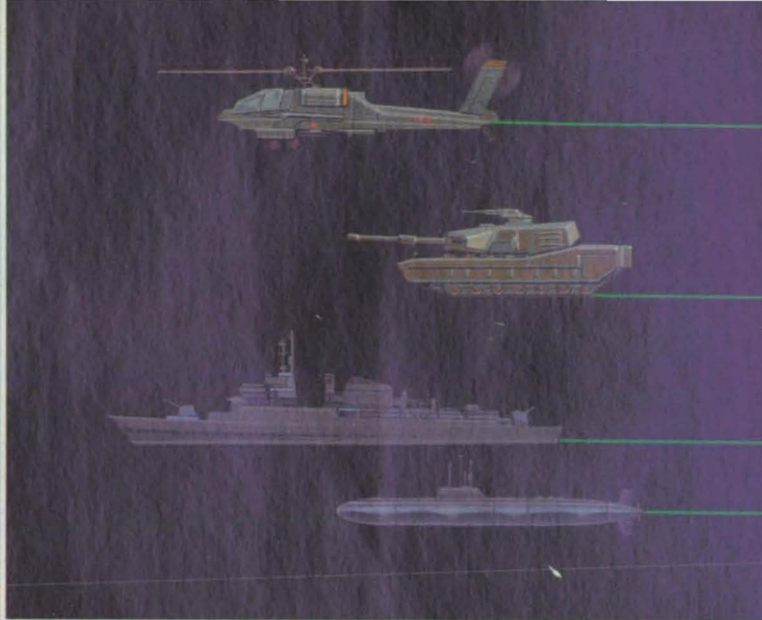
Whether or not bias current was used, once the lasing segment deteriorated below specifications, the full lasing current could be switched to another segment. This process could be repeated until all segments were used up. If the losses in the waveguide could be reduced, the array could be made longer. This, in turn, would enable the addition of segments and the consequent further prolongation of operating life. Of course, more than one — or even possibly all — of the segments could be operated at or above the threshold current at the same time to obtain greater output power, albeit at the expense of operating lifetime.

This work was done by John C. Connolly of David Sarnoff Research Center for **Langley Research Center**. *No further documentation is available.*
LAR-14378



Multiple Integrated Collinear Semiconductor Lasers would share a common optical waveguide but could be individually electrically excited. A separate-confinement, single-quantum-well configuration with three segments is shown here for example, but other configurations might also be chosen.





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Electronic Systems

Hardware, Techniques, and Processes

36 Digital Phase-Locked Loop With Phase and Frequency Feedback

38 Vapor-Screen-Density Controller

40 Estimating Baselines From Constrained Data on GPS Orbits

46 Compensating for Movement of Eye in Laser Surgery

46 Dynacounter Electronic Data-Reduction System

47 Nonlinear Dynamic Compensation for Feedback Control

Books and Reports

48 Study of Candidate Architectures for Data Processor

48 Ambiguity of Doppler Centroid in Synthetic-Aperture Radar

Digital Phase-Locked Loop With Phase and Frequency Feedback

Sophistication allowed by software processing provides better performance.

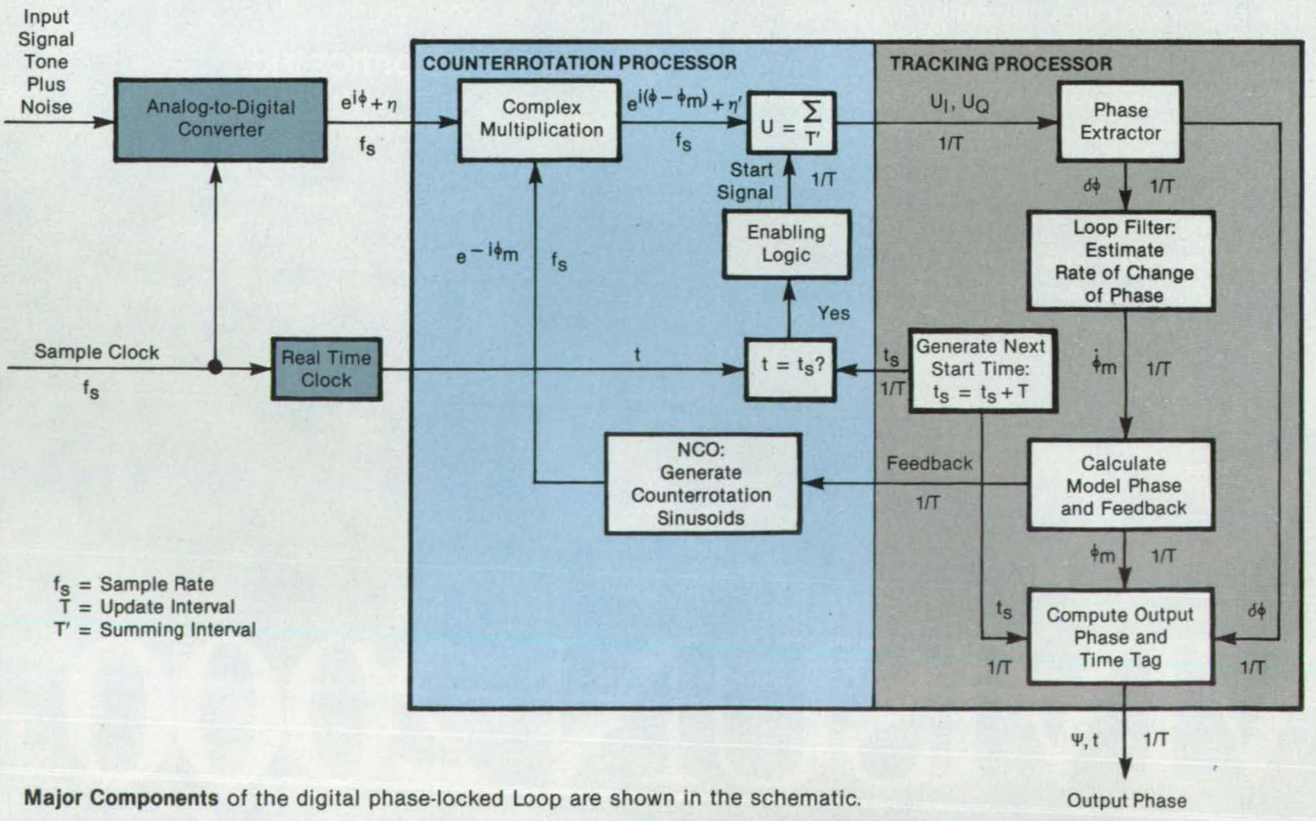
NASA's Jet Propulsion Laboratory, Pasadena, California

An advanced design for a digital phase-lock loop (DPLL) allows loop gains higher than those used in other designs. Notable features include the use of both phase and rate-of-change-of-phase (i.e., frequency) feedback instead of frequency feedback alone, a normalized sine phase extractor, an improved method for extracting measured phase, and an improved method for "compressing" the output rate. The new design takes advantage of the flexibility provided by progress in digital technology.

The DPLL is divided into two major components: a counterrotation processor (CP) and a tracking processor (TP) (see figure). The operations of the CP, which are carried out at the input sampling rate by special-purpose high-speed instrumentation, include the operations of a numerically controlled oscillator (NCO), a complex multiplication to counterrotate, and a complex sum. The operations of the TP, which are carried out much less frequently, include the extraction of phase, loop filtering, computation of model phase, computation of NCO feedback, computation of starting and stopping times, and computation of measured phase and time tag. The operations of the TP have been implemented in software.

Two DPLL designs have been analyzed in terms of pole plots, loop noise bandwidth, maximum loop gain, and dynamic response. Both designs are based on a conventional loop filter, but one updates only the rate of the NCO, while the other updates both the phase and the rate. For each, the computation delay is set either to a negligibly small value or to one update interval. The analysis shows that the phase/rate DPLL can operate at substantially higher loop gains than can the rate-only DPLL. At the highest gain setting before loop deterioration, the phase/rate DPLL can track more than twice the dynamics of the rate-only DPLL, for a given update interval.

Unlike a conventional loop with rate-only feedback, the new loop precalculates, in the tracking processor, the phase to be applied by the NCO across an interval and then drives the NCO to attain this phase. Thus, model phase attained by the NCO at sum-interval center is accurately predetermined by the tracking processor, including integer and fractional cycles. This approach can provide accurate phase measurements even when NCO phase is



Major Components of the digital phase-locked Loop are shown in the schematic.

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discontinuously updated, as in the design with phase and phase-rate feedback. The total measured phase is computed as the sum of the predetermined model phase and residual phase. (A conventional DPLL "reads" the "NCO phase" and neglects the important information contained in the residual phase.) When the model phase and the residual phase are combined, the tracking error is essentially eliminated, leaving only noise to corrupt the output.

A typical conventional DPLL "compresses" the output rate by extracting the phase produced for every *N*th sum interval (e.g., by "strobing" the NCO phase) while ignoring the other values. That approach does not use all the information produced by the loop, and unnecessarily sets the output bandwidth equal to the loop bandwidth. In the compression scheme used here, it is possible to set the output rate and the bandwidth of the compressed phase independently of loop parameters. The selected approach "averages" loop output phase by fitting a polynomial to the phase values from all update intervals in a specified averaging interval (e.g., 1,000 values over a 1-second interval).

This work was done by J. Brooks Thomas of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 74 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

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

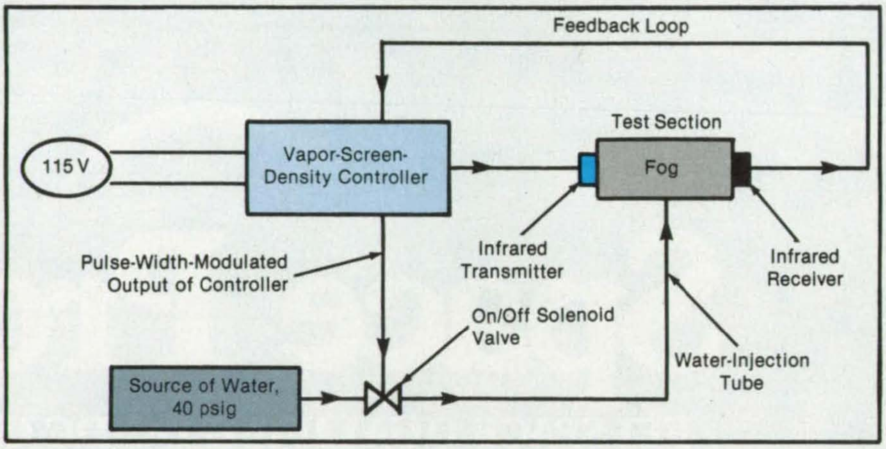
Refer to NPO-17722, volume and number of this NASA Tech Briefs *issue, and the page number.*

Vapor-Screen-Density Controller

The density of a vapor screen in a wind tunnel is maintained for vapor-screen photography.

Langley Research Center, Hampton, Virginia

The vapor-screen method for the visualization of flow is used in NASA Langley Research Center's Unitary Plan Wind Tunnel (UPWT) to acquire data on flow fields and the locations of shocks. Droplets of water condensed in the tunnel jet are illuminated by external lights, producing a light sheet called a "vapor screen." Variations in local static temperatures and pressures induced by models and the flows about them cause the vapor screen to reflect varying amounts of light. Shocks and other flow-field phenomena become visible under these conditions and are photographed for later analysis.



This **Closed-Loop Device** maintains the vapor screen in the undisturbed flow ahead of a wind-tunnel model at constant density.

Currently, the proper density of the vapor screen in the UPWT is established manually, by visual inspection. This method does not provide the ability to establish a repeatable vapor density from test to test. Also, this method involves a low-frequency step process, in which the maintenance of a vapor screen at constant density would be difficult if not impossible.

One way to maintain the vapor screen at constant density is to control its reflectivity by closed-loop means. A control system that could do this would eliminate large step-response corrections and possess more than enough frequency response to maintain a nearly constant density in the vapor screen in undisturbed flow ahead of the model. The model-induced variations in reflectivity would then be the only truly independent variable.

The vapor-screen density controller (see figure) was developed with the foregoing considerations in mind. It includes a diode source of infrared light, an infrared phototransistor receiver, and two convex lenses on opposite sides of the test section, one to spread the infrared beam initially from the essentially point source out into a parallel beam across the test section and the other to reconverge the parallel beam back into a point for detection by the phototransistor. An amplifier increases the output of the infrared phototransistor, and an active low-pass filter reduces the sensitivity of the controller to rapid fluctuations in the density of the vapor screen in the test section.

A buffer amplifier sends a signal representative of the current in the infrared source to establish proper drive levels to analog panel meters that indicate values of percent transmittance, percent set point, and controller error. A differential amplifier detects and amplifies the error in the percent transmittance compared to the percent transmittance at the set point. This signal is used to direct the duration of the water-injection pulse. A comparator circuit is used to determine when the controller has commanded the injection of more water than is necessary to establish a requested percentage of vapor-screen density.

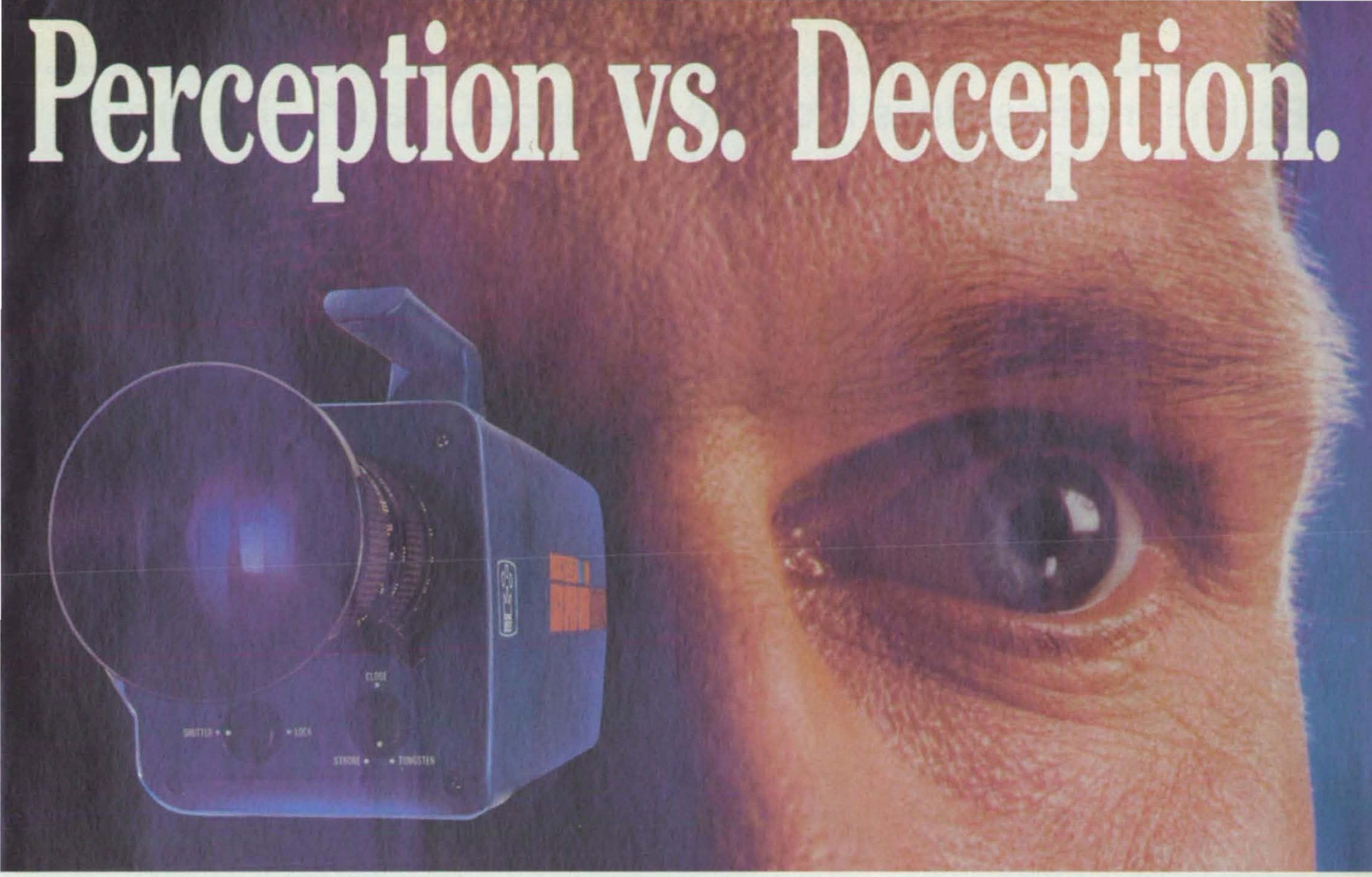
An astable oscillator is used as a low-frequency clock, the period of which is adjustable from 10 to 25 s to time the correction response of the controller. A pulse-width modulator varies the duration of the water-injection so that large errors cause water to be injected for 5.0 s and small errors cause water to be injected for 0.5 s to correct errors in the density of the vapor screen with respect to the set-point density. A solid-state relay drives an electromechanical water valve to control the injection of water into the diffuser of the test section. A modular 12-V supply capable of supplying 2 A of current activates the integrated circuits of the controller.

The vapor-screen-density controller imparts repeatability to the density of the vapor screen. This is important in making comparative aerodynamic analyses between test runs. This device enables the user to control the density of the vapor screen via a set-point indicator. The user will, for the first time, have an indication of the percentage transmittance across the test section.

This work was done by James E. Byrd of Planning Research Corp. for **Langley Research Center**. *For further information, Circle 1 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 26]. Refer to LAR-14099.

Perception vs. Deception.



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Estimating Baselines From Constrained Data on GPS Orbits

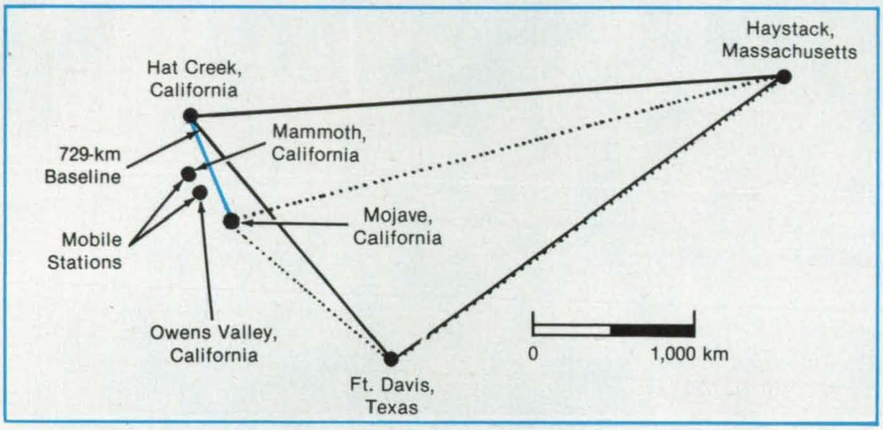
Potential applications include measurements of seismic and volcanic displacements and movements of tectonic plates.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of processing measurements of signals received at terrestrial stations from satellites in the Global Positioning System (GPS) increases the precision of estimates of both the orbits of the GPS satellites and the locations of the stations, which are computed from the measurement and orbital data. The locations of the stations can be used, in turn, to establish baselines for geodesy.

The method involves a network of fiducial GPS stations collocated with very-long-baseline-interferometry (VLBI) stations, for which independent VLBI determinations of baselines are available. GPS measurements are taken in continuous sequences ("data arcs") approximately 1 day long (as distinguished from multiday data arcs used in a previous technique). In addition, theoretical orbits fit in an iterative manner to the ephemeris data broadcast during the preceding 1 to 2 weeks are used to generate weak a-priori constraints on the parameters of the estimated GPS orbits. These constraints are independent of the GPS measurements.

An essential part of the method is resolution of the integer ambiguity in the phases of the received GPS carrier signals (called "bias fixing" in GPS jargon) by use of the precise P-code GPS pseudorange data. The orbital parameters are correlated with the ambiguities in the phases of the carrier signals to resolve the ambiguities and thereby increase the accuracies of the estimated orbits of the GPS satellites. Another essential part of the method is the choice of a set of fiducial stations that are located optimally for the determination of a given set of mobile GPS stations (see figure). As a general rule, the most favorable geometry is obtained when the mobile stations are near fiducial stations and when the spatial extent of the fiducial network is maximized.



Two **Candidate Fiducial Combinations** of three stations each are indicated by the solid and dotted triangles. The one indicated by the solid triangle turns out to be best for the 729-km baseline.

A third essential part of the method is the application of the constraints to the orbits. The dynamics of a satellite are expressed by a mathematical model that accounts for solar-radiation pressure, the gravitational field of the Earth to degree and order 12 in spherical harmonics, and the gravitational fields of point masses that represent the Sun, Moon, and other planets. An orbit is estimated in two steps: In the first step, a nominal trajectory is integrated on the basis of a least-squares fit to a time series of a-priori values of the position and velocity of the satellite and of the parameters of the solar-radiation pressure. In the second step, the epoch-state values of the parameters of the orbit are adjusted by use of the GPS carrier-phase and pseudorange data in a factorized Kalman filter.

In a test, the method yielded a horizontal precision of 3 to 4 mm and a vertical precision of 13 mm on the 729-km baseline shown in the figure. The baseline determined by this method agreed with that determined by VLBI to within 10 to 20 mm in all components.

This work was done by Ulf J. Lindqwister, Stephen M. Lichten, and Geoffrey I. Blewitt of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 111 on the TSP Request Card.*
NPO-18173

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- A Pre-Show Reception on Monday, Dec. 2 in the exhibit hall, offering attendees and the media the chance to preview the exhibits and meet the presenters in a relaxed, informal atmosphere;
- The second annual Technology Transfer Awards Dinner, recognizing outstanding achievements in tech transfer to industry. This event offers a unique opportunity to network with government and industry executives in an elegant setting—the Imperial Ballroom of the San Jose Fairmont Hotel. (Seating is limited, so reserve tickets early!)

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Show Schedule

Monday, Dec. 2	
6:00 pm - 8:00 pm	Opening Reception
Tuesday, Dec. 3	
9:00 am -10:30 am	Plenary Session
1:00 pm - 3:00 pm	Technical Sessions
4:30 pm - 6:00 pm	Govt./Industry Workshops
Wednesday, Dec. 4	
8:30 am -10:30 am	Technical Sessions
1:00 pm - 3:00 pm	Technical Sessions
4:30 pm - 6:00 pm	Govt./Industry Workshops
7:00 pm -10:00 pm	Awards Dinner
Thursday, Dec. 5	
8:30 am -10:30 am	Technical Sessions
1:00 pm - 3:00 pm	Technical Sessions
4:30 pm - 6:00 pm	Govt./Industry Workshops

Exhibit Hours

Dec. 3	10:00 am - 5:00 pm
Dec. 4	10:00 am - 5:00 pm
Dec. 5	10:00 am - 4:30 pm

Technology 2001 Program

TUESDAY, DECEMBER 3

Plenary Session
9:00 am — 10:30 am
Keynote address and overviews of the Technology 2001 and Intelligent Processing Equipment conferences by top-level government officials.

Concurrent Technical Sessions
1:00 pm — 3:00 pm
(Each presentation will last 30 minutes, including questions and answers.)

Advanced Manufacturing
Ceramic Susceptor for Induction Bonding of Metals, Ceramics, and Plastics
Applying NASA's Explosive Seam Welding
Laser-Based Weld Joint Tracking System
Precision Joining Center

Biotechnology
Cooperative R&D Opportunities with the National Cancer Institute
Technologies from the Centers for Disease Control
Enhancement of Biological Control Agents for Use Against Forest Insect Pests and Diseases
Use of T7 Polymerase to Direct Expression of Outer Surface Protein A from the Lyme Disease Spirochete, *Borrelia burgdorferi*

Communications
Applications of ACTS Mobil Terminal Millimeter-Wave Antennas
Antennas for Mobile Satellite Communications
MMIC Linear-Phase and Digital Modulators
Phased-Array Antenna Beamforming Using an Optical Processor

Computer Graphics and Simulation
Global Positioning System Supported Pilot's Display
Application of Flight Simulation Technology
FAST: A Multi-Processed Environment for CFD Visualization
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Analog VLSI Neural Network Integrated Circuits
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A Noncontacting Waveguide Backshort for Millimeter and Submillimeter Wave Frequencies

Materials Science
Novel Applications for TAZ-8A
Test Methods for Determining the Suitability of Metal Alloys for Use in Oxygen-Enriched Environments
A Major Advance in Powder Metallurgy
Permanent Magnet Design Methodology

Government-Industry Workshops
4:30 pm — 6:00 pm

WEDNESDAY, DECEMBER 4

Concurrent Technical Sessions
8:30 am — 10:30 am

Advanced Manufacturing
Concentrating Solar Systems: Manufacturing with the Sun
Ultra-Precision Processes for Optics Manufacturing
Integrated Automation for Manufacturing of Electronic Assemblies
Air Force MANTECH Technology Transfer

Electronics
Gallium Arsenide Far Infrared Array Imaging Radiometer
A Video Event Trigger for High-Frame-Rate, High-Resolution Video Technology
Camera Orientation of Pan, Tilt, and Zoom with No Moving Parts
Fiber Optic TV Camera Direct

Environmental Technology
Waste Management Technology
Regulated Bioluminescence as a Tool for Bioremediation Process Monitoring and Bacterial Culture Control
Fiber-Optic-Based Biosensor
Ambient Temperature CO Oxidation Catalysts

Materials Science
High-Temperature Adhesives
Fluorinated Epoxy Resins with High Glass Transition Temperatures
Polyimides Containing Pendent Siloxane Groups
Corrosion-Protective Coatings from Electrically-Conducting Polymers

Medical Advances: Computers in Medicine
Computation of Incompressible Viscous Flows through Artificial Heart Devices
Computer Interfaces for the Visually Impaired
Extended Attention Span Training System
Man/Machine Interaction Dynamics

Software Engineering
Hybrid Automated Reliability Predictor Integrated Workstation
Using Ada and the Rapid Development Lifecycle
Advances in Knowledge-Based Software Engineering
Reducing the Complexity of Software Development through Object-Oriented Design

Concurrent Technical Sessions
1:00 pm — 3:00 pm

Data and Information Management
Techniques for Efficient Data Storage, Access, and Transfer
A Vector-Product Information Retrieval System Adapted to Heterogeneous, Distributed Computing Environments
AutoClass: An Automatic Classification System
Silvabase: Flexible Data File Management

Electro-Optics
Optical Polymers for Electro-Optic Signal Processing
High-Resolution Optical Data Storage on Polymers
Laser Discrimination by Stimulated Emission of a Phosphor
Pulsed Laser Prelasing Detection Circuit

Life Sciences
Application of CELSS Technology to Controlled Environment Agriculture
Advanced Forms of Spectrometry
Ion-Selective Electrode for Ionic Calcium Measurements
A 99% Purity Molecular Sieve Oxygen Generator

Materials Science
Advanced Composite Materials and Processes
RTM: Cost-Effective Processing of Composite Structures
Testing Compression-After-Impact Strength of Composite Laminates
Resonant Acoustic Determination of Complex Elastic Moduli

Robotics
A Unique Cable Robot for Space and Earth
A Lightweight, Dexterous Manipulator Arm
Real-Time, Interactive Simulator System
A Hazard Control System for Robot Manipulators

Test and Measurement
Knowledge-Based Autonomous Test Engineer
Advanced Computed Tomography Inspection System
High-Resolution Ultrasonic Spectroscopy System
Force-Limited Vibration Testing

Government-Industry Workshops
4:30 pm — 6:00 pm

THURSDAY, DECEMBER 5

Concurrent Technical Sessions
8:30 am — 10:30 am

Advanced Manufacturing
Rotary Joint Fluid Coupling for Space Station
Spline Screw Comprehensive Fastening Strategy
Commercial Application of an Innovative Nut Design
Inflatable Traversing Probe Seal

Artificial Intelligence
CLIPS: An Expert System Building Tool
Fuzzy Logic Applications to Expert Systems
Neural Network Technologies
From Biological Neural Networks to Thinking Machines

Biotechnology
The Microassay on a Card
Flow Immunosensor for Drug Detection
Nucleic Acid Probes in Diagnostic Medicine
The Rotating Spectrometer: New Biotechnology for Cell Separations

Electronics
Method for Producing High-Quality Oxide Films
Advanced Silicon on Insulator Technology
High-Temperature Superconducting Stripline Filter
An Adjustable rf Tuning Element for Microwave, Millimeter Wave, and Submillimeter Wave Circuits

Materials Science
Passive Chlorophyll Detector
Application of Thermal Protection System Technology
Oxynitride Glass Fibers
Applications of Advanced Photovoltaic Technologies

Software Engineering
Software Reengineering
COSTMODL: An Automated Software Development Cost Estimation Tool
Increasing Productivity through Total Reuse Management
How Hypermedia Can Increase the Productivity of Software Development Teams

Concurrent Technical Sessions
1:00 pm — 3:00 pm

Advanced Manufacturing
Intelligent Robotic System with Real-Time Vision
Neural Network Software for Distortion-Invariant Object Recognition
Constraint-Based Scheduling
COMPASS: A Computer-Aided Scheduling Tool

Data and Information Management
ELAS: Powerful Image Processing Software
TAE Plus: A Tool for Building and Managing Graphical User Interfaces
Instrumentation, Performance Visualization, and Debugging Tools for Multiprocessors
Operations Automation Using Temporal Dependency Networks

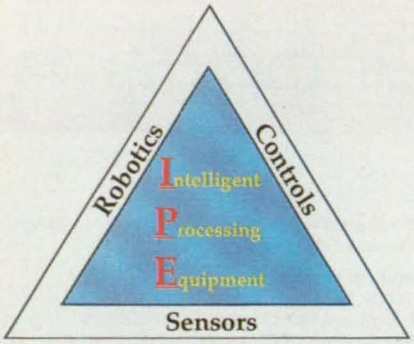
Electronics
Thermoacoustic Refrigeration
Ambient Temperature Recorder
Fiber-Optic Push-Pull Sensor Systems
Commercial Capaciflector

Environmental Technology
Water Quality Monitor
Remote Flowrate Logging Seepage Meter
Calcification Prevention Tablets
Automated Carbon Dioxide Cleaning System

Materials Science
Applications of Biologically-Derived Microstructures
Structural Modification of Polysaccharides
Cryogenic Focusing, Ohmically Heated On-Column Trap
Study of the Effect of Hydrocarbon Contamination on PFTE Exposed to Atomic Oxygen

Medical Advances
Applications of the SDI's Compact Accelerator Technology
Acoustically-Based Fetal Heart Rate Monitor
Surgical Force Detection Probe
Dynamic Inter-Limb Resistance Exercise Device

Government-Industry Workshops
4:30 pm — 6:00 pm



Advanced Manufacturing Technology

IPE Conference Program

The Intelligent Processing Equipment (IPE) Conference will focus on federally-developed innovations in robotics, sensors, and controls that industry can apply to a broad range of manufacturing processes, including machining, forming, welding, heat-treating, inspection, and assembly. Sixteen federal organizations will report on their present R&D efforts in intelligent processing during sessions held concurrently with Technology 2001 symposia in the San Jose Convention Center on Tuesday, Dec. 3 and Wednesday, Dec. 4.

On Thursday, Dec. 5, these presentations will be reviewed and discussed in panel sessions led by select industry leaders in manufacturing. A luncheon featuring a talk by a nationally-recognized expert in advanced manufacturing is also planned for Thursday in the convention center. Proceedings will be published and mailed to attendees after the conference.

The IPE sessions are open to all Technology 2001 registrants at no additional charge. Technology 2001 registrants are also invited to attend the Thursday luncheon, which will involve a small fee for food costs. Further information on the luncheon will be mailed to all Technology 2001 preregistrants prior to the show, and will also be available on-site at an information counter in the lobby.

The final program issued at the show will list all IPE Conference speakers and meeting room locations. The meeting rooms are in close proximity, making it easy for registrants to attend portions of both conferences.

IPE Conference Schedule:

Tuesday, December 3

Technical Session
1:00 pm — 3:00 pm

1:00 **Department of Agriculture**
Dr. Ruxton Villet, National Program Leader, Product Utilization, Agricultural Research Service

1:30 **Department of Commerce**
Dr. John Simpson, Director, Manufacturing Engineering Lab, National Institute of Standards and Technology

2:00 **Department of Energy**
Rick Peavy, Physical Scientist, Defense Programs Technology Transfer Div.

2:30 **Environmental Protection Agency**
Dan Greathouse, Operations Research Analyst

Technical Session
4:30 pm — 6:00 pm

4:30 **Federal Emergency Management Agency**
Anne Marie Suprise, Industrial Specialist

5:00 **Department of Interior**
Fred Schottman, Engineer, Div. of Minerals and Materials Science

5:30 **National Aeronautics and Space Administration**
Clyde Jones, Materials Engineer, Marshall Space Flight Ctr.

Wednesday, December 4

Technical Session
8:30 am — 10:30 am

8:30 **National Institutes of Health**
Dr. Caroline Holloway, Director, Office of Science and Policy

9:00 **National Science Foundation**
Dr. Suren Rao, Program Director, Div. of Design and Manufacturing

9:30 **Department of the Air Force**
Captain Paul Sampson, Program Mgr., Machine Tools, Processing and Fabrication Div.

10:00 **Department of the Army**
Amy Knutilla, PE, Assistant for ManTech, HQ US Army Material Command

Technical Session
1:00 pm — 3:30 pm

1:00 **Department of the Navy**
Dr. Phillip Nanzetta, Dept. of Commerce, NIST

1:30 **Defense Advanced Research Projects Agency**
Lt. Col. Eric Mettala, Deputy Director, Software and Intelligent Systems Office

2:00 **Defense Logistics Agency**
John Christensen, Industrial Engineer, Manufacturing Engineering Research Office

2:30 **Strategic Defense Initiative Organization**
Greg Stottlemyer, Director, Producibility and Manufacturing

3:00 **Manufacturing Technology Information Analysis Center**
Michal Safar, Director, MTIAC

Thursday, December 5

Industry Review Panels
8:00 am — 11:00 am

8:00 **Robotics Panel**
(Panelists to be announced)

9:30 **Controls Panel**
(Panelists to be announced)

IPE Luncheon
11:30 am — 1:00 pm

Industry Review Panels
1:30 pm — 4:30 pm

1:30 **Sensors Panel**
(Panelists to be announced)

3:00 **IPE Summary Session**
(Panelists to be announced)

For more information on the IPE Conf., call Robert Schwinghamer at (205) 544-1001.

Reserve Your Place At Technology 2001 Today

Save time and money: Preregister for Technology 2001 by calling (800) 944-NASA. **Deadline for phone preregistration has been extended to November 22.**

Choose from four types of registrations:

- Complete Registration—includes technical sessions, workshops, and exhibits for all three show days; tickets to the opening reception on Monday, Dec. 2 and the Technology Transfer Awards Dinner on Wednesday, Dec. 4; and a copy of the Technology 2001 proceedings.
- Symposia/Exhibits Registration—covers technical sessions, workshops, and exhibits for all three days.
- One-Day Symposia/Exhibits Registration
- One-Day Exhibits Only Registration

	By 11/22	On-Site
Complete Registration	$300	$325
Symposia/Exhibits Reg.	$200	$225
One-Day Symposia/Exhibits Reg.	$100	$125
One-Day Exhibits Only Reg.	$25	$30

Federal government employees are entitled to a 50 percent discount on above prices. Discounts are also available to groups of ten or more; call (800) 944-NASA for details.

Special Bonus: Technology 2001 registrants are invited to attend the Federal Conference on Intelligent Processing Equipment (see previous page) at no additional cost. Your Technology 2001 badge will allow you access to the IPE meeting rooms, the location of which will be listed in the Official Show Program distributed on-site.

Tickets to the Technology Transfer Awards Dinner may be purchased separately for $150 each by calling (212) 966-3100. Preregistrants can pick up their badges and reception/dinner tickets at the San Jose Convention Center, 150 West San Carlos St., during the hours listed below.

On-Site Registration Hours

Monday, December 2	8:00 am - 5:00 pm
Tuesday, December 3	7:00 am - 4:00 pm
Wednesday, December 4	7:00 am - 4:00 pm
Thursday, December 5	7:00 am - 3:00 pm

The new San Jose Convention Center is situated in the heart of Silicon Valley.

Special Hotel Rates

Hotel space is limited, so act early to secure these special conference rates:

	Single	Double
Fairmont Hotel (headquarters hotel) (800) 527-4727	$105	$105
Hyatt San Jose (408) 993-1234	$85	$105
Red Lion (408) 453-4000	$80	$80
Hotel De Anza (800) 843-3700	$115	$130

The Fairmont and Hotel De Anza are within walking distance of the Convention Center; the Hyatt and Red Lion are approx. ten minutes away by Light Rail—San Jose's modern, efficient public transit system. When making reservations, you must mention Technology 2001 to obtain the special rates.

Transportation Discounts

Ground: Hertz Corp. is offering special discounted car rental rates with unlimited mileage. For reservations, call Hertz Meeting Services at (800) 654-2240 and identify yourself as an attendee of Technology 2001, meeting #9208.

Air: Discounted air fares are available to Technology 2001 attendees through American Airlines. Call American Airlines' Meeting Service Desk at (800) 433-1790 and ask them to display Star File #S01N1BG. Make reservations as the lowest applicable fare from your departure city and give your mailing address. Nepal Travel Bureau—the official travel agency for Technology 2001—will mail you the tickets. For follow-up inquiries about your tickets, call Nepal Travel at (800) 666-4519.

An Ideal Location

The Convention Center is located just three miles from San Jose International Airport, and offers plenty of indoor parking. At the heart of the downtown cultural center, the Convention Center is within easy walking distance of restaurants, shops, and entertainment. For information on cultural activities, attractions, and tours, call the San Jose Convention and Visitors Bureau at (408) 295-9600.

Questions? Call Joseph Pramberger or Justina Cardillo at (800) 944-NASA.

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Deadline For Phone Registration: November 22, 1991.

Compensating for Movement of Eye in Laser Surgery

An optical joint transform would track the lateral position of the retina.

Lyndon B. Johnson Space Center, Houston, Texas

A conceptual system for laser surgery of the retina would include a subsystem that would track the position of the retina. The tracking signal would be used to control galvanometer-driven mirrors that would keep the laser aimed at the desired spot on the retina as the eye moves. Alternatively or additionally, the indication of position could be used to prevent the firing of the laser when the eye has moved too far from the proper aiming position.

The retina would be viewed continuously by a video camera. An initial frame of video would be recorded as a positional reference. Thereafter, the reference image and the current image would be presented on two halves of a spatial light modulator to obtain the optical joint Fourier transform. The spatial light modulator would impress the two images on a coherent wavefront, and the joint transform correlation would thus be formed rapidly. The location of the bright spot in the correlation plane (the correlation peak) would represent directly the difference between the lateral positions of the current and reference images.

The image in the correlation plane could be digitized and processed conventionally to obtain the signal indicative of the location of the correlation peak — the tracking signal. In the alternative version, a simpler array of detectors — for example, a central detector and a surrounding ring-shaped detector — would provide a simply and speedily processable signal that would indicate whether the correlation peak lies within a predetermined positional tolerance. In this case, the sizes and spacing of the detectors would be calculated to support use in a fast, simple logical inhibition of the surgical laser when the eye is too widely mispositioned.

This work was done by Richard D. Juday of **Johnson Space Center**. *For further information, Circle 30 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 26]. Refer to MSC-21509.

Dynacounter Electronic Data-Reduction System

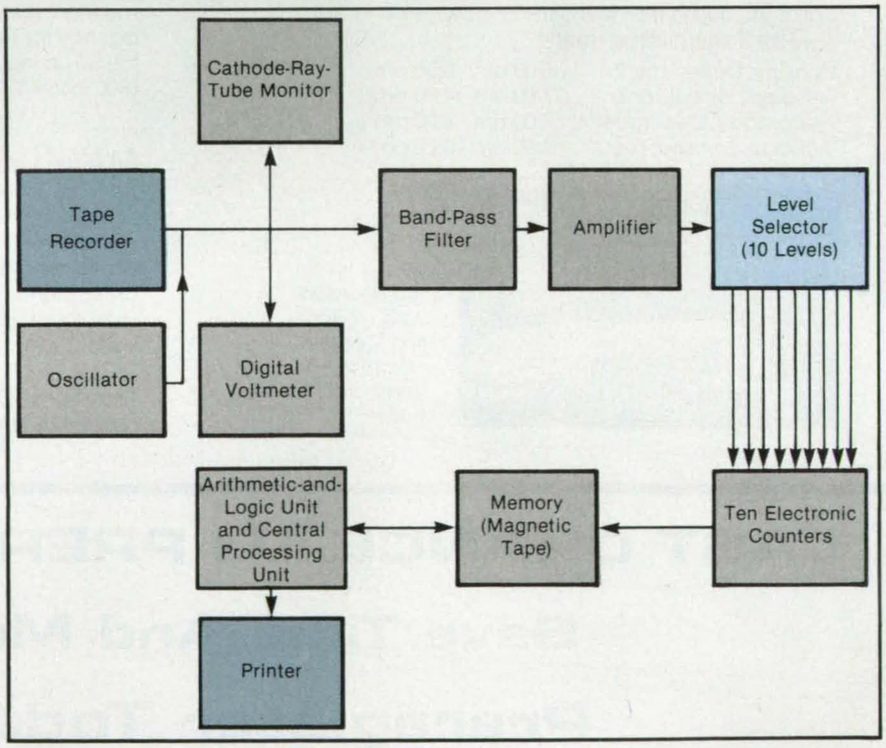
Output data would be suitable for calculations of fatigue.

Lyndon B. Johnson Space Center, Houston, Texas

The proposed "dynacounter" electronic data-reduction system would acquire statistics on the occurrence of various amplitude levels in a signal. More specifically, it would tabulate the number of times the amplitude of a component of a signal within a given frequency band exceeded any of 10 specified levels. If the signal is, for example, the output of an accelerometer or another signal related to the dynamics of the instrumented object, then the output data on the statistical distribution of amplitudes would be useful in calculations of fatigue in the instrumented object.

The raw accelerometer or other input signal would be recorded on magnetic tape during the test and subsequently fed into the dynacounter from the tape recorder (see figure). Alternatively or in addition, an oscillator would supply a calibrating input signal at a specified frequency. Calibration would be performed with the help of a digital voltmeter and a cathode-ray-tube monitor, which could also display the tape-recorded input signal.

The input or calibrating signal would be band-pass-filtered at the frequency of interest, then amplified, then fed to the level selector. Each level in the level selector would be chosen by setting a corresponding bucking voltage. Whenever the band-pass-filtered, amplified signal exceeded one of the bucking voltages, the level selector would put out a pulse that would add 1 to the count in an electronic counter assigned to the corresponding level. The outputs of the 10 counters (1 for each level) would be stored on magnetic tape.



The **Dynacounter** would process the tape-recorded signal from an accelerometer (or other sensor) into data on the statistical distribution of amplitudes in the signal at a given frequency.

Thousands of data could be tabulated in this manner.

An arithmetic-and-logic unit and a central processing unit would manipulate the stored data into the required statistical format. The central processing unit would send the data to a printer.

This work was done by Roy W. Mustain of Rockwell International Corp. for **Johnson Space Center**. *For further information, Circle 52 on the TSP Request Card.*
MSC-21568

Nonlinear Dynamic Compensation for Feedback Control

Bandwidth is reduced at low error signals.

NASA's Jet Propulsion Laboratory, Pasadena, California

A nonlinear dynamic compensation scheme enhances the stability of a feedback control system in which the feedback signal includes quantization noise. For example, it can improve control of the aim of a mirror mounted on a shaft instrumented with a device that measures the shaft angle in finite increments.

The nonlinear dynamic compensation scheme represents an attempt to satisfy two competing requirements. The ability of the control system to reject disturbances that originate in the controlled plant (e.g., disturbance torques in the case of the shaft that supports the mirror) and the speed of the response of the control system to a change in the commanded angle can be increased by increasing the feedback bandwidth. On the other hand, the contribution of quantization noise to the output error (the difference between the actual and commanded angles) can be reduced by decreasing the feedback bandwidth. Therefore, in the nonlinear dynamic compensation scheme, the bandwidth is reduced at small output error to reduce the effect of quantization noise and increased at large output error to increase the speed of response.

The nonlinear dynamic compensator is essentially a filter that includes a limiter and a compensating filter and that is placed in tandem with another filter called the "control" filter (see figure). Provided that the gain of the compensating filter is less than 1, whenever the magnitude of the error signal θ_e greatly exceeds the limit of the limiter, the output θ_k of the nonlinear dynamic compensator is approximately θ_e. Under this circumstance, the overall filtering effect on the error signal is approximately that of the control filter alone. The control filter is designed so that the overall control system (including the actuator and mirror) has the desired rapid response. In the original intended application, the bandwidth of this response is chosen to be 7 Hz.

The limit of the limiter (7 microradians in the original application) is chosen to be slightly greater than twice the magnitude of the quantization noise. Whenever the magnitude of the error signal falls below this limit, the output of the nonlinear dynamic compensator becomes that of the compensating filter alone. Under this circumstance, the overall filtering effect on the error signal is that of the compensating and control filters in tandem. The compensating filter is slower than the control filter is and is designed so that the overall control system has the desired slower response (characterized by a bandwidth of 2 Hz in the original application).

This work was done by Yu-Hwan Lin and Boris J. Lurie of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 118 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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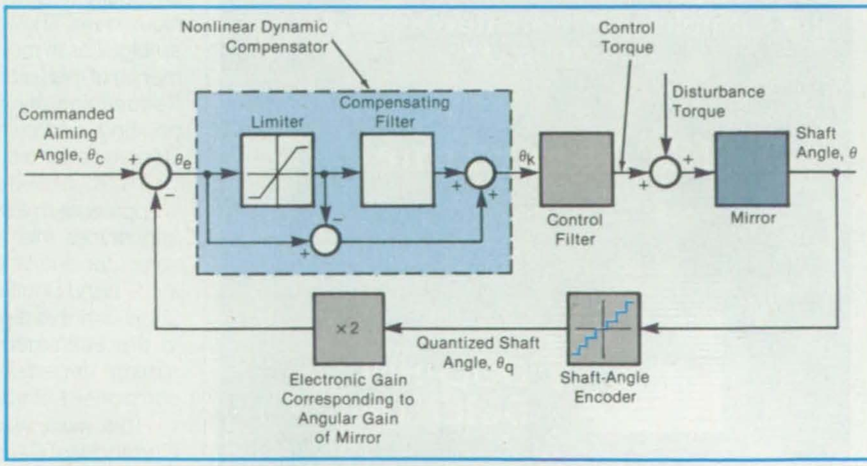
Refer to NPO-17993, volume and number of this NASA Tech Briefs *issue, and the page number.*



The **Nonlinear Dynamic Compensator** slows the response of the control system at low error signals to diminish the effect of quantization noise but provides a faster response at large error signals to speed the correction of large errors.

Books and Reports

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

Study of Candidate Architectures for Data Processor

Several architectures are analyzed in terms of performance, power, size, bit-error rate, and reliability.

A report discusses candidate architectures for a digital computer system that is to be part of a communication system in a spacecraft. The computer system is to include an 80386 microprocessor, a direct-memory-access (DMA) controller, a random-access memory (RAM) of 8K words of 32 bits each, an input/output channel based on the MIL-STD 1553a protocol, and a port to a Multibus II (or equivalent) bus.

The candidate architectures are the following:

- **Baseline**. The direct-memory-access controller contends with the microprocessor to obtain access to memory. There is no error-detecting-and-correcting coding (EDC).
- **Dual-Port**. The contention for access to memory is eliminated by making the RAM a dual-port unit. In one version of this architecture, the RAM is equipped with full EDC; in the other, with partial EDC.
- **Dual-Bus**. This represents a compromise between the baseline and dual-port architectures. A bus-arbitration unit resolves the contention for access to memory.

These architectures were analyzed on the basis of data supplied by the manufacturers of the component circuits. The primary issues in the analysis were performance, rates of bit errors attributable to single-event upsets (caused by ionizing radiation), reliability, size, and dissipation of power. In the analysis of performance, the effect of printed-circuit-board capacitances on cycle times was an important consideration.

The numerical results of the analysis show that the dual-port architecture with full EDC offers the highest performance (in terms of speed), with bit-error rates equal to those of the baseline and dual-bus architectures. The most significant disadvantage of the dual-port architecture is that its size, demand for power, and number of component integrated-circuit chips are greater than those of the baseline architecture. The increase in the number of chips requires an increase in the number of wire bonds, with a concomitant moderate reduction in reliability.

This work was done by Lou McRoberts of Motorola Inc. for **Johnson Space Center**. *To obtain a copy of the report, "Processor Architecture Analysis," Circle 39 on the TSP Request Card.* *MSC-21690*

Ambiguity of Doppler Centroid in Synthetic-Aperture Radar

The performances of two ambiguity-resolving algorithms are investigated.

A paper discusses the performances of two algorithms for the resolution of the ambiguity in the estimated Doppler centroid frequency of the echoes in a synthetic-aperture radar. An accurate and unambiguous estimate of the Doppler centroid frequency is needed to process the echoes into radar images of high quality. Because the echo spectrum is sampled at the radar-pulse-repetition frequency, the frequency range of unambiguous Doppler spectrum is limited to the pulse-repetition frequency. The ambiguity arises if the uncertainty in the aim of the radar antenna results in a Doppler shift greater than half the pulse-repetition frequency.

After presenting a brief overview of the problem, the paper discusses the effects of the ambiguity on synthetic-aperture-radar imagery. These effects include degradation of the point-target response, degradation of the signal-to-noise and signal-to-ambiguity-level ratios of an image, geometric distortion, and misregistration between independent looks with consequent error in the multilook overlay process. To quantify the effects of the ambiguity on the point-target response, the paper presents the results of a computer simulation based on parameters typical of the C-band Shuttle Imaging Radar.

Next, the paper describes the two ambiguity-resolving algorithms: one based on the range-cross-correlation technique, the other based on the multiple-pulse-repetition-frequency technique. The range-cross-correlation technique involves the cross-correlation of two independent single-look images to detect the crosstrack misregistration. It requires high-contrast radar targets to detect the ambiguity reliably. The multiple-pulse-repetition-frequency technique is well known in the industry as a technique for resolution of ambiguities in moving-target-indicator radar systems. The performance of this technique is limited by the available pulse-repetition frequencies, by the unknown drift rate of the radar antenna pointing, and by that component of the error in the estimated Doppler centroid which is not attributable to the ambiguity.

The multiple-pulse-repetition-frequency algorithm in this study is applicable to a system in which there are three pulse-repetition frequencies that are not related by a large common factor. A computer simulation was conducted, using parameters typical of the C-band Shuttle Imaging Radar. The results of the simulation show that this algorithm is capable of resolving the ambiguity in the estimated Doppler centroid frequency for antenna-aiming uncertainities of about 2° to 3° and an unknown component of about 0.026°/s of the rate of drift in the aim.

This work was done by Chi-Yung Chang and John C. Curlander of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Doppler Centroid Estimation Ambiguity for Synthetic Aperture Radars," Circle 157 on the TSP Request Card. NPO-17943*

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Physical Sciences

Hardware, Techniques, and Processes
52 Single-Exposure Long-Equivalent-Wavelength Interferometry
54 Reversible Chemisorption Gas-Gap Thermal Switch
54 Conical Mirrors for Quasi-Retroreflection
58 Measuring Electrical Resistivity of Compacted Powder
Books and Reports
60 Effects of Interference on Scattering by Parallel Fibers
60 Proceedings of Infrared-Detector Workshop

Single-Exposure Long-Equivalent-Wavelength Interferometry

Spatial filtering extracts infrared-equivalent interferograms from nonlinearly recorded two-visible-wavelength interferograms.

NASA's Jet Propulsion Laboratory, Pasadena, California

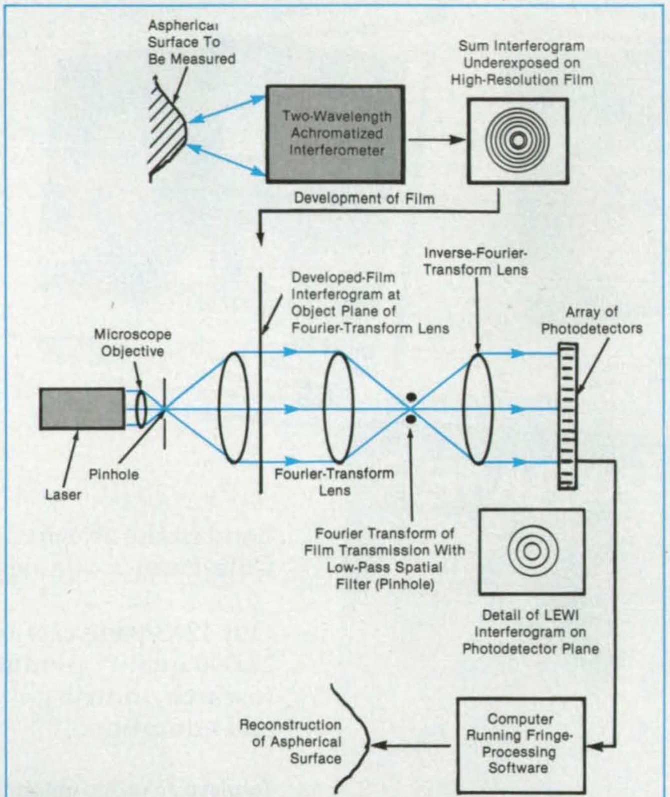
A proposed single-exposure technique for producing long-equivalent-wavelength interferograms (LEWI's) would involve the use of photographic film to record a two-wavelength interferogram nonlinearly in a single exposure. Previously, LEWI's were obtained through multiplicative combinations of pairs of interferograms, each interferogram recorded in a separate exposure at a different wavelength. The single-exposure technique will make it possible to use LEWI's to measure the surface contours of such objects as human corneas, which cannot be expected to remain stationary for two exposures. Commercial interferogram-processing computer programs can then be used to convert the LEWI's into topographical representations of the surfaces.

Two-wavelength techniques are often used for topographical measurements of strongly aspherical surfaces. Using wavelengths λ_1 and λ_2, an interferogram with a fringe pattern corresponding to a longer wavelength $\lambda_{effective}$ can be created where

$$\lambda_{effective} = \lambda_1\lambda_2/(\lambda_1 - \lambda_2)$$

For example, the 633-nm red and 613-nm orange helium/neon laser lines can be used to synthesize an interferogram equivalent to that obtained by using an infrared wavelength of 19.4 μm. The use of these visible wavelengths avoids the problem of invisibility and the need for special sources, detectors, and optical materials that complicate testing in the infrared. Thus, at the price of reduced topographical sensitivity (in the example above, the LEWI fringes are approximately 30 times as coarse as the fringes at either visible wavelength alone), an unambiguous determination of surface topography can be obtained without the resolution problems associated with single (typically visible) wavelengths.

In the single-exposure technique, the nonlinearity required to produce the difference-spatial-frequency Fourier component that contains the LEWI information would be obtained by adjusting the exposure so that it falls on the nonlinear portion of the sensitivity curve of the film. After the two-wavelength interferogram was thus recorded, the film would be developed in the conventional manner.



Topographical Analysis of a highly aspherical surface can be accomplished by use of a long-equivalent interferogram produced by appropriate spatial filtering of information previously recorded nonlinearly in a single-exposure, two-wavelength interferogram.

The figure illustrates the optical train that would perform the low-pass spatial filtering necessary to extract the LEWI information. Light from a laser would be sent through a microscope objective and pinhole to form a diverging spherical wave front of high quality. A first collimating lens would form the spherical wavefront into a collimated beam. The developed film containing the nonlinear sum transmission interferogram would be placed in the object plane of the next lens, which would form the Fourier transform of the interferogram at its image plane. A pinhole at this image plane would be sized to pass only the low spatial frequencies associated with the LEWI information. An inverse-transform lens would recollimate the spatially filtered light and inverse-Fourier-transform it to produce the LEWI on a two-dimensional array of photodetectors. The array would have sufficient resolution to accommodate the highest spatial frequency in the LEWI. The output of the array would be digitized and processed into a topographical representation of the object used to make the interferogram.

This work was done by Eric B. Hochberg of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 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

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Refer to NPO-17580, volume and number of this NASA Tech Briefs *issue, and the page number.*

Reversible Chemisorption Gas-Gap Thermal Switch

Gas/sorbent combinations provide means to turn heat-conduction paths on and off.

NASA's Jet Propulsion Laboratory, Pasadena, California

Several well-known combinations of gas and sorbent have been proposed as means to turn heat-conduction paths on and off in sorption refrigeration systems. The proposed gas-gap thermal switches would require relatively low power. Because they would operate without vibrations and without moving parts, they could be used in sorption refrigeration systems designed to operate for long times without maintenance.

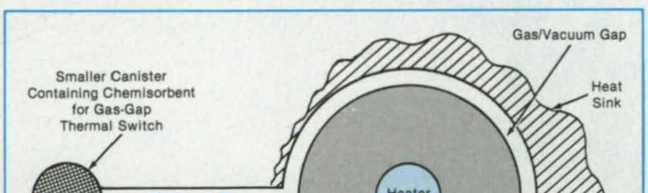
In the normal operating cycle of a sorption refrigeration system, a canister of sorbent is heated electrically to drive off a gas at relatively high pressure. This gas expands through an orifice to provide cooling, and the resulting low-pressure gas is resorbed by cooled sorbent in another canister. While a canister of sorbent is being heated, it is insulated from its surroundings by means of a vacuum; i.e., the heat-conduction path is switched off. During the next half cycle, the power to the electrical-resistance heater in the previously heated canister is turned off, and the gas is injected into a gap between this and a cooled heat sink; i.e., the heat-conduction path is switched on, and the hot canister is cooled.

In one of the proposed thermal switches, the gas would be supplied to or withdrawn from the gap by heating or cooling a smaller canister containing a chemisorbent/gas combination that undergoes a reversible chemical reaction, depending on its temperature (see Figure 1). For example, $ZrNiH_2$ in the smaller canister could be heated to about 145 °C, causing it to desorb H_2 via the reversible reaction $ZrNiH + \frac{1}{2}H_2 \rightleftharpoons ZrNiH_2$. The desorbed H_2 would fill the thermal-switch gap at a pressure of about 10^{-2} atm (about 1 kPa) — a pressure sufficient to provide the required thermal conduction across the heat-switch gap. When the smaller canister was cooled to about 35 °C, the ZrNiH would reabsorb most of the H_2, nearly evacuating the gap to a pressure of about 10^{-5} atm (about 20 Pa). At this low pressure, the thermal conductance of the gap would be low enough that the larger canister of the sorption refrigeration system could be reheated with minimal parasitic loss of heat to the environment. It has been estimated that less than 1 g of ZrNiH would be sufficient to switch heat to a 100-g canister of a sorption refrigeration system; this would help to make the overall system very efficient.

Figure 2 shows a more-elaborate two-stage version for thermal switching between central hot canisters and surrounding warm sorption canisters and between the warm canisters and the environment. This type of heat cascading is used in certain types of sorption refrigeration systems that operate in different sorption temperature ranges. In this system, O_2 for the heat-switch gas would be supplied by desorption in one stage via the reaction $4MnO_2 \rightarrow 2Mn_2O_3 + O_2$. The oxygen would be withdrawn by the reaction $4Cu + O_2 \rightarrow 2Cu_2O$ at lower pressure. The copper would be dispersed on zeolite — the copper/zeolite material is now commercially available and has been used as an oxygen getter.

This work was done by Jack A. Jones, Steven Bard, and Gary Blue of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 59 on the TSP Request Card.*
NPO-17568

Figure 1. A **Single-Stage Gas-Gap Thermal Switch** would be based on the reversible chemisorption of hydrogen gas by ZrNiH.



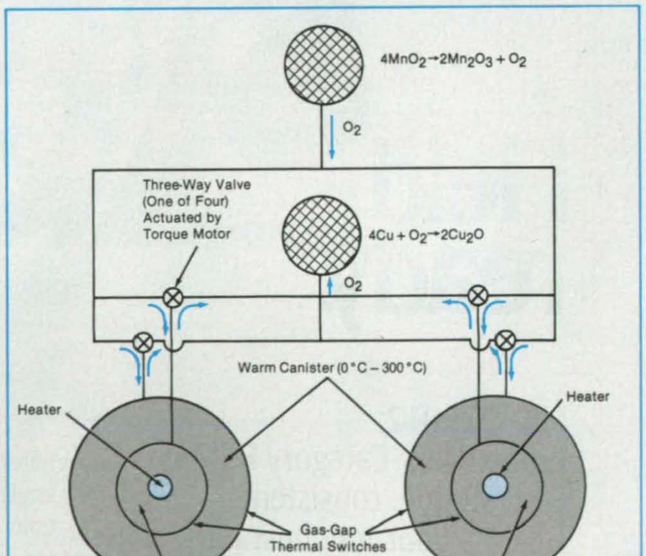


Figure 2. A **Two-Stage Gas-Gap Thermal Switch** would be based on the reversible desorption of O_2 from MnO_2 in the first stage, followed by absorption in Cu on zeolite in the second stage.

Conical Mirrors for Quasi-Retroreflection

Angles of incidence could range more widely than they do for corner-cube reflectors.

NASA's Jet Propulsion Laboratory, Pasadena, California

Single and multiple-nested conical mirrors can be assembled and positioned to provide several distinct orders of retroreflection. The design and orientation of the "cones" will determine the positions of, and the solid angles subtended by, the discrete orders of retroreflection.

This type of retroreflector accommodates a larger range of incident angles than do traditional corner-cube reflectors. In addition, these proposed reflectors will provide greater spectral coverage than that of conventional lens-and-mirror retroreflectors. Potential applications include interferometry, metrology, lasers, position and motion sensors, instrument test and calibration, and expanded capability of highway markers and signs.

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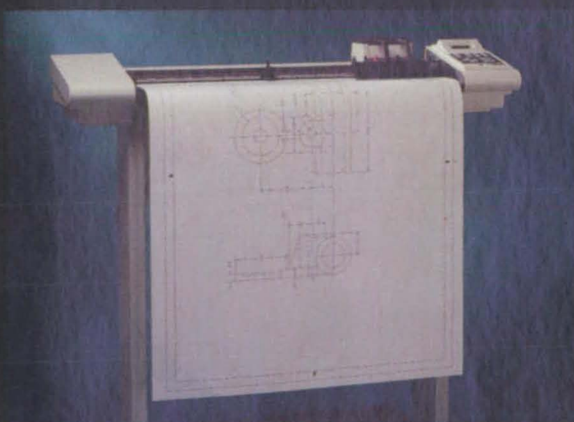

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Figure 1 illustrates the circular cone, in the meridional plane, and its first four orders of retroreflection. Unlike a corner-cube reflector, which retroreflects over all angles in its acceptance range, a conical reflector accurately retroreflects only beams that are incident along an axis corresponding to one of the prescribed orders. Each order provides retroreflection for a bundle of rays within a finite angular extent. This angular spread is dependent on the angle of incidence of the incoming beam. Angular coverage decreases with increasing order number.

The price for obtaining acceptance angles greater than that provided by corner-cube reflector is partial angular coverage and a decrease in the size of the accepted ray bundle. This compromise may be acceptable in cases in which the directions of the incoming beams are predetermined. For the cases where a wider acceptance angle is required and continuous coverage is not important, the conical reflectors may serve as practical alternatives to corner-cube reflectors.

The ranges of acceptance angles can be selected by choosing the shapes and arrangements of the cones. For example, round cones would have axisymmetric reflection patterns. Cones with rectangular cross sections would provide for the independent selection of angular ranges in two perpendicular directions. The number of discreet directions, or planes of coverage, can be increased by using multi-sided reflectors such as the hexagonal cone shown in Figure 2. A greater range of angles could be obtained by nesting several of these reflectors within each other. These nested conical reflectors would then provide increased flexibility over that of single reflectors.

This work was done by Richard G. Dekany and Ronald G. Holm of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 36 on the TSP Request Card.*
NPO-18005

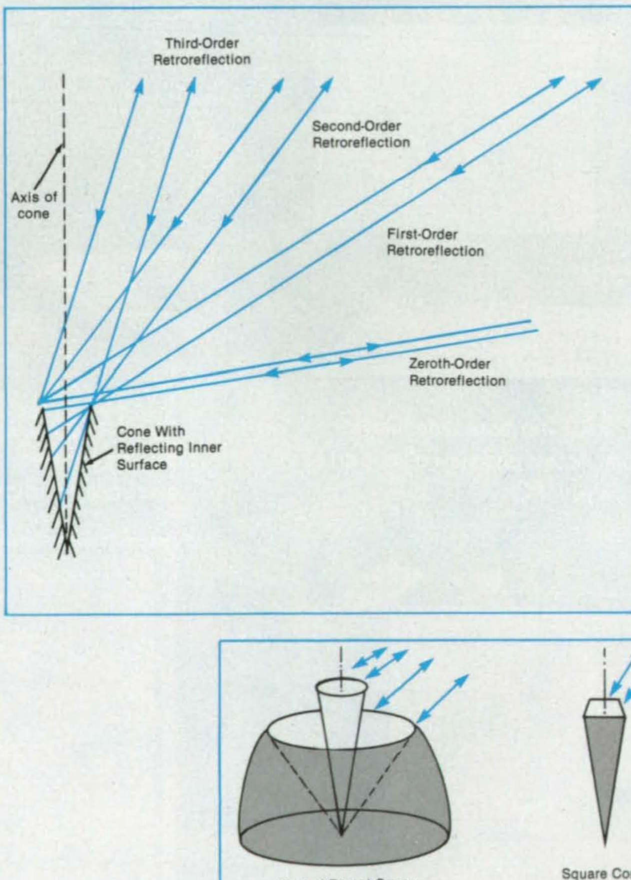


Figure 1. **Rays of Light Are Retroreflected** to various orders when incident on the conical reflecting surface along specific directions in a meridional plane.

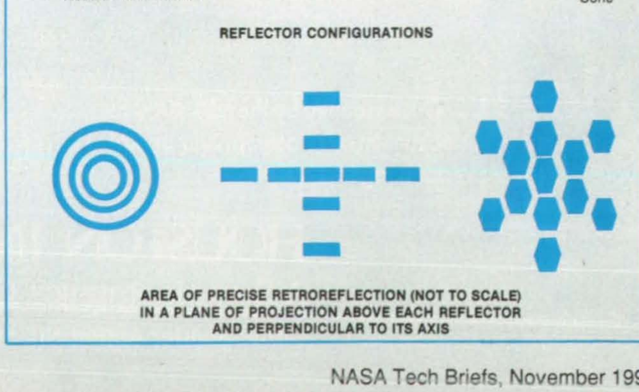
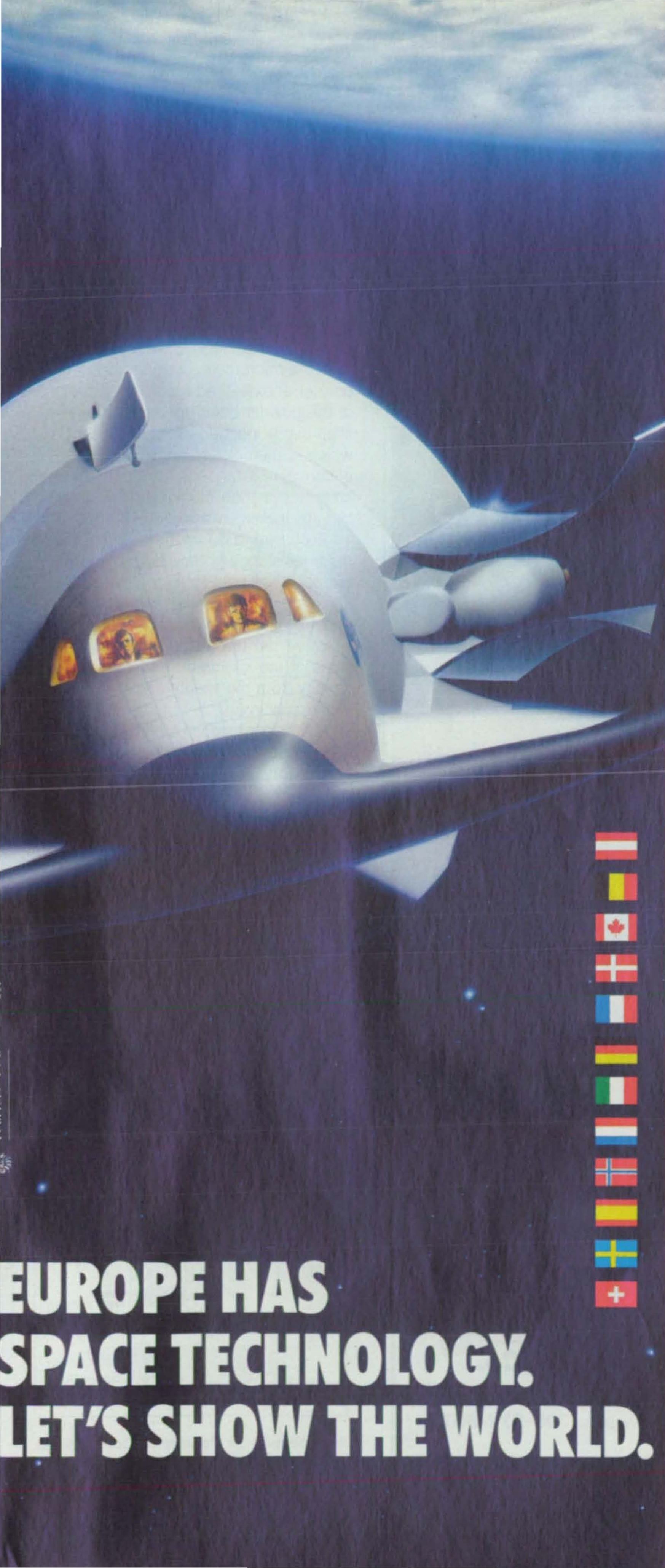


Figure 2. **Conical Reflectors Can Be Configured** in various ways to tailor the partial angular coverage of exact and approximate retroreflection.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Measuring Electrical Resistivity of Compacted Powder

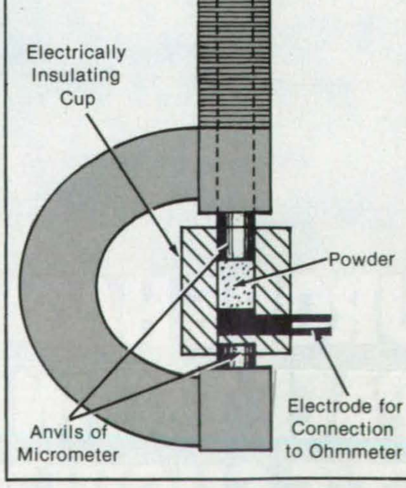
A simple device compacts a specimen and measures both its resistance and its dimensions.

NASA's Jet Propulsion Laboratory, Pasadena, California

A slightly modified micrometer is used in conjunction with a special cup to measure the electrical resistance of a specimen of powder as a function of the packing fraction. The powder is pressed between the anvils of the micrometer, which make electrical contact with the specimen. This device could be used in manufacturing batteries, for example, to determine the effective electrical conductivities of powders that are to be loaded into plastic sheets to make battery substrates. Coupled with a good mathematical description of the expected conductivity of a particulate composite as a function of packing density, this device could serve as a tool for evaluating the conductivity of a dispersed phase, as well as for evaluating the electrical resistances of interparticle contacts.

The procedure for measuring the resistivity of a specimen of powder as a function of the packing fraction is straightforward (see figure). First, the empty cup is inserted in the micrometer, which is then closed until the ohmmeter shows a low resistance. Then the ohmmeter is adjusted to zero, and the null reading of the micrometer is recorded. Next, the cup is removed from the micrometer, weighed, filled with powder, and weighed again, the net weight of the powder being recorded. Then the filled cup is inserted into the micrometer, which is then closed until a measurable electrical resistance is detected. The micrometer is then closed further, in successive increments of 0.002 in. to 0.005 in. (0.05 mm to 0.1 mm), while the electrical resistance is recorded at each micrometer setting. Finally, the data are fed into a simple personal-computer spreadsheet program, which calculates the resistivity from the resistance and dimensions of the specimen and the packing density from the weight and dimensions of the specimen.

This work was done by Paul J. Shlichta of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 55 on the TSP Request Card. NPO-18056*



A Specimen of Powder Is Compressed between the anvils of a micrometer, and its electrical resistance is measured via the anvils, which also serve as contacts.

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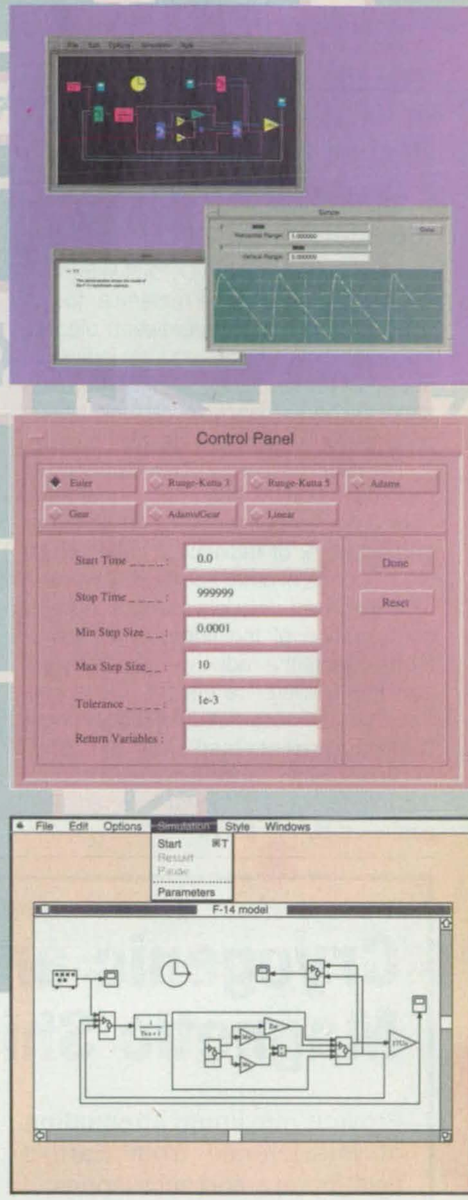

(Top) Use the Scope block to see the "real-time" response of this F-14 model during the simulation; (Center) Specify simulation parameters via dialog boxes or the MATLAB command line; (Bottom) SIMULAB takes full advantage of the X/Motif and Macintosh windowing systems.

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Effects of Interference on Scattering by Parallel Fibers

Interference decreases the scattering efficiency.

A report discusses the radiative transfer of heat through fibrous materials, focusing on the interactions between electromagnetic waves scattered from individual fibers. Such scattering and interference affect the performances of ceramic fabrics used as high-temperature thermal insulation.

The classical theory of such phenomena is based on the assumption that each fiber acts independently as an absorber and scatterer of radiation, unaffected by the presence of other fibers. However, the highly-ordered, closely-spaced, parallel configuration of the fibers in a yarn or fabric affects the radiative transfer by enhancing interference effects. The departure from the assumption of independent scattering arises primarily from the coherent addition (i.e., constructive and destructive interference) of the far-field radiation scattered by the fibers.

Equations for the coherent addition of the scattered waves are presented and used to derive equations for the intensity of the scattered radiation, with emphasis on the cases of evenly spaced coplanar fibers and randomly positioned fibers. This theory predicts that the scattering efficiency of the randomly positioned fibers is less than that predicted by the independent-scattering theory.

Experiments to test this theory are described. In essence, they involved measurements of the scattering from an array of 60 parallel, closely and randomly spaced, coplanar quartz fibers, each 9 μm in diameter, at wavelengths from 2.5 to 15 μm. The results of the experiments confirm the predictions of the theory. More specifically, the two significant parameters that govern the scattering of light by one fiber and the interference between the scattering fields caused by the proximity of other fibers are the scaled fiber diameter, $\pi d/\lambda$ (where d = the diameter and λ = wavelength), and the scaled distance between the fibers, a/λ (where a = the distance). These parameters range over several orders of magnitude as the wavelength of incident radiation is varied over the range of interest in the experiments. The measurements exhibit the expected oscillations caused by interference and validate the quantitative predictions of the theory for size parameters less than π.

This work was done by Susan M. White of **Ames Research Center** *and Sunil Kumar of the University of California. Further information may be found in AIAA paper 89A-43232, "Interference Effects on Scattering by Parallel Fibers."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500. ARC-12530

Proceedings of Infrared-Detector Workshop

Advances in infrared imagers for astronomy are reported.

The Proceedings of the Third Infrared Detector Technology Workshop is a 474-page volume that contains 37 papers presented at a scientific conference at Ames Research Center in February 1989. The conference focused on infrared detectors, arrays of such detectors, and cryogenic electronics relevant to infrared astronomy. Though the emphasis was on the development of equipment to make low-background observations from platforms in outer space, there was also some discussion of observations from ground-based and airborne platforms.

The volume includes papers on intrinsic and extrinsic semiconductor detectors and arrays thereof, readout circuitry, and cameras. Recent developments in the infrared spectrometer for the second-generation Hubble Space telescope and in detectors and arrays for the European Space Agency's Infrared Space Observatory are discussed. Reports on the statuses of the Space Infrared Telescope Facility and the Stratospheric Observatory for Infrared Astronomy are presented.

In addition to the 37 technical papers presented at the conference, the volume includes an introductory paper that places the conference in historical perspective and discusses the technical requirements of infrared astronomy from outer space. A foreword also gives some historical perspective and summarizes the progress detailed in the papers that follow. Finally, a list of attendees and their institutions near the beginning of the volume may be useful to scientists, engineers, and technicians who need more-detailed information.

These proceedings were compiled by Craig R. McCreight of **Ames Research Center**. *Further information may be found in NASA TM-102209 [N90-21313], "Proceedings of the Third Infrared Detector Technology Workshop."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12851

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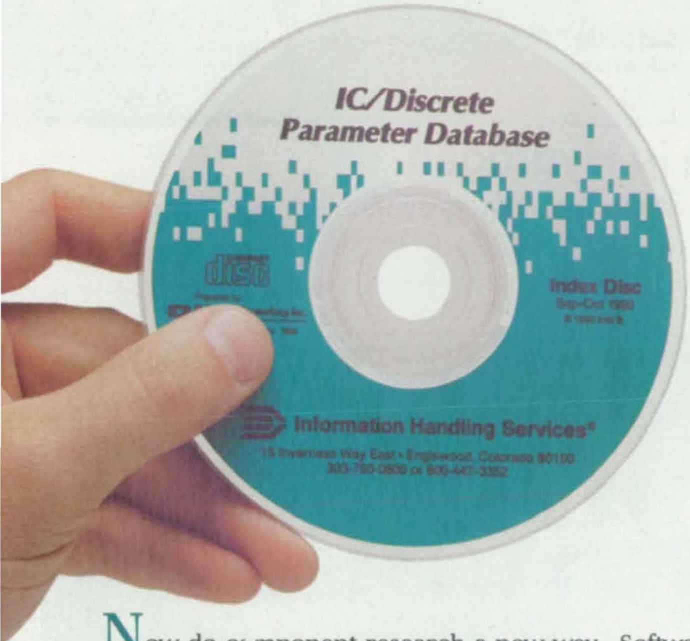

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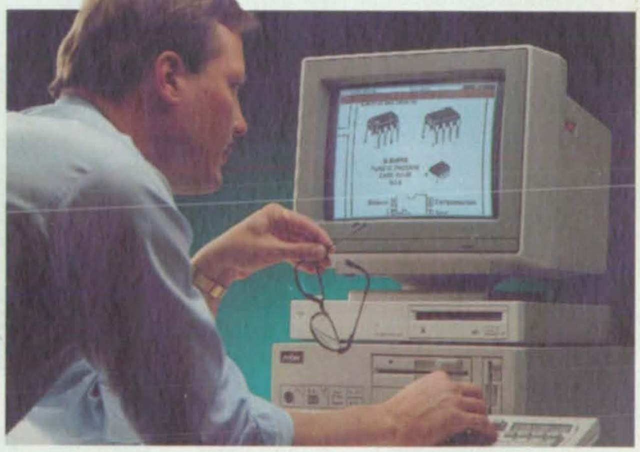

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Hardware, Techniques, and Processes

62 Alloy Has High Fatigue Strength in Hydrogen

63 Fluidized-Bed Silane-Decomposition Reactor

Alloy Has High Fatigue Strength in Hydrogen

High-energy microstructural surfaces that entrap hydrogen are largely eliminated.

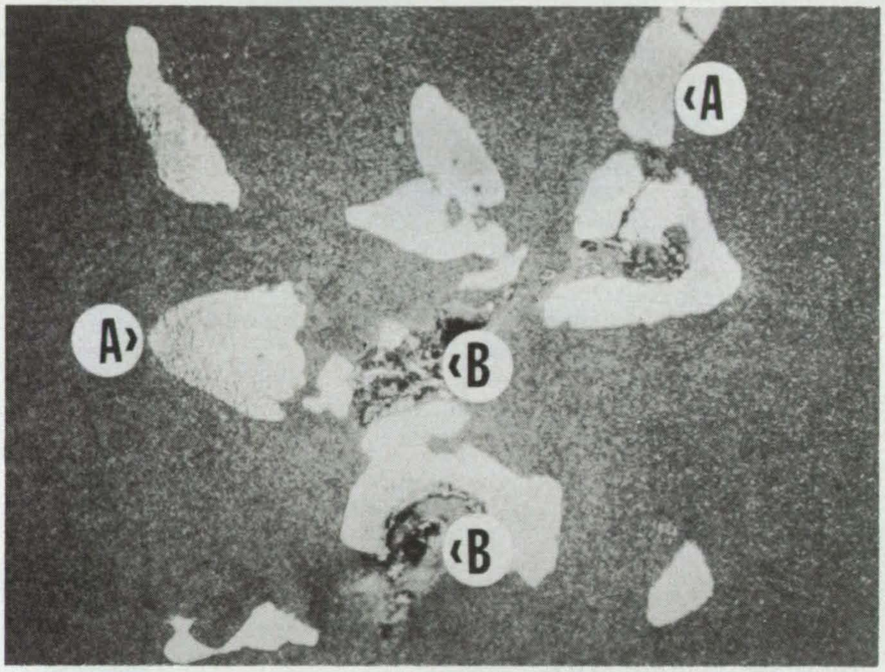
Marshall Space Flight Center, Alabama

An experimental nickel-base alloy exhibits exceptional low-cycle-fatigue strength in hydrogen. The alloy is one of many that are intended to be produced by the strategy of (1) formulating compositions that have the potential for exceptional low-cycle-fatigue strength in air, (2) casting these alloys into single crystals, and (3) processing these crystals in such ways that their microstructures contain minimal numbers of both sites that favor the initiation of fatigue and sites that have high surface energies for the entrapment of, and infiltration by, hydrogen.

The third step is essential because the combination of sites of the two types leads to embrittlement by hydrogen and the consequent loss of resistance to fatigue. This process of embrittlement requires not only a source of hydrogen but also the dissociation of hydrogen molecules into hydrogen atoms on the surface of the metal, the migration of the hydrogen atoms into the metal, and the recombination of the hydrogen atoms into molecules of hydrogen gas at the high-surface-energy interior sites. Traditionally, these sites have been identified as grain boundaries, interfaces between inclusions and the metal matrix, pores, cavities, and voids. More recently, the interfaces between the γ and γ' subphases of the γ/γ' eutectic phases of superalloys have been identified as such sites.

In the new alloy concept, the composition is chosen to obtain high strength and a high volume fraction of γ'. Such an alloy is amenable to a heat treatment that takes all the γ' in the microstructure into solution and reprecipitates it as fine, uniform particles. This treatment also eliminates the high-energy γ/γ' eutectic phase, which commonly forms in alloys that contain high volume fractions of the γ' phase. In general, the composition of such an alloy satisfies the following criteria:

1. $4.11Re + 5.15Cr + 14.10V - 24.92Ti - 15.5Nb - 0.63W + 110 - 7.04Ta - 10.42Al + 1.11Co - 80Hf \geq 0$, where each standard chemical symbol denotes the weight percentage of the corresponding element; and
2. the proportions of carbon, boron, oxygen, and nitrogen are all less than 200 parts



PWA1480 Alloy

Experimental Alloy

The **Microstructures of Two Alloys** are different in ways that affect their abilities to resist embrittlement by hydrogen. The PWA1480 alloy contains large eutectic islands (A) and incipient melted regions (B), while the experimental alloy contains a fully-solid-solution microstructure with neither incipient melted regions nor porosity.

per million by weight.

Inclusions are eliminated by taking proper precautions during melting. For example, to prevent the formation of carbide, boride, and nitride phases, the interfaces of which with the metal matrix are surfaces of high energy, one refrains from intentionally adding boron, carbon, and nitrogen to the alloy. All pores, cavities, and voids can be eliminated by hot isostatic pressing after initial casting.

The experimental alloy was formulated and processed according to this concept and compared with the previously best single-crystal alloy, PWA1480, which had been processed under standard conditions. The resistance of a notched specimen of the new alloy to low cycle fatigue in air at room temperature proved to be an order of magnitude greater than that of PWA1480. The low-cycle-fatigue strength of the new alloy in hydrogen at room temperature was found to be almost equivalent to that of PWA1480 in air.

The microstructures of the two alloys are quite different, as shown in the figure. The microstructure of PWA1480 cannot be fully homogenized because it contains large volume fractions of γ/γ' eutectic islands, which cannot be dissolved without excessive incipient melting. However, the new alloy contains a fully-solid-solution microstructure that contains neither γ/γ' eutectics, nor incipient regions, nor porosity.

This work was done by Alan D. Cetel, Bradford A. Cowles, David N. Duhl, Daniel P. Deluca, and Maurice L. Gell of United Technologies Corp. for **Marshall Space Flight Center**. *For further information, Circle 95 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-28464.

Fluidized-Bed Silane-Decomposition Reactor

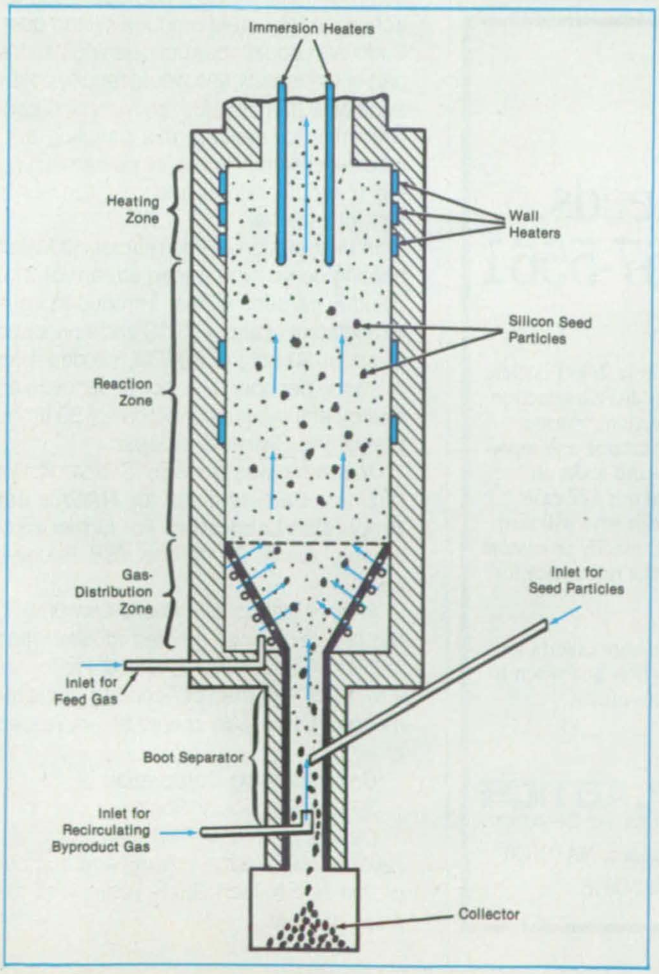
Silicon is deposited on fluid-bed particles instead of on the reactor walls.

NASA's Jet Propulsion Laboratory, Pasadena, California

A fluidized-bed pyrolysis reactor produces high-purity polycrystalline silicon from silane or a halosilane via efficient heterogeneous deposition of silicon on silicon seed particles. The formation of silicon dust via the homogeneous decomposition of silane is minimized, and the deposition of silicon on the wall of the reactor is effectively eliminated. The silicon can be used to construct solar cells and other semiconductor products.

Closed to the surroundings, the reactor (see figure) has an inlet for the entrance of the silane (and/or halosilane) feed stream, another inlet for recirculated byproduct gases, a boot separator for the removal of silicon particles, and an upper outlet (not shown) for the removal of the byproduct gasses. Silicon seed particles, introduced into the entering stream of byproduct gas below the gas-distribution zone, are fluidized and carried upward in the feed stream through an upwardly increasing temperature gradient. As the mixture of particles and gases passes through the reaction zone (where the temperature increases with height from a range of

In this **Fluidized-Bed Silane-Decomposition Reactor**, silane decomposes into silicon and byproduct hydrogen on the surfaces of hot silicon particles in the reaction zone but does not decompose on the relatively cool reactor wall.



about 450 to 650 °C at the lower end to about 650 to 800 °C at the upper end), effectively all of the feed stream is decomposed, the resulting silicon depositing on the seed crystals.

About 70 to 90 percent of the total heat input of the reactor is provided at the heating zone, heating the fluidized silicon particles to a temperature of 650 to 800 °C. These hot particles are returned to the reaction zone by the mixing action of the fluidized bed, thereby heating the reaction zone. There, these hot particles cause the heterogeneous decomposition of the feed stream, and more silicon is deposited on their surfaces. Because the wall of the reactor is relatively cool in this zone, the deposition of silicon on the hot particles is greatly favored over deposition on the wall. When the silicon particles have achieved diameters from about 400 to about 1,500 μm or larger depending on the size of the reactor, they descend from the reaction zone into the collector.

In the gas-distribution zone, which is immediately below the reaction zone, the wall of the reactor is cooled to a temperature between about 200 °C and about 400 °C by a flow of water, nitrogen, or the like. At this temperature, negligible decomposition of silane and/or halosilane to silicon occurs. Because of the relatively high concentrations of silane and/or halosilane in this region, any formation of silicon would be predominantly via a homogeneous reaction, which would produce silicon dust. Such dust could obstruct openings in this part of the reactor and would require costly additional handling for recovery and consolidation for melting; this handling also would increase the risk of contaminating the ultrapure silicon and result in some loss of material.

In one version of this reactor, 10 kW of heating power and a feed stream of 21.6 volume percent silane, introduced at a temperature of about 25 °C and a pressure of about 30 psig (0.2 MPa), yielded 1 kg of silicon per hour. This corresponds to an energy efficiency approximately 30 times that of the Siemens process.

This work was done by Sridhar K. Iya of Union Carbide Corp. for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 92 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention, covered by U.S. Patent No. 4,818,495. Inquiries concerning rights for its commercial use should be addressed to

Union Carbide Corporation
39 Old Ridgebury Road
Danbury, CT 06817-0001

Refer to NPO-18014, volume and number of this NASA Tech Briefs *issue, and the page number.*

Computer Programs

65 Software Models Impact Stresses
66 Video Image Communication and Retrieval—Updated
69 Program for Parallel Discrete-Event Simulation
70 Computing Availability and Reliability for a System

COSMIC: Transferring NASA Software

COSMIC, NASA's Computer Software Management and Information Center, distributes software developed with NASA funding to industry, other government agencies and academia.

COSMIC's inventory is updated regularly; new programs are reported in *Tech Briefs*. For additional information on any of the programs described here, circle the appropriate TSP number.

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Mechanics

Software Models Impact Stresses

This program computes the propagation of elastic waves in a body after impact.

The elastic impact stresses generated within a struck body are of great concern. However, the complexity of the mathematics used to determine such stresses makes exact solutions infeasible for most engineers. The Generalized Impact Stress Software was designed to assist engineers in predicting stresses caused by a variety of impacts. The program is straightforward, is simple to implement on personal computers, is "user-friendly," and can handle a variety of boundary conditions applied to the struck body being analyzed.

The program has been verified by confirming results of several textbook cases and known solutions to simple problems. It has widespread applications, including the mathematical modeling of motions and transient stresses of a spacecraft. Other uses include analysis of the slamming of a piston, of fast valve shutoffs, and of the play of a rotating bearing assembly. This program provides a fast and inexpensive analytical tool for the analysis of stresses and should reduce dependency on expensive impact tests.

The program determines the impact stresses within a one-dimensional body by tracking both the acoustic waves generated by the impact and the reflections and transmissions of these waves as functions of position and time. The impact could take place at one end or both ends of the body. The program was originally conceived to compute impact stress of the liftoff seal of the high-pressure fuel pump in the main engine of the Space Shuttle. The program has been generalized to solve a range of problems and can be applied to any object that could potentially have a high impact load.

The program treats the collision as purely elastic, enabling analyses for many cases in which permanent deformations are not expected. The results of a simulation could also be used to determine whether the yield stress of the material is exceeded.

Prior to running the program, the struck body to be analyzed must be approximated as a series of one-dimensional elements. Non-rigid-body motions of elements are taken into account. Thus, compressions and tensile forces at the boundaries of elements after impact are modeled as functions of time. The user must specify the boundary conditions and applied loads along with the pressure-reflection coefficients for waves that encounter the external boundaries of the body from the interior of the body and the transmission coefficients for waves that propagate into the body from the outside environment.

After determining the stresses and the velocities of particles at each boundary within the body, the program prints the maximum and minimum stress calculated, with the locations and times when they occur. The output can be presented by printing stress and velocity values and by plotting spatial or temporal dependences of stresses.

The program was written in FORTRAN 77 in 1989 and has been verified on an IBM PC operating under MS-DOS 3.2. It has a memory requirement of 270 KB. The program requires the use of the commercial software package PLOT88, available from Plotworks, Inc.

IBM PC is a registered trademark of International Business Machines. MS-DOS is a registered trademark of the Microsoft Corp.

This program was written by Timothy C.

Hanshaw, Dipankar Roy, and Mark Toyooka of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 143 on the TSP Request Card.*
MFS-29628

Mathematics and Information Sciences

Video Image Communication and Retrieval — Updated

The newest version of this program is designed for the user's convenience.

The Video Image Communication and Retrieval (VICAR) package of computer programs is a general-purpose image-processing software system that has been under continuous development since the late 1960's. Originally intended for processing data from the Jet Propulsion Laboratory's unmanned planetary spacecraft, VICAR is now used in a variety of other applications, including the processing of biomedical images, cartography, studies of Earth resources, and geological exploration. The development of the newest version of VICAR emphasized a standardized, easily-understood user interface, a shield between the user and the host operating system, and a comprehensive array of image-processing capabilities.

Structurally, VICAR can be divided into roughly two parts: a (1) suite of application programs and (2) an executive program that serves as the interface among the application programs, the operating system, and the user. There are several hundred application programs ranging in function from interactive editing of images, compression and decompression of data, and map projection, to the removal of blemishes, noise, and artifacts, the generation of mosaics, and the recognition and location of patterns. An information-management system designed specifically for handling image-related data can merge image data with other types of data files.

The user gains access to these programs through the VICAR executive program, which consists of a supervisor program and a run-time-library program. From the perspective of the user and the application programs, the executive program creates a software environment that is independent of the operating system. VICAR does not replace the operating system of the host computer; instead, it overlays the host resources. The core of the executive program is the VICAR Supervisor, which is based on NASA Goddard Space Flight Center's Transportable Applications Executive (TAE). Various modifications and extensions have been made to optimize TAE for image-processing applications, resulting in a user-friendly software environment. The rest of the executive program consists of the VICAR Run-Time Library, which provides a set of subroutines for input and output of images, labels, parameters, and the like to facilitate the processing of images and provide the fastest input/output possible while maintaining a wide variety of capabilities.

The run-time library program also includes the Virtual Raster Display Interface (VRDI), which enables the writing of display-oriented application programs for a variety of display devices by use of a set of common routines. (A display device can be any frame-buffer-type device that is attached to the host computer and has memory planes for the display and manipulation of images. A display device may have any number of separate 8-bit image memory planes, a graphics-overlay plane, pseudocolor capabilities, hardware zoom and pan, and other features.) The VRDI supports the following display devices: VICOM (Gould/Deanza) IP8500, RAMTEK RM-9465, ADAGE (Ikonas) IK3000, and the International Imaging Systems IVAS. The purpose of VRDI is to provide a uniform operating software environment not only for an application programmer but for the user as well. The programmer is able to write programs without being concerned with the specifics of the device for which the application is intended.

The VICAR Interactive Display Subsystem (VIDS) is a collection of utility programs for easy interactive display and manipulation of images on a display device. VIDS has characteristics of both the executive program and an application program and offers a wide menu of image-manipulation options. VIDS uses the VRDI to communicate with display devices. The first step in using VIDS to analyze and enhance an image (one simple example of the numerous capabilities of VICAR) is to examine the histogram of the image. The histogram is a plot of frequency of occurrence for each pixel value from (0 to 255) loaded in the image plane. If, for example, the histogram shows that there are no pixel values below 64 or above 192, the histogram can be "stretched" so that the value of 64 is mapped to 0 and 192 is mapped to 255. Now the user can use the full dynamic range of the display device to display the data and see their contents better. Another example of a VIDS procedure is the JMOVIE command, which enables the user to run animations interactively on the display device. JMOVIE uses the concept of "frames", which are the individual frames that constitute the animation to be viewed. The user loads images into the frames after the size and number of frames have been selected.

The source languages of VICAR are primarily FORTRAN and C, with some VAX Assembler and array-processor code. The VICAR run-time library is designed to work equally easily from either FORTRAN or C. The program was implemented on a DEC VAX-series computer operating under VMS 4.7. The virtual-memory required is 1.5 MB. (Approximately 180,000 blocks of storage are needed for the save-set.) VICAR (version 2.3A/3G/13H) is copyrighted and available by license for a period of 10 years to approved licensees. This program was developed in 1989.

This program was written by Ray J. Wall, Paul L. Jepsen, Kurt K. Andersen, Paul D. Bartholomew, Robert G. Deen, Michael A. Girard, Thomas C. Greer, David R. Hodges, Merit Jentoft-Nilsen, Scott A. Lewicki, Jean J. Lorre, Chris C. Meisl, Florance F. Moss, Megan A. O'Shaughnessy, Steven Pohorsky, Sheila M. Tews, Allan J. Runkle, Cesar A. Vasquez, Neil Vuong, Gary M. Yagi, and Payam Zamani for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 163 on the TSP Request Card. NPO-18076*

Program for Parallel Discrete-Event Simulation

The user does not have to add any special logic to aid in synchronization.

The Time Warp Operating System (TWOS) computer program is a special-purpose operating system designed to support parallel discrete-event simulation. TWOS is a complete implementation of the Time Warp mechanism, a distributed protocol for virtual-time synchronization based on process rollback and message annihilation. TWOS supports only simulations and other computations designed for virtual time; it does not support general time-sharing or multiprocess jobs that use conventional message synchronization and communication. The program utilizes the resources of the underlying operating system.

TWOS runs a single simulation at a time, executing it concurrently on as many processors of a distributed system as are allocated. The simulation must be decomposed into objects (logical processes) that interact through time-stamped messages. TWOS provides transparent synchronization. The user does not have to add any special logic to aid in synchronization, or give any synchronization advice, or even understand much about how the Time Warp mechanism works.

The Time Warp Simulator (TWSIM) subdirectory contains a sequential simulation engine that is interface-compatible with TWOS. This means that an application designer and programmer who wishes to use TWOS can construct prototype code on TWSIM on a single processor and/or workstation before having to deal with the complexity of working on a distributed system. TWSIM also provides statistics about the application program, which statistics may be helpful for determining the correctness of an application program and for achieving good performance on TWOS.

The user's manual for TWOS assists the simulation programmer in the design, coding, implementation, and debugging of discrete-event simulations running on TWOS. The manual also includes a practical user's guide to the TWOS application benchmark, Colliding Pucks.

TWOS and TWSIM were written in, and support simulations in, the C programming language. They were implemented on Sun 3 and Sun 4 workstations running the SunOS version 3.5 or greater operating system, and on the BBN Butterfly Plus. The binary images of TWOS and TWSIM each require approximately 400 kbytes. A central memory of at least 4 Mbytes per workstation (or Butterfly processor) is needed for reasonable performance. TWOS 2.0 was developed in 1989.

This program was written by Brian C. Beckman, Leo R. Blume, John S. Geiselman, Matthew T. Presley, John J. Wedel, Jr., Steven F. Bellenot, Michael Diloreto, Philip J. Hontalas, Peter L. Reiher, and Frederick P. Weiland of **NASA's Jet Propulsion Laboratory**. *For further information, Circle 105 on the TSP Request Card.*
NPO-18037

Computing Availability and Reliability for a System

Elements that contribute most to the failure of the system are identified quickly.

The Reliability/Availability Analysis (RELAV) computer program is a comprehensive analytical software tool to determine the reliability or availability of any general system that can be modeled as embedded k-out-of-n groups of items (components) and/or subgroups. Both ground and flight systems at NASA's Jet Propulsion Laboratory have used this program. RELAV can be used to assess the performance of a system during the late testing phases of the design of the system, to model candidate designs and/or architectures, or to validate and form predictions during the early phases of a design.

Systems are commonly modeled as system block diagrams (SBD's). RELAV calculates the probability of success of each group of items and/or subgroups within the system, assuming that k-out-of-n operating rules apply for each group. The program operates on a folding basis; i.e., it works its way toward the system level from the most embedded level by folding related groups into single components. The entire folding process involves probabilities: therefore, problems of availability are solved in terms of probabilities of success, and problems of reliability are solved for missions of specific length. An enhanced cumulative binomial algorithm is used for groups in which all probabilities are equal, while a fast algorithm based upon "Computing k-out-of-n System Reliability," Barlow & Heldtmann, *IEEE Transactions on Reliability*, October 1984, is used for groups with unequal probabilities.

Inputs to the program include a description of the system and any one of the following: (1) availabilities of the items, (2) mean times between failures and mean times to repairs for the items from which availabilities are calculated, (3) mean times between failures and lengths of missions from which reliabilities are calculated, or (4) rates of failure and lengths of missions from which reliabilities are calculated. The results are probabilities of success of each group and the system in the given configuration.

RELAV assumes exponential failure distributions for calculations of reliability and unlimited repair resources for calculations of availability. No more than 967 items or groups can be modeled by RELAV. If larger problems can be broken into subsystems of 967 items or less, the results for the subsystems can be used as item inputs to a system problem. The calculated availabilities are steady-state values. Group results are presented in the order in which they were calculated (from the most embedded level out to the system level). This provides a good mechanism to perform trade studies. Starting from the result for the system and working backward, the granularity gets finer; therefore, elements that contribute most to the degradation of the system are detected quickly.

RELAV is a C-language program originally developed under the UNIX operating system on a MASSCOMP MC500 computer. It has been modified, as necessary, and ported to an IBM-PC-compatible computer with a math coprocessor. The current version of the program runs in the DOS software environment and was compiled with Turbo C vers. 2.0. RELAV has a memory requirement of 103 KB and was developed in 1989. RELAV is a copyrighted program.

This program was written by Paul N. Bowerman and Kevin P. Clark of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 104 on the TSP Request Card.*
NPO-18051

Mechanics

Hardware, Techniques, and Processes

71 Pneumatic Spoiler Controls Airfoil Lift
71 Redundant Toggle/Hook Release Mechanism
72 Flexure Bearing Reduces Startup Friction
74 Servo Reduces Friction in Flexure Bearing
74 Pressure-Actuated Flow-Control Valve
75 Fully-Stressed-Design Algorithm for Plate/Shell Structures
77 Contact Probe With Pivoting Tip
78 Improved Ultrasonic Transducer for Measuring Cryogenic Flow

Books and Reports

79 Three-Dimensional Structure of a Mixing Layer
80 Experiments To Verify Computed Flows
81 Temperature, Thermal Stress, and Creep in a Structure

Computer Programs

65 Software Models Impact Stresses

Pneumatic Spoiler Controls Airfoil Lift

Forward air ejection reduces lift locally to aid in balancing or maneuvering.

Ames Research Center, Moffett Field, California

Air ejection from the leading edge of an airfoil can be used for controlled decrease of lift. This pneumatic-spoiler principle was developed for equalizing the lift on helicopter rotor blades. It can also be used to enhance aerodynamic control of short-fuselage or rudderless aircraft such as "flying-wing" airplanes; for example, it can be adapted as pneumatic differential spoilers that create a turning moment while minimizing adverse yaw effects.

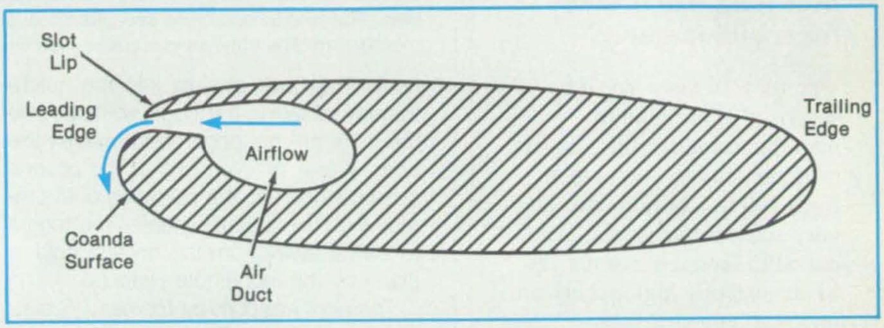


Figure 1. In the **Pneumatic Spoiler**, the ejection of air through a slot on the leading edge of an airfoil and over a Coanda surface (to which the ejected airstream tends to adhere) reduces the lift.

In the helicopter application, an air duct, Coanda surface, and slot would supply a stream of air at the leading edge of a rotor (see Figure 1). The pneumatic spoiler would be used in conjunction with existing circulation control in which air is blown from the trailing edge to augment blade lift; thus, little additional hardware would be needed since the plenum and control valves would be already in place.

The lift on the advancing half of a symmetrical blade is so much greater than the lift on the retreating half that even with trailing-edge augmentation on the retreating half, the helicopter tends to be out of trim. However, by blowing air out of the leading edge while it is advancing and temporarily stopping the flow of air from the trailing edge, the lift on the advancing half is decreased so that it more closely matches that of the retreating half (see Figure 2). The blade is thereby balanced, and helicopter performance is improved.

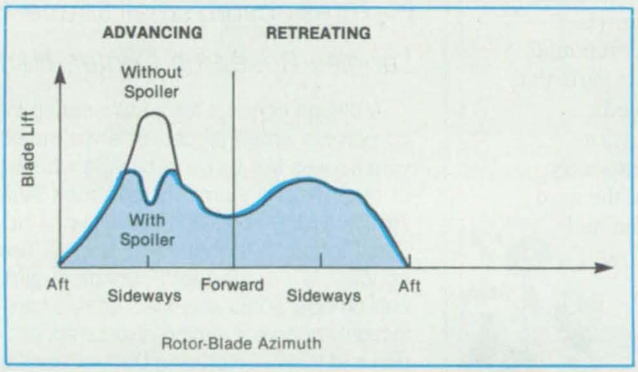


Figure 2. **Helicopter Rotor-Blade Lift** is shown as a function of blade azimuth, both with and without the pneumatic spoiler described in the text. The lift on the advancing and retreating sides is more nearly equal with the spoiler.

Leading-edge injection can also increase the maneuverability of such high-performance fixed-wing aircraft as fighters. For example, it can quickly eliminate the lift on one wing so that the plane can snaproll or on both wings so that the plane can drop almost instantly.

This work was done by D. Hunter and T. Krauss of United Technologies for **Ames Research Center**. *No further documentation is available. ARC-11519*

Redundant Toggle/Hook Release Mechanism

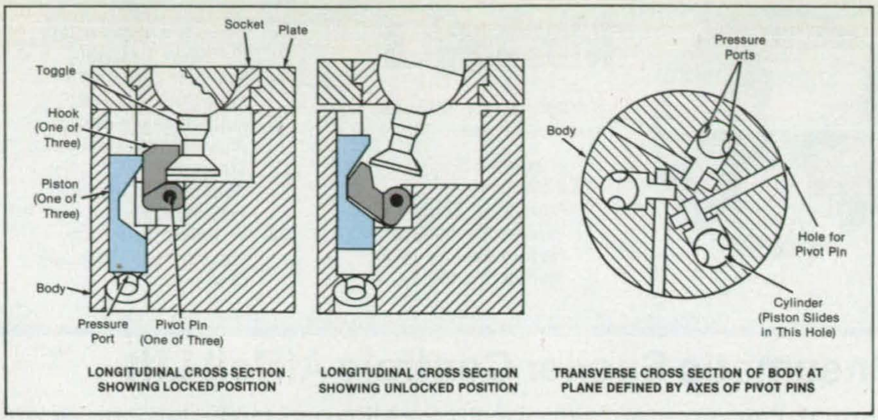
Advantages include shock-free separation and reliability.

Lyndon B. Johnson Space Center, Houston, Texas

A release mechanism ensures reliable separation of structural members while imparting minimal impulse to the members. The mechanism functions even when two of its three key elements have failed. The mechanism does not rely on pyrotechnics, which tend to shock or otherwise disturb the structure. Nor does it rely on the tricky concept of frangibility of a major load-bearing part, according to which the part must be strong enough to hold the members together until the time for separation, when it must be weak and brittle enough to fracture.

The mechanism includes a set of three hooks and pistons that hold a toggle and thereby clamp a plate (which is part of one of the two structural members to be separated from each other) to the body of the mechanism (which is part of the other structural member). In the locked position, each hook is prevented from rotating on its pivot pin (see figure).

To operate the release mechanism, gas is introduced via a pressure port under each piston. The pressure of the gas forces the pistons against pins that hold them in place, thereby shearing the pins. The pressure then drives the pistons upward, moving a notch into place at each



In the **Locked Position**, the pistons are down, and the hooks are held against the toggle. In the unlocked position, the pistons are up. The notches in the pistons let the hook swivel on the pivot pins. The longitudinal cross sections show only one of the three piston-and-hook sets in the mechanism. The transverse cross section shows the arrangement of the three pistons.

hook. The hook swivels into the notch, thereby releasing the toggle so that it and the plate are no longer held against the body. If one, or even two, of the pistons does not operate, the operation of the remaining piston(s) still enables the toggle to swivel away from the hook(s) held in place by the inoperable piston(s).

This work was done by Thomas J. Graves of **Johnson Space Center** *and Christopher W. Brown of Boeing Aerospace Operations. For further information, Circle 21 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 26]. Refer to MSC-21671.

Flexure Bearing Reduces Startup Friction

Flexures absorb small torque "bumps."

Langley Research Center, Hampton, Virginia

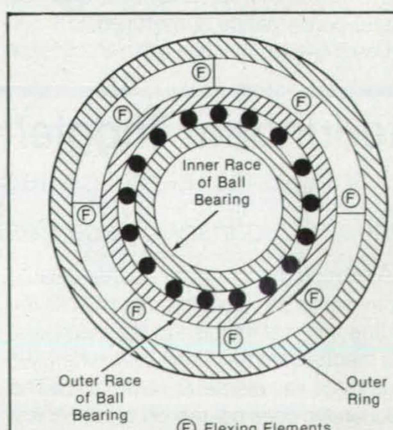
A design concept for a ball bearing incorporates small pieces of shim stock, wire spokes like those in bicycle wheels, or other flexing elements to reduce both stiction and friction slope (derivative of frictional torque with respect to angle). The concept is intended for bearings in gimbals on laser and/or antenna mirrors, wherein highly accurate aiming is required; stiction and friction (including Dahl friction) at startup and turnaround degrade accuracy. Previously, to overcome friction, designers used servos as described in the following article.

In the flexure bearing, the flexing elements would be placed between the outer race of a ball bearing and an outer ring. These elements would flex when the ball bearings encountered small frictional-torque "bumps" or even larger ones when bearings balls encounter buildups of grease on the inner or outer race. The flexure of these elements would reduce the high friction slopes of these "bumps," helping to keep the torque between the outer ring and the inner race low and more nearly constant.

In a simulation of a high-performance gimbaled platform, a friction slope of 2,000 lb•ft (2,712 N•m) per radian caused unsatisfactorily large aiming errors. When the friction slope was reduced to 500 lb•ft (678 N•m) per radian, the aiming performance was satisfactory because the control loop was fast enough to correct for the buildup of friction. The design of a flexure bearing to limit the friction slope to 500 lb•ft/rad has not been completed.

In some designs, the flexing elements could be placed between an inner ring and the inner race. In addition, the basic flexure principle could be applied to linear-motion bearings.

This work was done by W. Dean Clingman of Boeing Aerospace and Electronics for **Langley Research Center**. *No further documentation is available. LAR-14348*



Flexing Elements (e.g., shims or spokes) would help smooth out frictional-torque "bumps" in a ball bearing.

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- Critical vacuum
- Choice of end connections from 1/16" to 1"
- Connects to various weld, SWAGELOK Tube Fitting, NPT and straight thread components
- Variety of configurations
- Sold as individual components to minimize inventories
- 316L & 316 stainless steel
- Helium leak tested to 4.0×10^{-9} atm. cc/sec.
- Pressures — vacuum to 11,000 psi
- Temperatures to 1000°F (537°C)

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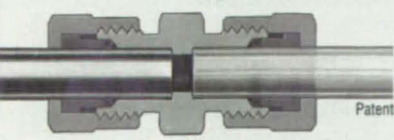
O-Ring face seal

Patented

- Zero-clearance for disassembly
- Variety of configurations
- Connects to various weld, SWAGELOK Tube Fitting, NPT and straight thread connections
- Sold as individual components to minimize inventories
- Brass & 316 stainless steel
- 1/8" to 2"
- Helium leak tested to 4.0×10^{-9} atm. cc/sec.
- Pressures — vacuum to 10,000 psi
- Temperatures to 450°F (232°C)
- Fast make-up

Ultra-Torr® Fitting

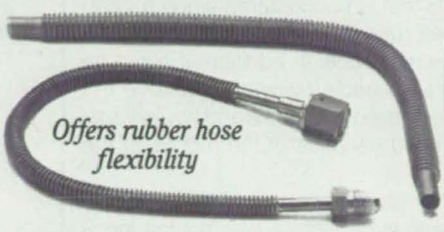
Provides vacuum-tight seal on glass, metal or plastic



Patented

- Quick finger-tight assembly, reuseable
- Helium leak tested to 4.0×10^{-9} atm. cc/sec.
- 1/16" to 1-1/2"
- Use with undersize tubing
- Variety of configurations
- Brass & 316 stainless steel
- Temperatures to 450°F (232°C)

Flexible Tubing



- 321 stainless steel construction
- Compressible by 20%, extendable by 50%
- Absorbs vibration, relieves thermal expansion, compensates for misalignment
- 1/4" to 1-1/2" tube O.D.
- Nominal lengths 1" to 36"

Flexible Glass End Tubing

Isolates vibration in glass systems

- Relief for thermal expansion
- Compressible by 20%, extendable by 50%
- 1/4" to 1"
- Nominal lengths 2" & 3"
- 321SS fused to 7740 Pyrex glass
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Circle Reader Action No. 380

Servo Reduces Friction in Flexure Bearing

Resistive torques would be reduced.

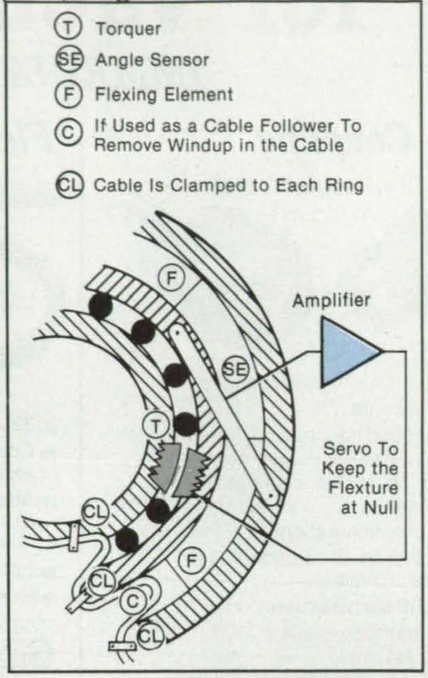
Langley Research Center, Hampton, Virginia

A proposed servocontrol device would reduce such resistive torques as stiction, friction, ripple, and cogging in a flexure bearing described in the preceding article. It would also reduce the frictional "bump" torque that is encountered when a bearing ball runs into a buildup of grease on the bearing race. In addition, it could be used as a cable follower to reduce the torque caused by a cable and hoses when they bend because of the motion of the bearing.

In the past, to overcome friction, designers used larger servos with control loops characterized by band-pass frequencies higher than warranted. They also had to use very expensive low-friction bearings that contained special grease.

The new device (see figure) would include a torquer across the ball race. The torquer would be controlled by a servo that would strive to keep the flexure at null, thus removing the torque to the outer ring. In effect, the device would be an inner control loop that would reduce friction, but it would not control platforms or any outer-control-loop functions.

This work was done by W. Dean Clingman of Boeing Aerospace & Electronics for **Langley Research Center**. *No further documentation is available.* LAR-14349



Flexure Bearing Used as a Cable Follower would be equipped with the servocontrol device to reduce friction.

Pressure-Actuated Flow-Control Valve

Orifice area varies according to supply pressure.

Marshall Space Flight Center, Alabama

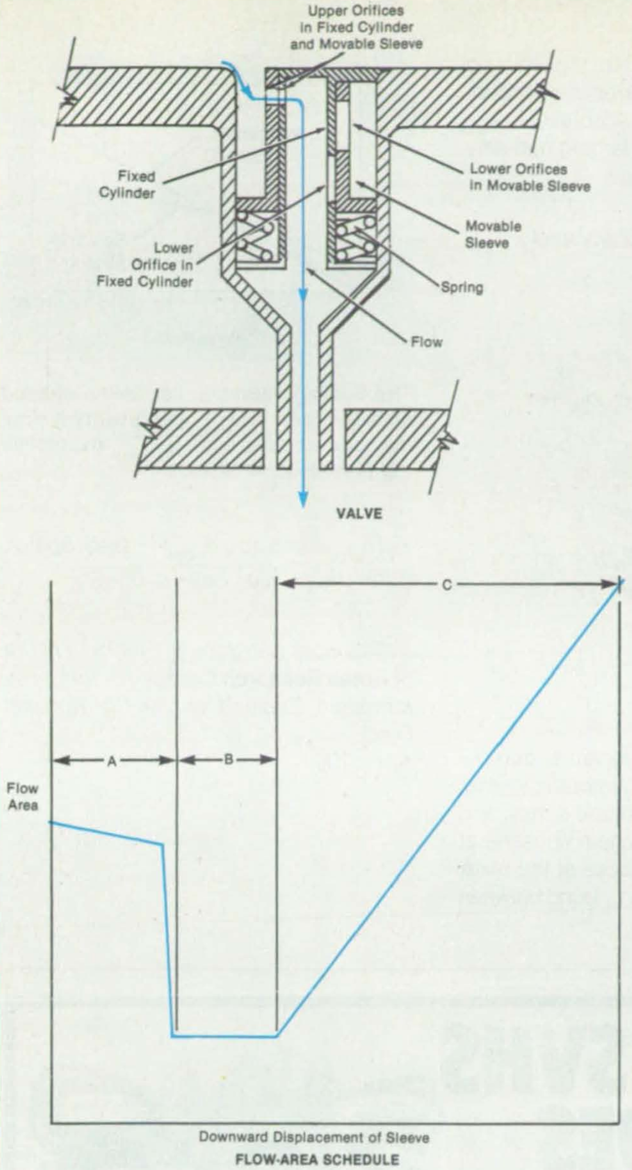
A flow-control valve varies its cross-sectional area with the drop in pressure. The valve was conceived for controlling the flow of oxidizing fluid in a rocket engine, and presumably the valve concept is applicable to other situations in which it is necessary to vary flows over wide ranges. In the rocket-engine application, the fluid can be liquid or gaseous, depending on the chosen operating conditions.

The valve is part of a coaxial oxidizer-injecting nozzle located coaxially within an annular fuel-injecting passage. Many such elements are spaced around the periphery of the combustion chamber of the engine. The valve includes a spring-loaded sleeve that slides on a fixed cylinder (see figure). Both the sleeve and the cylinder have upper and lower orifices. Increased pressure in the fluid forces the sleeve downward, thereby exposing a varying orifice area for the oxidizer to flow through. As the sleeve moves downward, the open area of the upper pair of orifices decreases, and the open area of the lower pair increases. The dimensions of the orifices can be chosen to produce the desired schedule of flow area vs. position of the sleeve.

In a typical sequence of operating conditions, the pressure in the fluid is low, and the fluid is a gas, which flows through the valve in region A of the flow schedule in the figure. As the pressure is increased, fluid is compressed into a liquid. The dimensions of the orifices are chosen so that the orifice area exposed at the higher pressure is smaller to accommodate the higher density of the flow (region B). As pressure is increased further, the sleeve exposes a progressively larger orifice area to accommodate the increasing flow of liquid (region C).

This work was done by George B. Cox, Jr., of United Technologies Corp. for **Marshall Space Flight Center**. *For further information, Circle 62 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-28513.



The **Sliding Sleeve in the Valve** exposes a varying orifice area to produce the flow-area schedule shown below.

Fully-Stressed-Design Algorithm for Plate/Shell Structures

A modification of the basic stress-ratio algorithm enhances convergence.

Ames Research Center, Moffett Field, California

The stress-ratio algorithm associated with the fully stressed design of a plate or shell structure has been modified to increase the rate of convergence of its iterations toward a solution. The iterations of the basic, unmodified version of the algorithm tend to oscillate, converging slowly to solutions of plate-thickness-design problems that involve transverse bending loads. The modified algorithm speeds convergence in the presence of any combination of membrane and bending loads.

In the fully-stressed-design technique, one attempts to minimize the weight of a structure by letting plate, shell, bar, or other

members be so thin that at some point in the structure, the computed stress reaches the prescribed allowable stress under at least one loading condition. In conjunction with a reliable stress-analysis algorithm, the stress-ratio algorithm is used to compute such a fully stressed state to obtain an efficient distribution of materials in the structure.

In the unmodified stress-ratio algorithm, each iteration requires a new value of the sizing parameter of a component to be designed (e.g., the thickness of a plate or the cross-sectional area of a bar). In the case of a plate, this parameter is computed from $s = s_0\,(\sigma_{max}/\sigma_{allow})$ for pure membrane stress (no bending moments) or $s = s_0\,(\sigma_{max}/\sigma_{allow})^{1/2}$ for pure transverse bending stress, where s = the next value of the sizing parameter, σ_0 = the present value of the sizing parameter, σ_{allow} = the prescribed maximum allowable stress, and σ_{max} = the computed maximum stress in the component at its present size. Neither of the above equations results in satisfactory convergence when both membrane and transverse bending stresses are present, because in that case, what is needed is a scaling factor between $(\sigma_{max}/\sigma_{allow})$ and $(\sigma_{max}/\sigma_{allow})^{1/2}$.

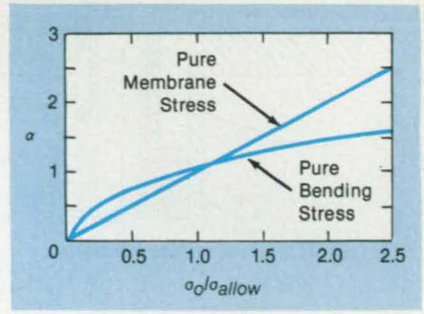
In the modified algorithm, the effects of both kinds of stress are taken into account. The thickness, t, scaled according to $t_{new} = \alpha t_{old}$, where α is the largest real solution of

$$A\sigma^4 - B\sigma^2 \pm C\sigma - D = 0$$

and the following definitions apply:

$$A = \sigma^2_{allow}$$
$$B = \sigma^2_{Sx} + \sigma^2_{Sy} - \sigma_{Sx}\sigma_{Sy} + 3\tau^2_{Axy}$$
$$C = 2\sigma_{Sx}\sigma_{Dx} + 2\sigma_{Sy}\sigma_{Dy} - \sigma_{Sy}\sigma_{Dy} + 6\tau_{Sxy}\tau_{Dxy}$$
$$D = \sigma^2_{Dx} + \sigma^2_{Dy} - \sigma_{Dx}\sigma_{Dy} + 3\tau^2_{Dxy}$$
$$\sigma_{Sx} = (\sigma^T_x + \sigma^B_x)/2$$
$$\sigma_{Dx} = (\sigma^T_x - \sigma^B_x)/2$$
$$\sigma_{Sy} = (\sigma^T_y + \sigma^B_y)/2$$
$$\sigma_{Dy} = (\sigma^T_y - \sigma^B_y)/2$$
$$\tau_{Sy} = (\tau^T_y + \tau^B_y)/2$$
$$\tau_{Dy} = (\tau^T_y - \tau^B_y)/2$$

σ_x and σ_y denote perpendicular components of compressive membrane stress; τ_{xy} denotes shear membrane stress; and superscripts T and B denote stresses at the top and bottom surfaces of the plate, respectively. In general, α is found between $(\sigma_0/\sigma_{allow})$ and $(\sigma_0/\sigma_{allow})^{1/2}$ (see figure), where $\sigma_0 = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}^2}$.



The **Scaling Factor**, α, lies in the shaded area between σ_0/σ_{allow} (representing pure membrane stress) and $\sqrt{\sigma_0/\sigma_{allow}}$ (representing pure bending stress).

This work was done by Hirokazu Miura of **Ames Research Center**. *For further information, Circle 11 on the TSP Request Card.*
ARC-12687

Contact Probe With Pivoting Tip

The tip remains perpendicular as a curved surface is scanned.

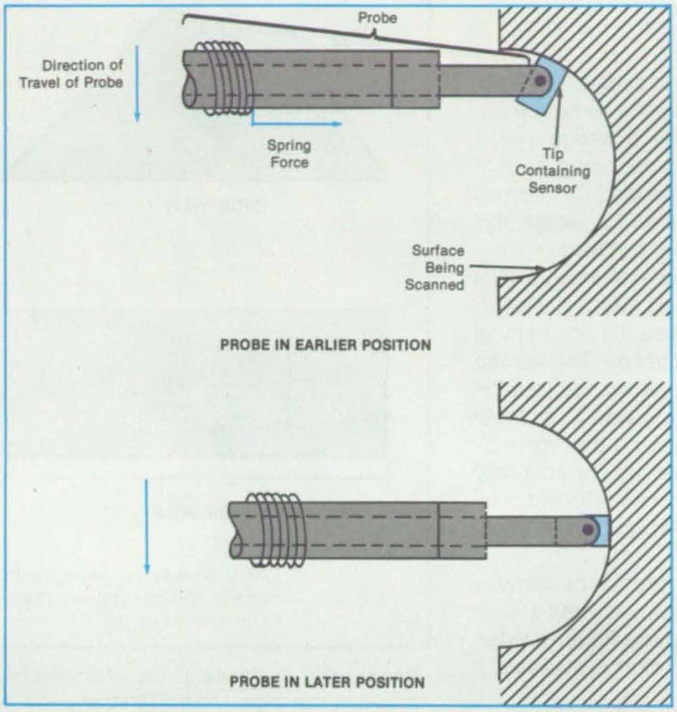
Marshall Space Flight Center, Alabama

A sensor probe follows curved contours, always keeping the sensor in contact with, and perpendicular to, the contoured surface. It is not necessary to change the sensor or manipulate the probe to match the orientation of the surface.

The probe includes a freely pivoting tip, which contains the sensor (see figure). A spring holds the tip in contact with the surface being scanned. As the user moves the probe along the surface, the force of contact keeps the tip oriented along the local perpendicular to the surface. Slopes of up to 90° from the axis of the probe can be accommodated.

This work was done by Jay M. Amos and David A. Raulerson of United Technologies Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-28536.



The **Pivoting Tip** keeps the sensor embedded in it oriented properly with respect to the surface being scanned.

Improved Ultrasonic Transducer for Measuring Cryogenic Flow

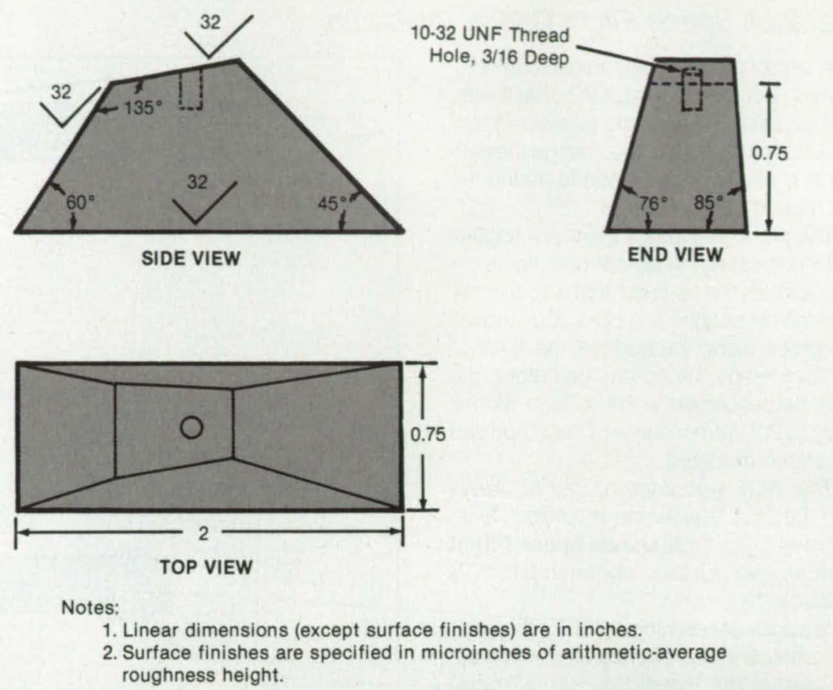
Slanted surfaces reduce ringing.

Marshall Space Flight Center, Alabama

An improved ultrasonic transducer is used to measure the flow of a cryogenic fluid. Like a previous ultrasonic-flowmeter transducer designed for the same application, this one includes a wedge that is made nonintrusive by machining it out of the bulk material of the duct that carries the fluid. Unlike the previous wedge, this wedge has no parallel surfaces.

The parallel surfaces of the previous wedge supported ringing, which is undesirable because it reduces the accuracy of the measurement of the flow. The skewed surfaces of the improved wedge (see figure) suppress standing waves, thus reducing ringing and increasing the signal-to-noise ratio. This increases the accuracy of measurements of times of arrival of ultrasonic pulses, from which times the flow is inferred.

This work was done by Sarkis Barkhoudarian of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29687



Nonparallel Surfaces of the improved transducer wedge suppress standing waves to increase the signal-to-noise ratio.

Books and Reports

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

Three-Dimensional Structure of a Mixing Layer

Quantitative data show the evolution of streamwise (in addition to spanwise) vortexes.

A report describes an experimental study of the three-dimensional structure of a nominally planar two-stream mixing layer. The main purpose of the study was to obtain quantitative data on the evolution of streamwise vortexes. The results of this and related studies have practical implications because turbulent mixing layers are fundamental to combustion chambers, chemical-flow reactors, and airfoils.

The experiments were conducted in a newly designed mixing-layer wind tunnel, which consists of two separate legs driven independently by centrifugal blowers connected to variable-speed motors. The two streams merge at the sharp edge of a splitter plate that has a taper of about 1°. The test section is 36 cm wide across the edge, 91 cm in the spanwise direction (along the edge), and 366 cm long.

The leg driven by the bigger blower was operated at a free-stream velocity in the test section of 15 m/s while the other leg was run at 9 m/s. The free-stream velocities were held constant to within 1 percent during a typical run lasting 2 hours. Under these operating conditions, the measured streamwise turbulence level was about 0.15 percent, and the transverse levels were about 0.05 percent. The mean core flow was found to be uniform to within 0.5 percent, and crossflow angles were less than 0.25°. The boundary layers on the splitter plate were laminar.

Measurements were made with a cross-wire probe held on a three-dimensional traverse and linked to a fully automated data-acquisition-and-reduction system controlled by a computer. The cross-wire probe had 5-μm tungsten sensing elements about 1 mm long and positioned about 1 mm apart. The probe was calibrated statically in the potential core of the flow, assuming a "cosine-law" response to yaw, with the effective angle determined by calibration. The probe output signals were low-pass-filtered at 30 kHz, dc offset, amplified, and digitized to 12 bits at 400 samples per second.

Data were obtained in two planes by rotating the cross-wire probe about its own axis. This method yielded all three components of mean velocity, five independent components of the Reynolds stress tensor, and selected products of higher order. Measurements were made at nine streamwise stations. Typically, measurements were taken at 1,200 points on a rectangular cross-plane grid at each streamwise station.

Analysis of the measurements indicates that the streamwise vortexes form from small spanwise variations in the boundary layer on the high-speed side of the splitter plate. These variations are amplified by the developing mixing layer, and concentrated streamwise vortexes are observed by the location of the first spanwise vortex roll-up. The streamwise vortexes first appear in clusters, containing vorticity of both signs, but reorganize into a single row of alternating-sign vortexes further downstream. The spacing between vortexes increases in a stepwise fashion, with the location of the steps corresponding to the estimated locations of spanwise vortex-pairing events. As the vortexes travel downstream, they weaken; peak mean vorticity decreases as approximately $1/X^{1.5}$, where X is the distance downstream. The presence of streamwise vortexes in the mixing layer is associated with peaks in the secondary Reynolds shear stress, $\overline{u'w'}$. Levels of mean streamwise vorticity and secondary shear stress are well correlated in both position and strength. There is some indirect evidence that the streamwise structures persist through to the self-similar region, although by this point they are very weak and the mixing layer appears to be nominally two-dimensional.

This work was done by James H. Bell and Rabindra D. Mehta of Stanford University for **Ames Research Center**. *Further information may be found in AIAA paper 89A-25109, "Three-Dimensional Structure of a Plane Mixing Layer."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500.
ARC-12506

Experiments To Verify Computed Flows

Computations and experiments should be planned in coordination.

A technical memorandum discusses the role of experiments in the development of computational fluid dynamics (CFD) for the prediction of aerodynamic flows. Because the flow fields susceptible to numerical simulation are becoming more complicated and CFD shows increasing potential for use in design, there is a need to verify the details of simulations with flow-field and boundary-condition measurement data in addition to the traditional model-surface and integral measurement data. Nonintrusive measurement techniques will have to be improved and developed to obtain greater accuracy, especially in hypersonic and chemically reacting flows. Furthermore, there will have to be more redundancy in measurements and experiments to enhance accuracy and credibility. Thus, the progress of CFD is becoming increasingly dependent on the coordinated planning of computations and experiments.

The memorandum discusses the types of experiments needed, citing the concepts of validation and calibration. As used here, "validation" denotes detailed comparisons of computed and predicted surface-measurement and flow-field data to verify the accuracy of the prediction of the critical physics of a flow, while "calibration" denotes the comparison of some of the CFD predictions with experimental data for realistic flows similar to those of interest in design, to verify the accuracy of prediction of parameters important to design objectives. Experiments are categorized broadly as flow-physics, physical-modeling, calibration, or verification experiments.

The requirements upon measurements are discussed from the perspectives of completeness and accuracy. Completeness involves such concepts as the various types of data needed, the range of operating conditions in which measurements should be performed, and adequate data from all critical points in a flow. Accuracy involves not only the calibrations and perturbations of measuring instruments but also accounting for errors introduced by computational procedures.

The requirements upon wind tunnels are discussed. These include versatility, well-defined test and boundary conditions, appropriate ranges of scale and speed, accessibility to nonintrusive instrumentation, provisions for fast data-processing systems, and dedication to use for verification experiments.

Prospects for future advantages in CFD are discussed, using examples of "benchmark" experiments coordinated with computations as parts of a continuing program at Ames Research Center. These are the turn-around-duct, transonic wing and wing/body, three-dimensional supersonic shock interaction, and hypersonic all-body experiments.

This work was done by Joseph G. Marvin of **Ames Research Center**. *Further information may be found in NASA TM-100087 [N88-20423], "Accuracy Requirements and Benchmark Experiments for CFD Validation."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12231

Temperature, Thermal Stress, and Creep in a Structure

A better creep law may be needed.

A report presents a comparison of predicted and measured temperatures, thermal stresses, and residual creep stresses in a heated and loaded titanium structure. This study is part of a continuing effort to develop the design capability to predict and reduce the deleterious effects of creep, which include excessive deformations, residual stresses, and failure.

The structure was a skin reinforced by spars of approximately-Z-shaped cross section. The structure — treated, in effect, as a horizontal beam — was supported at its ends, loaded vertically at two positions, and heated radiantly along a portion of its length between the loading points. The spars and skin were instrumented with thermocouples and strain gauges.

A two-dimensional finite-element mathematical model that includes conductive, radiative, and convective transfers of heat was found to predict the measured transient temperatures quite well. The thermal calculation was not a pure prediction, however. The emissivity and the convective film coefficient were adjusted to fit empirical data.

Several finite-element mathematical models were used to examine the relationship between the computed and measured thermal stresses. As part of this effort, the suitabilities and densities of the finite elements in the various models and the differences between the temperatures predicted by the various models were studied to determine the effects of the choice of model on the calculated thermal stresses. Both bar and plate elements were found suitable for the uniaxial-stress situation of this structure. The number of elements in the web area of the spar was found to be critical to accurate calculation of thermal stress.

The optimum number of elements was established from a balance between the density of elements and suitable safety margins, such that the numbers are acceptably safe yet computationally economical. Because the differences between the computed temperatures were generally quite small, the differences between thermal stresses computed with measured temperatures and with computed temperatures was also quite small. It was noted that in some situations, relatively small excursions of calculated temperatures from measured values result in far more than proportional increases in calculated thermal stresses.

The measured residual stresses due to creep were found to exceed significantly the values computed by the piecewise-linear inelastic-strain-analogy approach. The most important element in the computation was found to be the correct definition of the creep law. Available literature was found to reveal such a wide variety of viscoelastic properties that the creep law was considered the major contributor to the discrepancy. Advances in the computation of residual stresses due to creep will require significantly more characterization of the viscoelastic properties of materials than is currently available.

This work was done by Jerald M. Jenkins of **Ames Research Center**. *Further information may be found in NASA TM-86814 [N88-12125], "Comparison of Measured Temperatures, Thermal Stresses and Creep Residues With Predictions on a Built-Up Titanium Structure."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12213

Machinery

Hardware, Techniques, and Processes
82 Magnetic-Bearing Test Fixture
84 Selectable-Towline Spin-Chute System
87 Two-Phase Hero Turbine With Curved Nozzles

Books and Reports
89 Reusable Manned Lunar Vehicle
90 Computation of Flow in a Turbine Stage on a Refined Grid

Magnetic-Bearing Test Fixture

A microcomputer-controlled fixture measures bearing gaps, magnetic fluxes, and forces.

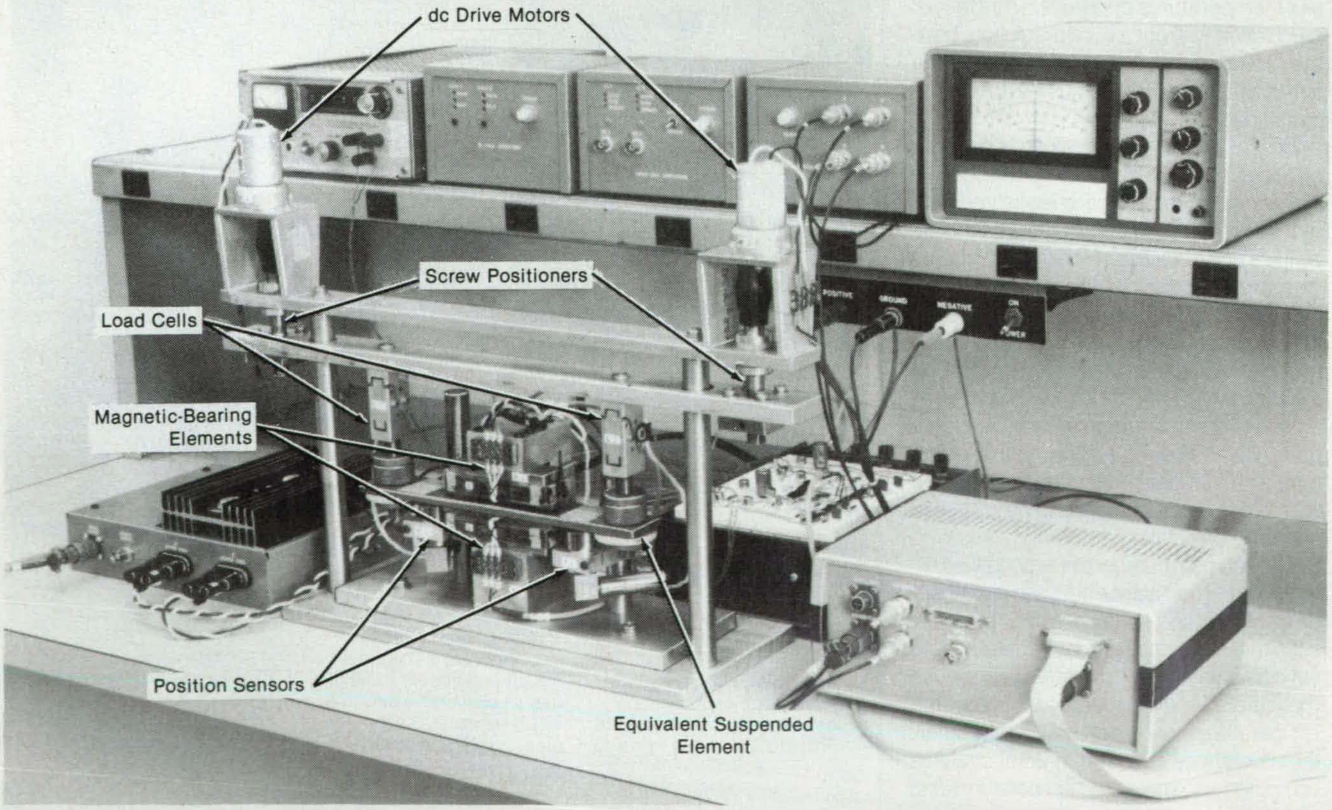
Langley Research Center, Hampton, Virginia

A microcomputer-controlled magnetic-bearing test fixture, which can be used to develop approaches to the design of controls for magnetic bearing actuators, has been designed and constructed. The fixture is configured for bearing elements similar to those used in a laboratory test model of an annular-momentum-control device (AMCD). The basic AMCD concept is that of a rotating annular rim suspended by a minimum of three magnetic-bearing suspension stations and driven by a noncontact electromagnetic spin motor.

The fixture (see figure) includes load cells mounted on a bar that is connected, through screw positioners, to geared dc drive motors. The equivalent suspended element can be set at any desired vertical position in the gap of the magnetic bearing by controlling these motors. The outputs of position sensors are used as feedback signals to control the drive motors. The position of the equivalent suspended element can be sensed by the position sensors at either end of the bar and can be independently controlled by the drive motors. The magnetic bearing elements contain no permanent-magnet material and include SAE 1010 soft steel as core material. To measure magnetic flux in the bearing gaps, a linear Hall-effect sensor was mounted on the pole face of each element. These sensors are covered by brass plates for protection.

The load cells are bending beams instrumented with strain gauges. The output of a bridge is a voltage proportional to the load applied to the beam. Each load cell has a load range of ±10 lb (±44.48 N) and a nominal scale factor of ±0.2 mV/lb-V (±0.45 mV/N-V). Because the scale factor and offset differ from cell to cell and vary with changes in test configuration, power-supply voltage, and temperature, software was developed to calibrate the system periodically. Calibration is accomplished by removing the load-cell/suspended-element assembly and applying a sequence of known loads. A first-order, least-squares curve fit is applied to the data to obtain voltage-vs.-force coefficients. The test fixture is designed to facilitate easy removal and replacement of the load-cell/suspended-element assembly.

The major components of the measurement and control system include a portable microcomputer subsystem, an analog interface, the motor-power driver, and the magnetic-bearing element power driver. The microcomputer includes a 6510 8-bit mi-



The **Magnetic-Bearing Test Fixture** includes load cells connected to a bar, which, in turn, is connected through screw positioners to geared drive motors. The position of the equivalent suspended element is sensed by the position sensors and controlled by the drive motors.

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croprocessor and is programmable in Basic and Assembly languages. All programs for this device were written in Basic, with some of the analog input/output subroutines compiled into machine language and called from the main Basic program. The analog interface subsystem provides eight multiplexed analog-to-digital input channels and one digital-to-analog output channel. These include sensor, load-cell, and Hall-effect-device inputs. The output channel supplies the command for the bearing-power drivers.

This fixture can provide control of the gap in the magnetic bearing and of the current in the electromagnet coil. Measurements that can be made include magnetic-bearing gaps, magnetic flux in the bearing gaps, and bearing forces. Although the test fixture is configured for bearing elements similar to those used in a laboratory test model AMCD, the approaches to linearization and control that can be developed by use of the fixture should be applicable to a wide range of small-gap suspension systems.

This work was done by Nelson J. Groom and William L. Poole of **Langley Research Center**. *Further information may be found in NASA TM-89081 [N87-20478], "Description of a Magnetic Bearing Test Fixture."*

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

LAR-14312

Selectable-Towline Spin-Chute System

One parachute can be deployed from multiple attachment points.

Langley Research Center, Hampton, Virginia

The selectable-towline spin-chute system was designed to enable the in-flight deployment of a single emergency spin-recovery parachute from more than one attachment point on an airplane. The selectable-towline spin-chute system eliminates multiple parachutes and multiple deployment systems, thereby reducing the weight and cost of the emergency system. It minimizes inertial and aerodynamic deviations on the airplane, contributing to overall simplification of the structure and aerodynamics.

Heretofore, when multiple parachute-attachment points have been required in flight tests of an aircraft, a complete parachute and deployment system has been used at each attachment point. In the example of the conventional wingtip-parachute system shown in Figure 1a, two complete systems are required: one for the right wing and one for the left wing. This type of system adds the weight and cost of double the number of parachutes, mortars, and related equipment required. This system also imparts the inertial disadvantage of masses unrepresentative of an airplane in normal operation located at the extremities of the airplane and an aerodynamic penalty in the form of unrepresentative structures in the vicinity of control surfaces.

The selectable-towline spin-chute system (see Figure 1b) features a parachute mounted on the middle of the airplane. From the confluence of the shroudlines of the parachute, a short riser is attached. This riser ends in a ring or other fitting. This ring is held in a fixture, and two (or more) lockable shackles are located at the ring such that either shackle can be secured to the ring by remote command (Figure 2).

Warning and advisory instrumentation can be installed at the shackle. From each shackle, a towline is routed to a desired separate attachment point on the airplane.

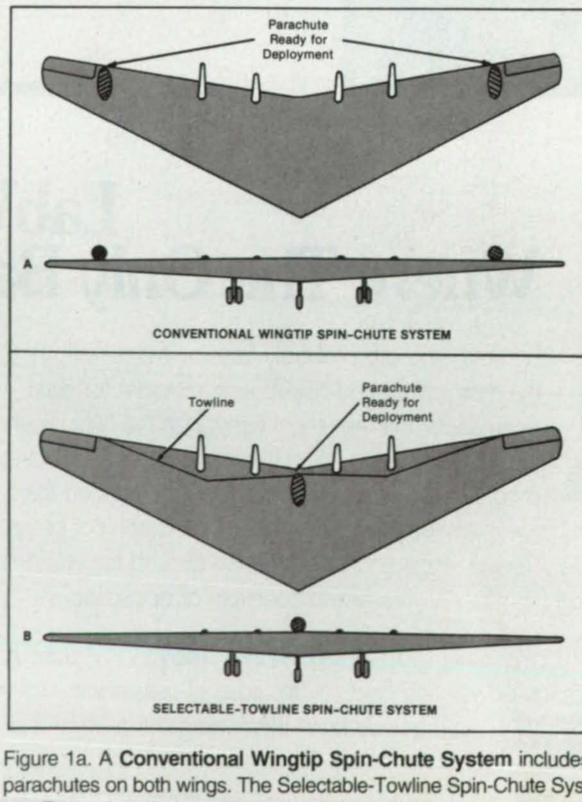

Figure 1a. A **Conventional Wingtip Spin-Chute System** includes parachutes on both wings. The Selectable-Towline Spin-Chute System, Figure 1b, includes one parachute with multiple attachment points.

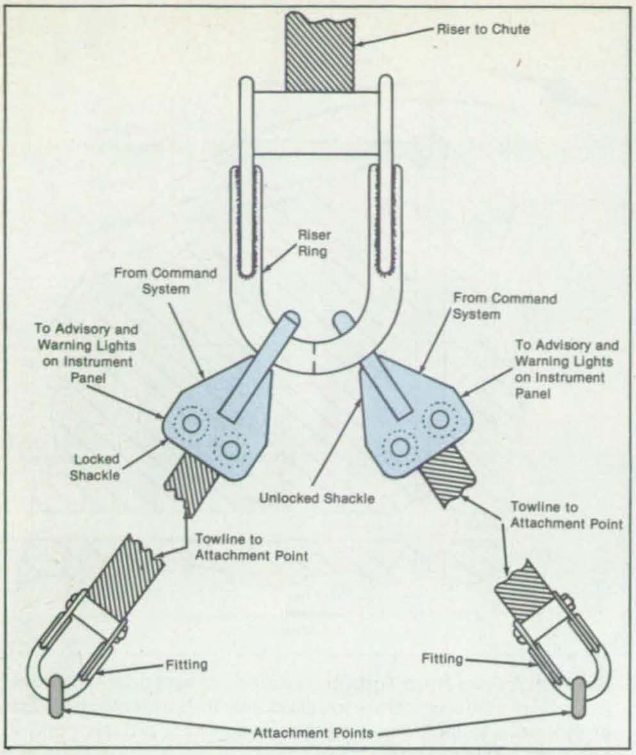

Figure 2. The **Detail of the Riser Assembly** shows the left riser mechanism locked to deploy the parachute from the corresponding attachment point.

Upon remote command, either manual or automatic, one shackle is locked to the riser ring. The parachute can then be deployed with recovery forces transmitted directly to the selected attachment point on the airplane. Other attachment points remain totally unaffected.

This work was done by Daniel M. Vairo of Planning Research Corp. and Raymond D. Whipple of **Langley Research Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 26]. Refer to LAR-14322.

Two-Phase Hero Turbine With Curved Nozzles

Curvatures would be designed to minimize separation of liquid from gas.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed two-phase Hero turbine would include curved de Laval nozzles for increased efficiency. Used in rocket engines, de Laval nozzles are converging/diverging nozzles that heretofore have had axisymmetric shapes. Hero turbines designed with the new curved de Laval nozzles could compete with rotary separator turbines, which are two-phase turbines that have been used in geothermal powerplants for several years. Other potential applications include heat pumps and thermal-energy conversion systems.

A Hero turbine is a reaction turbine that operates similarly to a rotary lawn sprinkler. Figure 1 illustrates one version of a two-phase Hero turbine that was introduced in 1978. In that version, hot water that was saturated (that is, in thermodynamic equi-

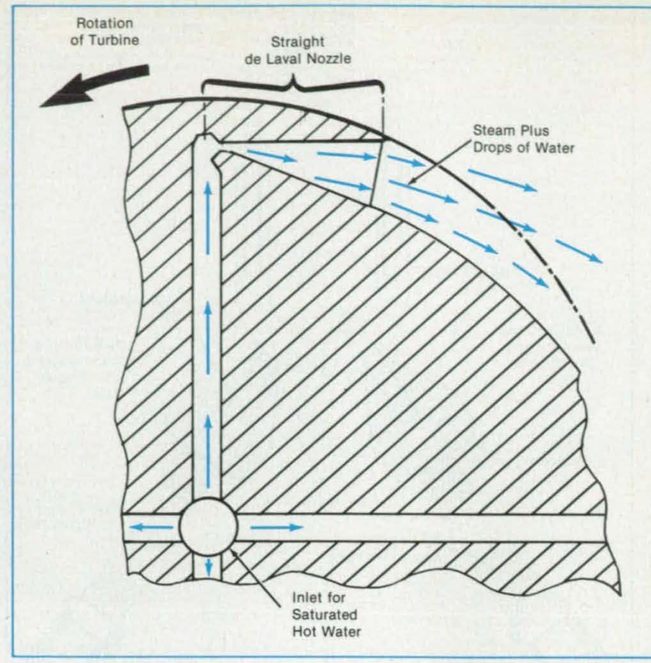

Figure 1. A **Prior Hero Turbine** included conventional short, straight de Lavel nozzles, which are too short and abrupt for efficient flashing of the water to steam and are not designed to prevent centrifugal separation of liquid from vapor.

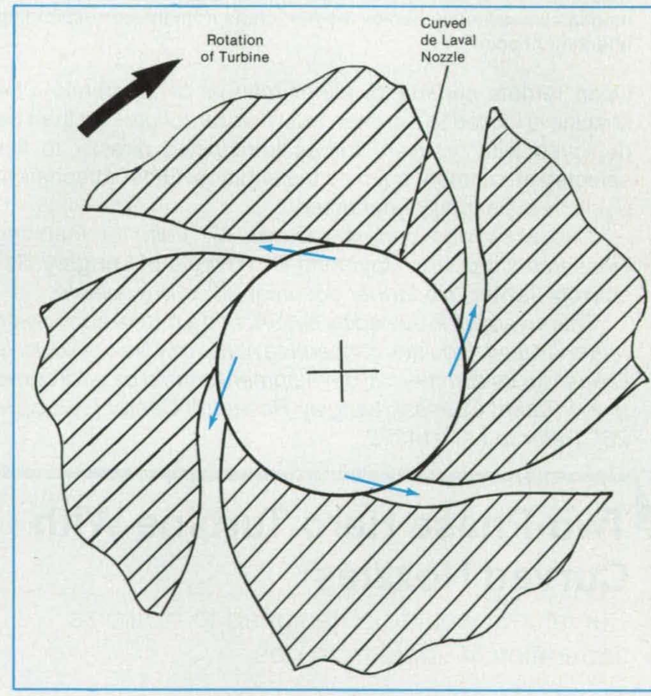

Figure 2. The **Proposed Hero Turbine** would include de Laval nozzles modified to a new curved, longer, more-gradually-tapered shape that would promote flashing and reduce separation.

librium with its vapor), was pumped into a rotor along its hollow shaft, then flowed radially outward, then was flashed partly to steam through very short tangential de Laval nozzles. The efficiency of the de Laval nozzles was 45 percent, while the overall efficiency of the turbine was 33 percent.

Stationary de Laval nozzles can exhibit efficiencies of 90 percent. The relatively low efficiency of the rotating de Laval nozzles of the prior Hero turbine has been attributed to two phenomena. One is severely delayed flashing in the nozzles. As the water travels radially outward in the rotor, centrifugal force causes an increase in pressure, thereby making the water highly subcooled. The flashing of subcooled liquid through very short nozzles yields low efficiency in most cases because nucleation sites do not have enough time to grow while the liquid passes quickly through the short converging part of the nozzle.

The second phenomenon believed to degrade efficiency is a direct result of the centrifugal acceleration itself. The centrifugal acceleration amounts to a lateral acceleration with respect to the axis of the nozzles. This acceleration tends to separate the liquid from the vapor, thereby drastically increasing the slip loss.

The curved rotating de Laval nozzles of the proposed Hero turbine would reduce the effects of both of these phenomena. To minimize separation, the curvatures would be selected so that at the design operating speed, there would be no overall component of acceleration lateral to the nozzle. To make the pressure drop gradually so that gradual flashing could take place during a relatively long travel time along the nozzle, the nozzle would be made longer, including a longer converging part starting close to center of rotor, and with a less-abrupt enlargement at the throat.

This work was done by Gracio Fabris of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 33 on the TSP Request Card.*

This is the invention of a NASA employee, and a patent application has been filed. Inquiries concerning license for its commercial development may be addressed to the inventor, Mr. Gracio Fabris. Refer to NPO-18059.

Books and Reports

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

Reusable Manned Lunar Vehicle

A conceptual integrated system would carry cargo, crew, and supplies on frequent, regular missions.

A report presents a concept for a reusable manned spacecraft to fly to and from the Moon. The concept calls for a lunar lander based in low orbit around the Moon and a transfer stage that would shuttle between the orbiting lander and Earth.

The lander would deliver 30 tonnes of cargo to the surface of the Moon robotically and return itself to low orbit around the Moon. Alternatively, it would land eight crewmembers and supplies for 165 days and return them to orbit.

The transfer stage would carry propellant for the lander from Earth. Upon return to the atmosphere of the Earth, it would slow itself by aerobraking.

The integrated vehicle system is designed to accommodate preliminary sorties to the Moon by a few crewmembers, as well as regular missions by a full crew. Designing the system for both purposes would lead to a faster installation of an operating Moon base.

The lander would be a single-stage vehicle with four spherical tanks — two containing liquid hydrogen and two containing liquid oxygen — supported by an X-plan truss frame. Four fixed landing pads would establish a wide footprint for stable landing and unloading. It would have three throttleable, gimbaled cryogenic engines. It could ascend and descend with one engine disabled. The crew cabin would be a pressurized sphere outfitted for lunar landing and ascent only. Cargo would be carried as fully outfitted working and living modules with airlocks for crewmembers to enter and leave.

The aerobrake would be an elliptical, deep, asymmetrical shell. A total of four spherical tanks would carry liquid hydrogen and liquid oxygen for departure from Earth, arrival in orbit around the Moon, refueling the lander, departure from orbit around the Moon, and return to Earth. It has four cryogenic engines on an X-truss.

The transit vehicle would hold a space-station module suitable for use by eight people for up to 24 days. The crew could transfer to the lander through a pressurized tunnel without donning space suits. For unmanned shipment of cargo and fuel only, the crew module would not be used.

This work was done by Brent Sherwood of Boeing Huntsville Advanced Civil Space Systems for **Marshall Space Flight Center**. *To obtain a copy of the report, "Manned Lunar Vehicle Configuration Concept," Circle 79 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-28454.

Computation of Flow in a Turbine Stage on a Refined Grid

The finer grid yields more accurate results.

A report describes a numerical simulation of the flow in an axial-turbine stage, showing the interactions between the rotor- and stator-airfoil rows. This study complements an earlier three-dimensional, time-accurate Navier–Stokes numerical simulation. In this study, a finer computational grid and a modified stator geometry (to account properly for blockage effects) are used.

In the previous study, a relatively coarse grid of 25 points in the spanwise direction (perpendicular to the axis of the turbine) was used to resolve both the main flow and the boundary layers at the hub and casing. In this study, twice as many points in the spanwise direction are used to resolve the end-wall and tip-clearance effects better.

The turbine stage considered has 22 airfoils in the stator row and 28 airfoils in the rotor row. In both this and the previous study, the amount of computation was reduced by imposing a periodicity that made it possible to reduce the number of airfoils to a single rotor–stator pair. This, however, required an enlargement of either the rotor or the stator airfoil in the axial and azimuthal directions, keeping the same pitch-to-chord ratio. In the previous study, the rotor airfoil was modified; the results from this study showed that the interaction effects were more pronounced in the rotor passages than in the stator passages. Consequently, to simulate the interaction effects more accurately in this study, the rotor airfoil was restored to its original geometry, and the stator airfoil was modified.

The previous study followed the patched-grid approach, in which adjacent grids come together along common lines. This study follows the overlaid-grid approach, in which grids have common areas of overlap. The overlaid-grid approach results in grids that are free of singularities, less skewed, and much more easily tailorable to a variety of geometries. The combination of the finer spanwise grid, the unmodified rotor geometry, and the overlaid grids results in a more realistic simulation of the physical conditions in the real turbine.

The authors conclude that the results of the previous coarse-grid and the present fine-grid calculations are in good agreement with each other and with experimental results. In general, both calculations yield similar results at the various spanwise locations, except at the hub and the outer casing. Several features, such as the surface flow in the rotor and pressures on the hub and casing, are predicted better by the present fine-grid calculations. The two calculations predict significantly different structures for the vortexes in the stator passage. It is believed that the fine-grid results are more representative of the real flow field.

This work was done by N. K. Madavan of Sterling Software, M. M. Rai of **Ames Research Center**, *and S. Gavali of Amdahl Corp. Further information may be found in AIAA paper 89A-25274, "Grid Refinement Studies of Turbine Rotor–Stator Interaction."*

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94 Layered Plating Specimens for Mechanical Tests
95 Jointed Holder for Welding Electrodes

Automatic Control of Length of Welding Arc

Nonlinear relationships among current, voltage, and length would be stored in electronic memory.

Lyndon B. Johnson Space Center, Houston, Texas

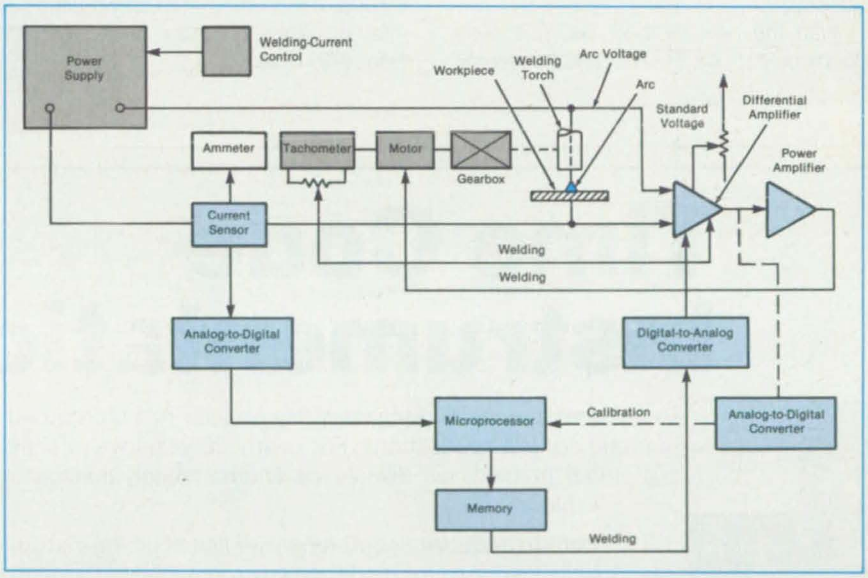
A conceptual microprocessor-based control subsystem would maintain constant the length of the welding arc in a gas/tungsten arc-welding system, even when the welding current is varied. The control subsystem could be added to an existing manual or automatic welding system equipped with automatic voltage control.

The control subsystem (see figure) would use feedback and a mathematical model of the electrical characteristics of the welding arc to generate commands for a motor that would control the distance of the welding torch from the workpiece and, thereby, the length of the arc. The mathematical model of the electrical characteristics of the arc would be stored in an electronic memory as the digitized values representative of the nonlinear voltage vs. current of the arc at various arc lengths and for various workpiece materials and welding gases.

Initially, the voltage-vs.-current data would be acquired in a calibration process in which the torch would be locked at a given length of arc. The current would be varied manually while signals proportional to the voltage and current would be fed to a differential amplifier. The output of the differential amplifier (ΔV) and the signal proportional to the current (I) would be digitized and fed through the microprocessor to the electronic memory. This process would be repeated at a number of lengths of arc.

During welding, the torch would be unlocked so that it could be positioned by the motor. The arc voltage and arc current signals would be obtained as before, and the differential amplifier would compare the arc voltage with a standard preset voltage. The differential amplifier would also act upon a signal from a tachometer on the motor and on the ΔV signal stored in the electronic memory for the instantaneous value of the welding current. The output of the differential amplifier would control a power amplifier, which would feed power to the motor as needed to maintain the arc at constant length.

This work was done by William F. Iceland of Rockwell International Corp. for **Johnson Space Center**. *For further information, Circle 68 on the TSP Request Card. MSC-21473*



The **Control Subsystem** would use feedback of current and voltage from the welding arc to maintain the length of the arc at a constant value. The subsystem would direct the motor to set the position of the torch according to the previously measured relationships among the current, voltage, and length of the arc. The signal paths marked "calibration" or "welding" are used during those processes only. The other signal paths are used during both processes.

Uniform-Dead-Weight Brazing

Uniformly distributed weight increases yield and reduces costs.

Lyndon B. Johnson Space Center, Houston, Texas

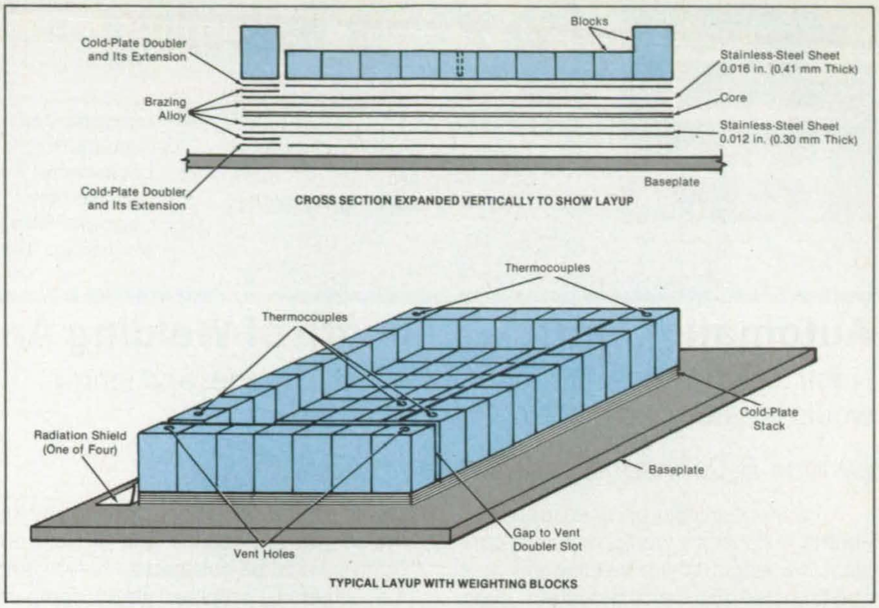
A method of deadweight loading for vacuum-furnace brazing improves the quality of the joint. In the application for which it was developed — fabrication of stainless-steel cold plates — the method decreased the rate of rejection from 57 percent to 0 percent.

Previously, the plates to be brazed together were pressed together under a one-piece glide plate. The glide plate became distorted from the furnace heat and therefore did not apply its weight uniformly over the surfaces of the plates to be joined. In the improved method, the plates are weighted with heavy stainless-steel blocks. The blocks act independently and are thus immune to distortion. Besides being uniformly distributed, the force they apply to the plates is larger and is repeatable from one brazing operation to the next. Larger blocks are used on the edges of the plates, where more thermal mass is needed to reduce the differences between the temperatures of the interior and the edge as the temperature of the furnace is varied — a refinement that was not possible with the one-piece glide plate.

The cold-plate layup consists of a stack of stainless-steel sheets separated by brazing-alloy tape 0.004 in. (0.1 millimeter) thick, all on a stainless-steel baseplate (see figure). A "stopoff" coat of zirconium oxide powder is sprayed onto those surfaces (e.g., between the layup and the baseplate) that are in contact with each other but are not intended to be brazed together, to ensure separation after brazing. The smaller blocks, 1.37 in. (35 mm) high and weighing 1.5 lb (0.68 kg), are placed on most of the top surface of the stack. The larger blocks, 2.6 in. (66 mm) high and weighing 2.9 lb (1.3 kg), are placed at the periphery of the top surface. The blocks are separated from each other by gaps 0.015 in. (0.4 mm) wide. Shields made of stainless-steel sheet are placed at the edges of the stack to prevent overheating of the edges by direct radiation. The shields are tack-welded in position. The assembly is brazed at a temperature between 1,900 and 1,985 °F (1,038 and 1,085 °C).

With the new method, two cold-plate doublers can be brazed simultaneously. This reduces fabrication time by a few weeks and fabrication cost by about $6,000. The finished part can withstand an internal gauge pressure of at least 135 lb/in.^{2} (931 kPa).

This work was done by William D. Gaw of Rockwell International Corp. for **Johnson Space Center**. *For further information, Circle 22 on the TSP Request Card. MSC-21627*



Stainless-Steel Blocks in two sizes weigh a stack of layers to be brazed together to make a cold plate. Radiation shields, two of which have been removed to show the stack, prevent overheating at the edges. Thermocouples at selected locations monitor brazing temperatures.

Diamond-Coated Wire-Feeding Nozzle

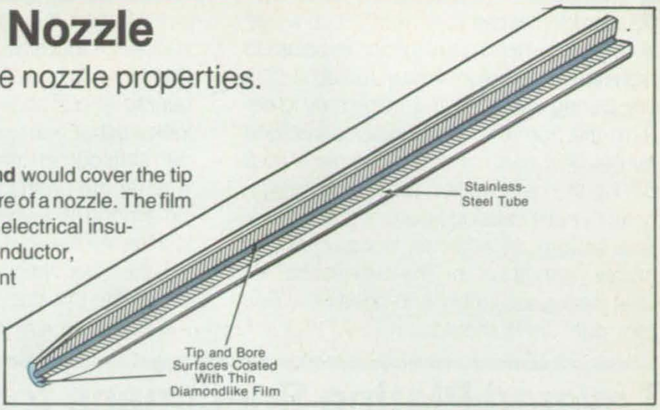
Hard vacuum-deposited film would greatly improve nozzle properties.

Marshall Space Flight Center, Alabama

The tip and bore surfaces of a proposed nozzle for feeding wire for gas/tungsten arc welding would be coated with a film of synthetic diamond (see figure). The film would give the nozzle the following advantages:

- Lower friction; the wire would pass through it easily, without snagging.
- Thermal conductivity higher than that of copper, the wire would be preheated more efficiently.
- Less wear; the coated nozzle would outlast conventional wire-feeding nozzles.
- Electrical isolation of the wire from the nozzle; this would help prevent burn-back fusion of the wire and nozzle.
- High resistance to corrosion.

The diamond coat would be deposited on the bare stainless-steel nozzle in a vacuum chamber. The nozzle would be heated to about 1,000 °C in the chamber, which would be backfilled with an atmosphere of methane and hydrogen. The gases would be bombarded by microwave to form a plasma. The methane would decompose into carbon and hydrogen, and the carbon would be deposited on the tip and bore, forming the diamondlike film. The hydrogen atmosphere would prevent the diamondlike molecular structure of the deposited carbon from collapsing into a graphitic structure.



A **Thin Film of Diamond** would cover the tip and extend along the bore of a nozzle. The film would reduce wear. An electrical insulator but a thermal conductor, diamond would prevent short circuits but enhance the transfer of heat to the welding wire passing along the bore.

This work was done by Jeffrey L. Gilbert of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

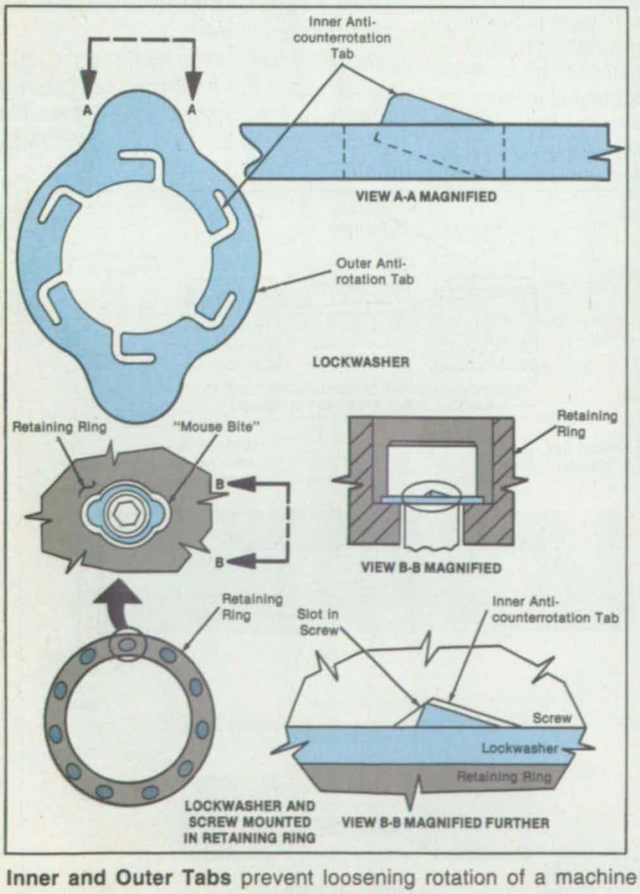
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-29714.

Lockwasher Strongly Resists Disassembly

Tabs engage slots in pawl-and-ratchet fashion.

Marshall Space Flight Center, Alabama

A lockwasher has been designed to prevent counter-rotation and loosening of a machine screw (colloquially, a bolt) once the screw has been fully tightened. The anti-counter-rotation features of the lockwasher and its mating screw-head are similar to those of a "childproof" cap on a pill bottle.



Inner and Outer Tabs prevent loosening rotation of a machine screw once the screw has been tightened on the lockwasher.

The lockwasher-and-screwhead combination is intended to replace a cup-washer-and-screwhead combination exposed to high-speed, turbulent flow in turbomachinery. During assembly, it is necessary to deform the cup washer. Vibrations induced by the flow can cause cracks generated during the deformation process to propagate, thereby causing failure of the antirotation feature. In addition, occasionally, a screw "hangs up" on the cup-washer radius during assembly and does not "bottom out" as it should.

The new design requires no permanent deformation during assembly. The lockwasher includes two outer antirotation tabs that fit in "mouse-bite" recesses in a retaining ring. These features prevent the lock washer from rotating. A number of inner anticounterrotation tabs on the lockwasher are preloaded upward to engage slots in the screwhead in pawl-and-ratchet fashion. As the screw rotates during tightening, the inner anticounterrotation tabs click easily into the slots. However, because of the asymmetrical shape of each slot, the tab that has sprung into the slot pushes against one of its walls, resisting any loosening rotation of the screw.

This work was done by Stephanie Z. Jeffers of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-29696.

Layered Plating Specimens for Mechanical Tests

Grips are augmented with material that can be plated more easily.

Marshall Space Flight Center, Alabama

Layered specimens that include difficult-to-plate metals can be readily made in standard sizes for tensile and other tests of mechanical properties. Specimens in standard sizes are necessary for high confidence in the results of the tests.

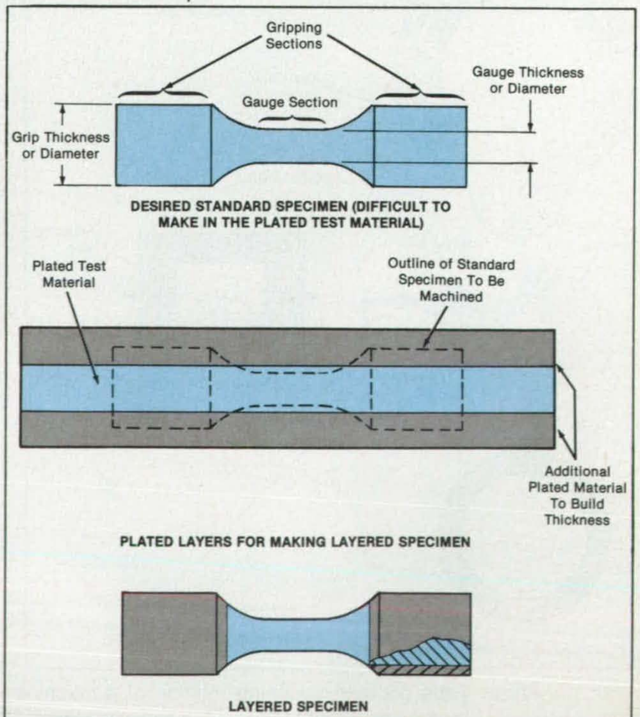
Typically, a specimen of standard size includes a middle gauge section of specified thickness and end gripping sections of greater thickness (see figure). Before layered specimens were conceived, it was difficult or impossible to fabricate standard-size specimens of difficult-to-plate metals. Either tests could not be performed, or else tests were performed on substandard specimens, with consequent low confidence in the results.

The fabrication of a layered specimen begins with the plating of a high-quality flat layer slightly thicker than standard (or a rod of diameter slightly greater than standard) of the material to be tested. Next, the thickness of the specimen is augmented by adding an easier-to-plate outer layer on a rod (or outer layers on both sides of a flat specimen) of either a different metal or else the same metal but of lower quality. The thickness of the outer layer(s) must be sufficient to bring the total thickness up to at least the standard thickness of the gripping sections.

The outer layer(s) is (are) machined away from the ends down to the standard grip thickness or diameter. The outer layer(s) and a small amount of the inner layer are machined away in the middle down to the specified thickness or diameter of the gauge section. The result is a specimen of standard size containing only the difficult-to-plate material to be tested in the gauge section.

This work was done by Linda B. Thompson and Cecil E. Flowers of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-29718.



A **Standard Specimen** of a metal ordinarily difficult to plate to the standard grip thickness or diameter can be made by augmentation with an easier-to-plate material followed by machining to standard size and shape.

Jointed Holder for Welding Electrodes

A custom-bent electrode becomes unnecessary.

Marshall Space Flight Center, Alabama

A jointed electrode holder for gas/tungsten arc welding is designed for use in workspaces to which access is limited. The jointed holder is mounted in a standard torch and is covered by a customized gas cup, shaped to the required welding angle(s) (see figure).

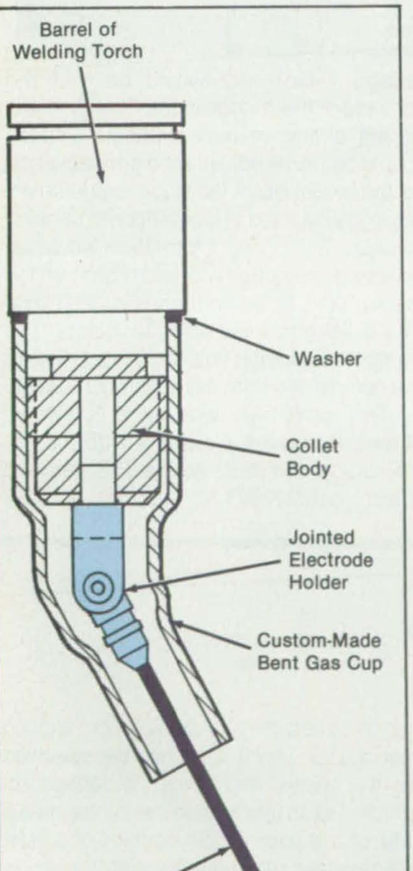
Heretofore, it has been necessary to custom-bend the electrode to match the angle(s) of the gas cup. Bending to the required configuration is difficult, and it is difficult to install and remove a bent electrode. Moreover, a bent electrode can be sharpened only a few times.

The new jointed holder requires only a standard straight electrode. The electrode can be replaced easily, without removing the cup, with the aid of a tool that loosens a miniature collet nut on the holder. The length of the electrode extending from the cup (the "stickout") can readily be adjusted to compensate for shortening as the electrode is consumed. In contrast, the stickout of a bent electrode cannot be adjusted, so that when the stickout becomes too short, the electrode must be replaced. Therefore, the jointed holder consumes fewer electrodes for a given amount of welding.

The angle of the holder is continuously adjustable to fit the angle of the gas cup or the geometry of the part to be welded. The holder could be made double-jointed to accommodate a gas cup that has compound angles.

This work was done by Jeffrey L. Gilbert of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-29739.



The **Adjustable-Angle Holder** enables the use of a standard straight electrode with a custom-fabricated bent gas cup for welding in difficult-to-reach places.

Mathematics and Information Sciences

Hardware, Techniques, and Processes
96 Digital Image Velocimetry
96 Algorithm Derives Rules From Data
98 Valve- and Switch-Monitoring Computer Program
99 Removing Ambiguities in Remotely Sensed Winds
101 Solving Constraint-Satisfaction Problems in Prolog Language
101 DOS Batch Files as Control Programs
102 Developing Confidence Limits for Reliability of Software

Computer Programs
66 Video Image Communication and Retrieval—Updated
69 Program For Parallel Discrete-Event Simulation
70 Computing Availability and Reliability for a System

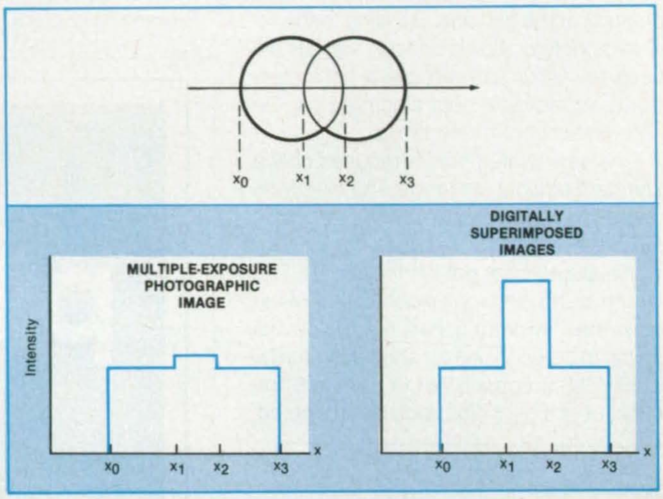
Digital Image Velocimetry

Images of seeded flows would be processed to obtain velocity maps.

Ames Research Center, Moffett Field, California

Digital image velocimetry is a proposed technique for the production of velocity maps from sequences of photographic video images of flows seeded with small particles. It is related to particle-image and laser-speckle velocimetry, both of which involve the analysis of multiple-exposure photographs, give ambiguous (forward vs. backward) indications of the directions of velocity vectors, and give indications of velocities only in relatively restricted dynamic ranges. Digital image velocimetry would eliminate the need to process photographs, indicate the directions of velocity vectors unambiguously, and offer increased dynamic ranges. Moreover, becaure all processing could be performed electronically, digital image velocimetry may eventually be capable of mapping flow-velocity fields in real time.

In digital image velocimetry, the single-exposure film or video images would be digitized, enhanced, and superimposed to construct a composite image field. There would be a subtle but important difference between this image field and a multiple-exposure photograph, particularly where high concentrations of seed particles or low velocities give rise to overlapping image elements of particles from different exposures. On a multiple-exposure photograph, the intensity in the overlap regions may not differ from that in the nonoverlap regions, but in the digitally superimposed image, the intensity in the overlaps would be the sum of the intensities in the corresponding positions in the individual exposures (see figure). This feature preserves the correlation between the image elements of the same particles.



Overlapping of Features in two consecutive image frames give rise to little or no change in intensity on a conventional multiple-exposure photograph. But in digital image velocimetry, the intensities of corresponding positions would be summed algebraically.

In digital image velocimetry, the image would be analyzed by digital Fourier transformation. This process would be free of noise. In comparison with optical Fourier transformation, which is used in laser-speckle and particle-image velocimetry, it would be more precise and would consume less time.

Another important advantage of digital image velocimetry would be that the phases of the fringes in the Fourier transforms of the multiple-exposure images could be retrieved. This is a consequence of the availability of the single-exposure images and the use of digital Fourier transformation. The phase information would be used in conjunction with information on the separations between fringes to determine the directions of the velocity vectors. The magnitudes of the velocity vectors would be determined from the separations alone.

This work was done by Y. C. Cho of **Ames Research Center**. *For further information, Circle 81 on the TSP Request Card.* ARC-12474

Algorithm Derives Rules From Data

A set of best rules is based on a quantitative measure.

NASA's Jet Propulsion Laboratory, Pasadena, California

The ITRULE (Information Theoretic RULE induction) algorithm induces rules from examples in a data base. The algorithm is novel in the sense that it not only learns rules for a given concept (classification) but also simultaneously learns rules that relate multiple concepts.

The data base in question is derived from a set of *M* samples that are assumed to be random and representative of the population of objects to be characterized. The datum that represents each sample is a set of *N* attributes, which can assume values in a corresponding set of *N* discrete alphabets. This data base can be regarded as a set of *M* attribute vectors.

In this context, a rule is a statement to the effect that if an event *y* occurs, then event *x* will probably occur. As used here, an event is a proposition or an instance of a particular attribute taking on a particular value from its alphabet. The degree of certainty of the rule is represented by the conditional or transition probability, $p(\mathbf{X} = x|\mathbf{Y} = y)$.

In generalized rule induction, the problem is to find the *K* best rules from a given set of data, where *K* is a number specified by the analyst and "best" is defined according to an information-theoretical measure of the information content of a rule. Generalized rule induction yields rules relating to all the attributes, whereas classification yields rules relating to only a single attribute representative of a given class.

To find the *K* best rules, the ITRULE algorithm ranks them quantitatively according to their *J*-measures. The *j*-measure is defined by

$$j(\mathbf{X};\ \mathbf{Y} = y) = \sum_{x} p(x|y)\cdot\log\left(\frac{p(x|y)}{p(x)}\right)$$

(see figure), where **X** and **Y** are two attributes, x and y are values of them in their discrete alphabets, and $p(x)$ is the a-priori probability of x. The *J*-measure of a general rule is given by

$$J_g = J(\mathbf{X};\ \mathbf{Y} = y)$$
$$= p(y)\left(p_g\cdot\log\frac{p_g}{p_x} + (1-p_g)\cdot\log\left(\frac{1-p_g}{1-p_x}\right)\right)$$
$$= p(y)j(\mathbf{X};\ \mathbf{Y} = y)$$

where $p_g = p(x|y)$ is also called the transition probability of the general rule. Several other *J*-measures are also used, including J_s, the *J*-measure of a specialized rule.

The algorithm begins by first finding *K* rules, calculating their *J*-measures, then placing these *K* rules in a list in descending order according to their *J*-measures. The smallest *J*-measure, that of the *K*th element of the list, is then defined as the running minimum, J_{min}. Thereafter, the *J*-measures of new rules that are candidates for inclusion in the list are compared with J_{min}. If the *J*-measure of a candidate rule exceeds J_{min}, the candidate rule is inserted in the list, the *K*th rule is deleted, and J_{min} is updated with the value of the *J*-measure of whatever rule is now *K*th on the list.

The critical part of the algorithm is the criterion for specialization, inasmuch as it determines how much of the exponentially large hypothesis space the algorithm must explore. For each of the *nm* possible right-hand sides of a given rule (where there are *n* *m*-ary attributes), the algorithm employs depth-first search over possible left-hand sides, starting with the second-order conditions and specializing from there. Specialization on a general rule occurs only if the bound above is less than J_{min}. Specialization can also cease if the transition probability of a given general rule equals 1 or 0. The algorithm systematically tries to specialize all $nm(n-1)2m$ first-order rules and terminates when it has determined that no more first-order rules can be specialized to achieve a *J*-measure greater than J_{min}.

The general situation occurs when one has a right-hand side $\mathbf{X} = x$ and a left-hand side $y_1,...,y_k$, where one has just evaluated J_g and inserted the rule to which it pertains in the list if $J_g > J_{min}$. In practical terms, to calculate J_g, one must have sorted the original data into a subtable conditioned on $y_1,...,y_k$. The problem now is to decide whether further specialization and consequent sorting are worthwhile. The decision whether to continue specializing or to back up on the depth-first search is determined by the following sequence:

(1) If $p_g = 1$ or $p_g = 0$, then back up the search, or else

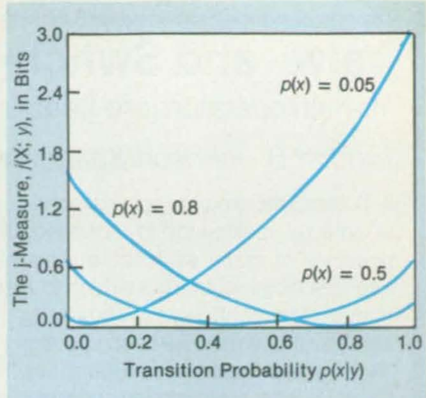
(2) If $J(\mathbf{X};y)$ of the general rule $\leq J_{min}$, then check whether, for any z (where z is the value of an attribute related to the specialized rule), one can hope to find $J_s \leq J_{min}$; i.e., calculate

$$J_1 = \max\left\{p(y)p_g\log\frac{1}{p_g},\ p(y)(1-p_g)\log\frac{1}{1-p_x}\right\}$$

and, if $J_1 \leq J_{min}$, then back up the search.

(3) Else, continue to specialize.

This work was done by Padhraic J. Smyth and Rodney M. Goodman of Caltech for ***NASA's Jet Propulsion Laboratory****. For further information, Circle 142 on the TSP Request Card.*
NPO-18114



J-Measures are plotted as functions of transition and a-priori probabilities.

Valve- and Switch-Monitoring Computer Program

Human operators are freed from tedious, repetitive monitoring tasks.

Lyndon B. Johnson Space Center, Houston, Texas

A computer program applies techniques of artificial intelligence to monitoring the positions of many switches and valves. The specific program was written to assist human flight controllers in comparing the actual with the expected configurations of switches and valves in the Space Shuttle; the underlying programming concept is applicable to such other complicated systems as chemical-processing plants, power-plants, and automated assembly lines. The program works with present monitoring equipment and computers.

Each raw position-sensor output is a binary signal that represents the absence or the presence of an "open" indication, a "closed" indication, or both. The binary signals from each device to be monitored constitute a 16-bit configuration word, and the set of such words from the various parts of the system is fed to the control center. The words are displayed in hexadecimal format to the controllers, who must repeatedly perform the tedious and error-prone task of observing the many valve- and switch-position-indicating signals, interpreting those signals in terms of valve and switch positions, and detecting valve and switch configurations that represent malfunctions.

The monitoring program speeds, automates, and reduces the probability of error in this task and quickly alerts the controllers to conditions that require human intervention. The program is a production-rule classification software system that attempts to generate a description, in high-level semantics, of the state of the equipment system. For example, instead of reading the propositions

p_1 = "The manifold 1 oxidizer-open indication is present,"

p_2 = "The manifold 1 fuel-open indication is present,"

p_3 = "The manifold 1 oxidizer-closed indication is not present,"

p_4 = "The manifold 1 fuel-closed indication is not present,"

the flight controller reads

"The manifold 1 valves are open."

Better still, if the state of the system includes the propositions

p_5 = "The manifold 1 valves are open,"

p_6 = "The manifold 2 valves are open."

p_7 = "The manifold 3 valves are open,"

p_8 = "The manifold 4 valves are open,"

p_9 = "The manifold 5 valves are open,"

then the best description is

"All five manifolds are open."

Descriptions presented in such terms as these are much more meaningful to flight controllers, who are thereby assisted in maintaining a broader mental picture of the equipment system than they could if they had to evaluate signals at the individual valve-position-indicator level.

The final output of the program is a textual description of the differences between the sets of actual and expected position signals. A typical output of this kind might be

1. Expect all 5 of the manifolds to be open, but
2. Manifold 1 is open,
3. Manifold 2 is open,
4. Manifold 3 is open,
5. Manifold 4 oxidizer-open indication is present,
6. Manifold 4 fuel-closed indication is present,
7. Manifold 5 is open.

The program uses a combination of procedural and declarative programming techniques. NASA's C Language Integrated Production System (CLIPS) provides rule-processing capabilities. The host program, written in C, acquires the necessary data and applies a valuation algorithm to generate knowledge-based propositions. This algorithm assigns to each component-position indication a description of the component, a description of the position indication (e.g., "open," "closed," "on," or "off"), and a qualifier as to whether that position belongs to the actual or expected configuration. When all necessary propositions have been generated, the production-rule software system evaluates them and generalizes the description of the state of the system as appropriate. The C program then expands the remaining propositions into English sentences for display to flight controllers.

This work was done by Matthew R. Barry and Carlyle M. Lowe III of Rockwell International Corp. for **Johnson Space Center**. *For further information, Circle 5 on the TSP Request Card.*
MSC-21720

Removing Ambiguities in Remotely Sensed Winds

An algorithm selects from among candidate wind vectors by use of a median filter.

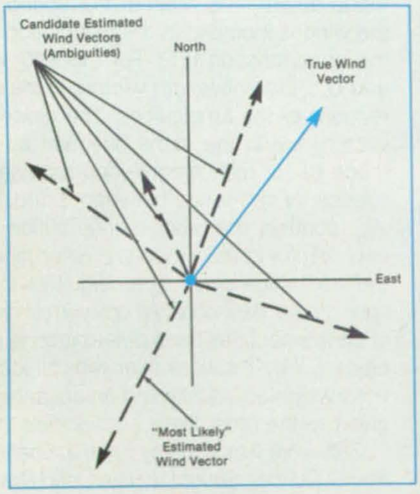
NASA's Jet Propulsion Laboratory, Pasadena, California

An algorithm removes ambiguities in choices of candidate ocean-surface wind vectors estimated from measurements of radar backscatter from ocean waves. The ambiguities arise unavoidably from the geophysical model function used to compute the relationship between wind vectors and coefficients of backscattering. By making better use of the data available from existing instrumentation, the ambiguity-removing algorithm will increase the accuracies of estimates of winds without requiring new instrumentation.

In processing the raw backscatter data according to the model, the radar swath is divided into wind-vector cells. Several candidate wind vectors called "ambiguities" are computed for each cell and ranked according to a maximum-likelihood algorithm. The ambiguity ranked highest in each cell is called the "most likely," while the ambiguity closest to the true wind vector is called the "closest." In practice, the most likely is sometimes not the closest (see figure).

The ambiguity-removing algorithm incorporates a vector-median filtering function. It can be "tuned" by adjustment of several parameters. The steps of the algorithm are the following:

1. Construct a two-dimensional array of



The **Ambiguity-Removing Algorithm** is needed because the "most likely" candidate wind vector is not necessarily closest to the true wind vector.

wind-vector cells of sufficient size to contain an entire swath.

2. Initialize the array of wind vectors by using the "most likely" wind vectors.
3. For each wind-vector cell, determine the ambiguity, k, at the point (i,j) that minimizes the error function E_{ij}^k for one of two possible modes of operation:

Mode 0: Direction-only median

$$E_{ij}^k = \frac{1}{(L_{ij}^k)^P} \sum_{m=i-1}^{i+1} \sum_{n=j-1}^{j+1} W_{mn} \cos^{-1}\left[\frac{\mathbf{A}_{ij}^k \cdot \mathbf{U}_{mn}}{|\mathbf{A}_{ij}^k|\ |\mathbf{U}_m|}\right]$$

Mode 1: Vector median

$$E_{ij}^k = \frac{1}{(L_{ij}^k)^P} \sum_{m=i-1}^{i+1} \sum_{n=j-1}^{j+1} W_{mn} \left|\mathbf{A}_{ij}^k - \mathbf{U}_{mn}\right|$$

where

$\mathbf{A}_{ij}^k$ = k'th ambiguity vector at point (i,j)

$\mathbf{U}_{mn}$ = (m,n)'th vector in the array of "selected" vectors

W_{mn} = location weight for the (m,n)'th vector

L_{ij}^k = likelihood of the k'th ambiguity at (i,j)

P = likelihood weight.

Wind-vector cells that do not contain data are ignored.

4. Replace $\mathbf{U}_{ij}^k$ with whichever $\mathbf{A}_{ij}^k$ yields the lowest error function.
5. Repeat steps 3 and 4 until no further replacements can be made (convergence).

The four adjustable parameters are the choice of direction-only or vector median, the size of the sampling window in terms of the number of wind-vector cells (N) on a side, the likelihood weight (P), and the location weights (W_{mn}). The choice of mode determines whether the speed of the wind is included in the calculation of the error function (E_{ij}^k). For mode 0, $\mathbf{A}_{ij}^k$ and $\mathbf{U}_{mn}$ are unit-length vectors in the directions of the ambiguities. The mode 1 vectors are in the same direction as in mode 0, but their magnitudes represent speeds. N can range between 3 and 11. W_{mn} controls the relative contribution of each vector in the window. P determines the advantage given to ambiguities that have greater likelihoods. An optimum choice of parameters has been determined to include a 7-by-7 square filter with all locations weighted equally and an advantage given to the most likely ambiguities.

This work was done by Scott J. Shaffer, Roy S. Dunbar, Shuchi V. Hsiao, and David G. Long of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 8 on the TSP Request Card. NPO-18079*

Solving Constraint-Satisfaction Problems in Prolog Language

Grammar-rule notation is regarded as "state-change notation."

Ames Research Center, Moffett Field, California

A technique for the solution of constraint-satisfaction problems uses the definite-clause grammars of the Prolog computer language. The technique exploits the fact that the grammar-rule notation can be viewed as a "state-change notation." Such notation facilitates the development of a dynamic representation that can perform informed as well as blind searches. The technique is applicable to design, scheduling, and planning problems.

In this technique, a program in Prolog can be constrained to perform a depth-first search to find one solution to a problem rather than to perform a traditional breadth-first search for all solutions to that problem. The Prolog grammar-rule notation is used to specify a goal state in such a way that the elements of a problem are addressed sequentially, one at a time. The breadth-first Prolog search is then applied to each step in the sequence individually, providing the effect of a depth-first search.

One of the disadvantages often cited for other Prolog formulations of problems concerns the computational inefficiency that can result for certain types of problems. The new technique is expected to reduce the processing time required to solve constrained-search problems formulated in Prolog. Furthermore, the informed-search feature permits a partial solution to be provided as a starting point, thereby permitting the omission of the testing associated with other possible starting points.

This work was done by Philip R. Nachtsheim of **Ames Research Center**. *Further information may be found in NASA TM-101031 [N89-13974], "A Technique for Solving Constraint Satisfaction Problems Using Prolog's Definite Clause Grammars."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703)487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12460

DOS Batch Files as Control Programs

Small subprograms fit within the limitation on random-access memory.

Lyndon B. Johnson Space Center, Houston, Texas

A computer-programming technique circumvents the maximum of 640K imposed on random-access memory (RAM) by DOS (Disk Operating System) software. The technique is needed because developers of software for personal computers sometimes find that the sizes of their application programs exceed this limit. (The limit exists in many aging versions of DOS now in use; newer operating systems are designed to circumvent the limit.)

The technique involves breaking an application program into smaller programs. Each resulting subprogram, when compiled and linked, must be small enough to fit within 640K of RAM, and is retrieved from storage on a disk as needed. In terms of DOS software, each subprogram is an ".EXE" file that can be executed in a "stand-alone" manner.

A DOS batch file coordinates the execution of the ".EXE" files, integrating these files into one seamless application program. Except for very straightforward applications, means must be provided to enable this controlling batch file to determine which ".EXE" file should be executed next; that is, to enable the batch file to vary the execution sequence dynamically during execution as needed. The determination depends on information generated during the present and previous parts of the execution sequence.

One way for the ".EXE" files to communicate this information back to the batch file is by setting a "flag" file on the disk. Most high-level computing languages and software-development tools provide software interfaces for the manipulation of files on disks. In particular, a batch file has the ability to check for the existence of other files on a disk. By making an ".EXE" file change the name of a certain flag file and making the batch file check for the existence of specified file names, one can make the ".EXE" file "talk" to the batch file, as required.

This work was done by David A. Van Dyk of Rockwell International Corp. for **Johnson Space Center**. *For further information, Circle 4 on the TSP Request Card.* MSC-21570

Developing Confidence Limits for Reliability of Software

The "pivotal" approach expands the estimation capability of the Moranda model.

Langley Research Center, Hampton, Virginia

A technique has been developed for estimating the reliability of software by use of the Moranda geometric de-eutrophication model. The major premise of Moranda's model with respect to the reliability of software is that the rate of failure of the software decreases in a geometric progression as bugs (design flaws and coding errors) are removed from the software, and this decreasing failure rate implies growth in the reliability.

Heretofore, work on mathematical models for the growth of reliability of software has emphasized the estimation of only the parameters of the models by least-squares or maximum-likelihood techniques. However, only single-point estimates and asymptotic approximations for reliability are directly attainable from the estimates of the model parameters. The emphasis of the work reported here has been on extending the estimation procedures by developing confidence limits for reliability and prediction limits for the time to the next failure based on Moranda's model.

Inasmuch as confidence and prediction limits for reliability are not directly obtainable from the estimates of the parameters of the model, a technique called the "pivotal method" is utilized. The pivotal method enables a straightforward construction of exact bounds with an associated degree of statistical confidence about the reliability of the software. The confidence limits thus derived provide precise means of assessing the quality of software. The limits take into account the number of bugs found while testing and the effects of sampling variation associated with the random order of discovering bugs.

The testing-and-development process consists of putting a series of randomly selected test cases into the software and correcting bugs as they occur. No assumptions beyond the proper repair of an identified bug are made as to whether new bugs are introduced during the repair. Interest is focused primarily on the times between detecting bugs. In general, as more bugs are repaired, the interfailure times are expected to increase.

Moranda's geometric de-eutrophication model is used to model the interfailure times resulting from the testing process. The parameters of the model are estimated by use of maximum-likelihood techniques. Then the pivotal approach to statistical estimation is used to derive the equations for the confidence limits for reliability and the prediction limits for the time to the next failure. The accuracy of asymptotic approximations to both the confidence and prediction limits is also examined. Further, the effect of departures from the assumed exponentially distributed interfailure times in the model is investigated by simulating interfailure times from Pareto, Weibull, and Γ distributions.

Results show that the method of pivotal functions produces exact confidence and prediction limits with corresponding degrees of statistical assurance of the quality of the estimates of reliability. The usual application of asymptotic results for estimating the limits is inadequate as compared with the pivotal approach, especially when only a small number of bugs have been found during testing. Furthermore, the distributional form of the interfailure times does influence the confidence level of the prediction limits, but the limits derived by the method of pivotal functions appear robust for a special case of Pareto-distributed interfailure times. Because of the sensitivity to the distribution of interfailure times, use of the Moranda model should be restricted to cases in which the interfailure times are distributed exponentially.

From this analysis, one obtains a much better understanding of the value and limitations of the Moranda model. This methodology should provide useful information to individuals concerned with assessment of the reliability of software.

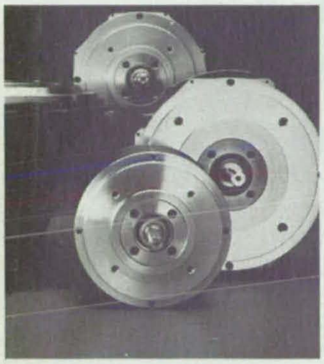
This work was done by Kelly J. Hayhurst of **Langley Research Center**. *Further information may be found in NASA TP-2709 [N87-23244], "Development of Confidence Limits by Pivotal Functions for Estimating Software Reliability."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LAR-14292

New on the Market

The PC-TV, an **adapter for displaying live action video on a computer monitor**, has been introduced by STB Systems Inc., Richardson, TX. Priced at $349, the PC-TV interfaces with a VCR and a SuperVGA card to display videotaped footage or a television signal on a monitor. Software allows the card to run as a normal MS-DOS program or within the Windows environment.
Circle Reader Action Number 790.

A line of compact **servo motors** from Infranor Inc., Naugatuck, CT, achieves zero cogging at speeds as low as 0.1 rpm. The motors incorporate lightweight, ironless, wire-wound epoxy-encapsulated rotors that can handle up to 10x overcurrent for high acceleration capability. Featuring a pancake shape, the motors can be employed in small spaces or where motor weight is a design consideration. Other features include output range from 35 oz.-in. to 17 horsepower and a brush life of 15,000 hours.
Circle Reader Action Number 800.



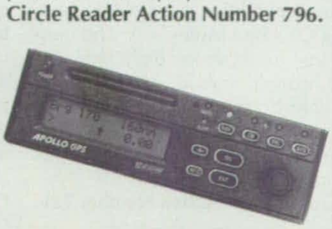
The new VME 9230 **bus analyzer** features a 200 MHz sampling window—the fastest available on a board-level bus analyzer, according to the manufacturer, Nissho Electronics, Irvine, CA. Targeted at laboratory and R&D environments, the VME 9230 offers simultaneous data capture and bus stimulation on both the VME P1 and P2, 32k or 128k trace buffer, and multiple trigger inputs.
Circle Reader Action Number 780.

Arnold Magnetics Corp., Camarillo, CA, has introduced the PB series of ruggedized **AC/DC conditioned power sources**. Available with 1ø or 3ø AC input and DC output from 24 to 300 v, the units feature true N+1 current sharing for loads to kilowatts, .99 power factor correction that provides 25 percent more usable power with low harmonic distortion, surge/spike protection, and -55° to 85° C operation without derating.
Circle Reader Action Number 782.

The industry's first production-speed highlight color **laser printer,** from Xerox Corp., Stamford, CT, allows users in production printing environments to use color to highlight variable data. The model 4850 employs a patented technology called tri-level xerography to print black plus red, blue, or green, and multiple shades and tints of that color, in a single pass at up to 50 pages per minute. The printer offers 300 dots per inch resolution and can print on both sides of a page.
Circle Reader Action Number 784.

Electronic Imagery Inc., Delray Beach, FL, has released ImageScale Plus, the first **image processing system** to be used aboard the space shuttle. ImageScale Plus supports resolutions up to 4096 x 4096 and offers full-color transformations, pseudo coloring, flexible image compression, unlimited macro recording, word processing, and unique zoom and pan. It includes a full complement of filters, image rotations, measurements, drawing utilities, histograms, and arithmetic operations.
Circle Reader Action Number 778.

The FLYBUDDY GPS, a low-cost **global positioning system receiver** for the general aviation market, is available from II Morrow Inc., Salem, OR. Listed at $2995, the standard panel-mount receiver uses a five-channel, fast-sequencing sensor to provide instantaneous, satellite-based navigation information virtually unaffected by weather or electronic interference. Basic features include direct-to navigation, a built-in database of US and Canadian airports and VORs, ten ten-leg flight plans, emergency search, 100 user-defined waypoints, and a supertwist LCD display.
Circle Reader Action Number 796.

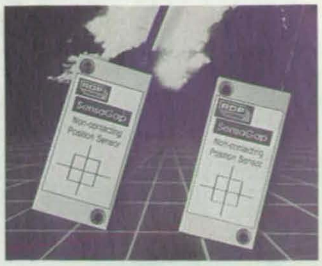


A superconducting four-bit **shift register chip** developed by Hypres Inc., Elmsford, NY, operates at 9.6 GHz and dissipates only 40 uW, making it the world's fastest superconducting shift register. This high speed is reached using 3.0-μm geometries. By comparison, GaAs circuits typically require 0.5-μm geometries to attain similar performance. The new device serves as a test bed for a unique edge-triggered circuit design developed by Hypres for building logic devices.
Circle Reader Action Number 792.

A small, lightweight **gyroscope** developed by Gyration Inc., Saratoga, CA, allows motion to be sensed and tracked digitally in real time with little power consumption. Called the GyroEngine, it is designed to expand gyroscope usage to high-volume, mainstream commercial products such as PCs, video cameras, and automobile navigation devices. Gyration has incorporated this technology in a new 2D/3D pointer input device, dubbed GyroPoint, for PC and workstation users.
Circle Reader Action Number 776.

Photo Research, Chatsworth, CA, has introduced a portable, NIST-traceable luminance **telephotometer/colorimeter** designated the PR-650 SpectraColorimeter™. The instrument allows simultaneous capture of the entire visible spectrum (380-780 nm) in near real time. An integrated circuit memory card retains the operating software and enables storage of over 150 full-spectrum measurements. Applications include photometry and colorimetry of displays in the automotive, aerospace, and computer industries; reflectance and transmittance of sources and samples; human factors testing; and vision research.
Circle Reader Action Number 794.

Dynamic Soft Analysis Inc., Pittsburgh, PA, has released the BETA-soft-System, **CAE software** for thermal analysis of total electronic systems. The software helps engineers to determine cooling strategy and the system's thermal specification, and to minimize overall product volume. Available on DOS-based PCs and Sun SPARCstations, BETA soft-system supports the design of electronic card-cages and cabinets containing multiple shelves with many boards on each shelf.
Circle Reader Action Number 798.



RDP Electrosense, Pottstown, PA, has introduced SensaGap, a **non-contacting sensor** based on a patented capacitive technique for detection and accurate measurement of linear displacement, position, proximity, vibration, gaps, and tolerances. An integral hybrid electronic circuit provides DC-in DC-out performance with a 0 to 3.5 v output from a 15 v supply. Available in 2.5, 5, and 10 mm sizes, SensaGap provides a linear performance of 0.5 percent FS maximum.
Circle Reader Action Number 774.

Quantum Magnetics Inc., San Diego, CA, has produced a prototype of the first commercial product to apply **superconducting electronics** to the field of nondestructive testing. The instrument, a high-resolution scanning magnetometer, will allow researchers to investigate the potential of SQUID (superconducting quantum interference device) magnetometers—the most sensitive magnetic field detectors in existence—for nondestructive testing of metallic and composite structures. Quantum Magnetics engineers are working to improve the magnetometer's spatial resolution to 100 microns, approximately the diameter of a human hair. Possible applications include testing the corrosion resistance of coatings, inspecting magnetic disk drives, locating subsurface cracks in metals, and identifying components likely to fail in nuclear power plants.
Circle Reader Action Number 786.

Micro Express, Santa Ana, CA, has developed a **notebook PC** that is powerful enough to be used as an engineering workstation. The 33 MHz, 80386-based NB3300 offers 32k of RAM cache, zero wait-state operation, and page-mode/interleaved memory organization. Its high-contrast, 9-inch black on white LCD screen has 640 x 480 pixel resolution and can display 32 levels of grey scale.
Circle Reader Action Number 788.

New Literature

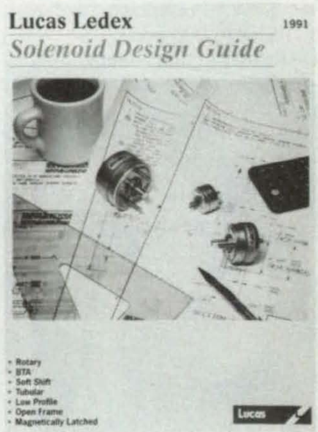
A new shortform catalog from Control Sciences Inc., Chatsworth, CA, describes over 60 families of **data converter products** for synchros, resolvers, LVDTs, RVDTs, and Inductosyns. Featured products include the first handheld synchro and resolver meters and a 16-bit S/D (R/D6) 2" x 2" micro-module with synthesized reference and three-state outputs.
Circle Reader Action Number 720.

Morgan Matroc's Duramic Division, Palisades Park, NJ, has published a brochure detailing the properties and potential mechanical and electric/electronic applications of precision **alumina components**. High-purity alumina offers high chemical resistance to both acids and alkalies, dimensional stability at high temperatures, excellent dielectric and nuclear properties, and abrasion resistance. The brochure includes a table of mechanical properties for materials with purities up to 99.5 percent.
Circle Reader Action Number 724.

A 16-page brochure describes the **custom hybrid design and fabrication capabilities** of Natel Engineering Co., Simi Valley, CA. The four-color publication highlights the company's hybrid and modular synchro conversion products, synchro simulators, and transducer instrumentation, and details its thick film production facility.
Circle Reader Action Number 726.

New and hard-to-find **electronic components** for industrial applications are featured in a brochure from Richardson Electronics Ltd., LaFox, IL. The 12-page catalog highlights power tubes, microwave magnetrons, SCRs, high-voltage capacitors, and resistors used in power supplies for induction and dielectric heating, resistance welding, motor controls, lasers, and RF sputtering/plasma etching.
Circle Reader Action Number 722.

A 144-page engineering guide from Lucas Ledex, Vandalia, OH, highlights standard **linear and rotary solenoids**, including high-precision rotary, low-profile, tubular, magnetic latching, and brushless torque actuation models. The guide provides unit specifications, application data, and solenoid fundamentals to aid designers in selecting the correct solenoid for an application.
Circle Reader Action Number 718.



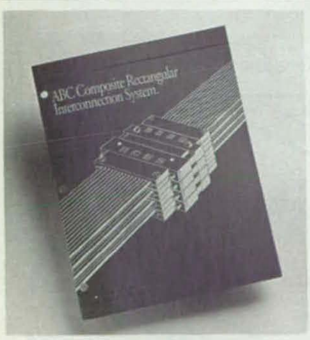
Daytronic Corp., Miamisburg, OH, has released a four-page brochure on its WorkBench PC™ **software for data acquisition and control**. The icon-driven software simplifies industrial and laboratory datalogging, monitoring, controlling, testing, analysis, and simulation. It can be used with Daytronic's IBM-compatible PC-I/O cards to measure and display temperature, pressure, flow, and other analog inputs from sensors or instruments, and can control heaters, pumps, and motors.
Circle Reader Action Number 716.

Endevco Corp., San Juan Capistrano, CA, has released a **pressure transducer** selection guide that details performance characteristics of its series 8500 transducers. The guide sorts products by application requirements in the automotive, aerospace, petrochemical, marine, and medical industries.
Circle Reader Action Number 728.

New Literature

Xerox Engineering Systems, Rochester, NY, is offering free subscriptions to *Template* magazine, written for professionals involved in the creation, management, and distribution of **engineering documents**. Introduced in 1989, *Template* has covered issues ranging from how engineers will create and manage their documents at the turn of the century to how the principle of concurrent engineering is becoming the status quo in US industry.
Circle Reader Action Number 742.

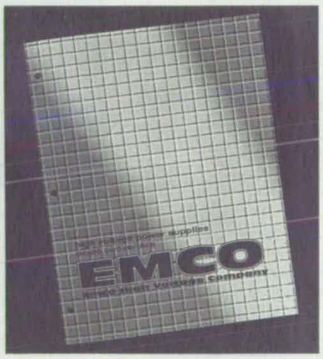
Zymark Corp., Hopkinton, MA, publishes a newsletter entitled *Environmental Lab Automation Notes* to inform environmental industry scientists and managers of developments in **laboratory automation**. The quarterly newsletter reviews recent regulatory developments and includes product updates. The latest edition features articles on GPC cleanup for environmental extracts, pesticide analysis using large-volume solid-phase extraction, and solvent reclamation using the TurboVap 500.
Circle Reader Action Number 732.



A free brochure from Deutsch Engineered Connecting Devices, Banning, CA, describes the new solderless ABC composite rectangular **connector**, a lightweight interconnection system for hi-rel applications such as radar and avionics. The connector's sealed design features composite material shells and modules that meet MIL-STD 1344A for high-altitude immersion testing of moisture resistance. Its metallized coating is resistant to temperature, pressure, and vibration.
Circle Reader Action Number 740.

Ultra-accurate **positioning systems** are featured in a new catalog from Teletrac Inc., Goleta, CA. The 28-page publication provides an introduction to the theory of laser interferometer systems and covers single- and multi-axis measurement systems, OEM components, controllers, and special configurations. Information about Teletrac's new Laser Tracking AutoFocus system, which adds autofocus capability to many popular microscopes, is also included.
Circle Reader Action Number 738.

EMCO High Voltage Co., Sutter Creek, CA, has released a **DC to DC power supply** catalog featuring several new lines of converters, such as the PD series, offering .001 percent regulation and low ripple in a small package suitable for photomultiplier tube applications, and the PC series, also highly regulated and PC board-mountable. Also included is EMCO's line of helium neon laser power supplies, which provide minimum 85 percent efficiency.
Circle Reader Action Number 704.



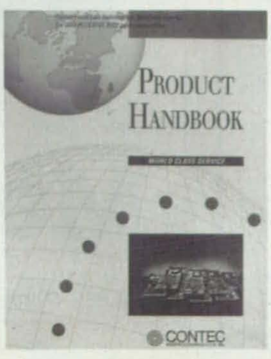
A shortform catalog published by Array Microsystems Inc., Colorado Springs, CO, describes its high-performance **digital signal processing** integrated circuits, board products, and software support tools. The 24-page catalog details the company's 400 million operations per second digital array signal processor and programmable array controller chipsets, as well as its VME-bus and PC-AT bus frequency domain array processor boards.
Circle Reader Action Number 710.

A full-color brochure published by Nicolet Instrument Corp., Madison, WI, showcases **electronic instruments** for chemical analysis and research, electrophysiological diagnosis and monitoring, and electronic test and measurement. The guide features Fourier transform infrared spectroscopes, liquid and gas analyzers, biomedical instruments, and digital oscilloscopes.
Circle Reader Action Number 702.

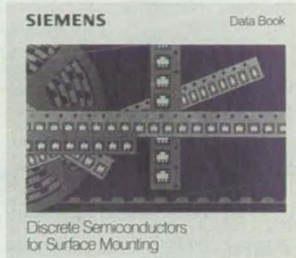
A new **microcomputer packaging systems** catalog from Schroff Inc., Warwick, RI, features VMEbus, VXIbus, Futurebus+, and Multibus II products and system components based on the euroboard standard. The free 144-page publication includes a new line of subracks, electronic cases, high-speed backplanes, test adaptors, drive units, and power supplies available as assembled systems or kits.
Circle Reader Action Number 734.

The use of copper vapor lasers (CVLs) to illuminate and freeze objects for **high-speed photography** is the subject of a paper by Oxford Lasers Inc., Acton, MA. The unique properties of CVLs enable photography of subjects not visible with standard light sources. A second paper discusses the **cryogenic processing of excimer laser gas mixtures** to reduce running and maintenance costs and enhance system performance. Cryogenic processing removes contaminants on an on-line, continuous basis to extend excimer laser gas lifetime.
Circle Reader Action Number 708.

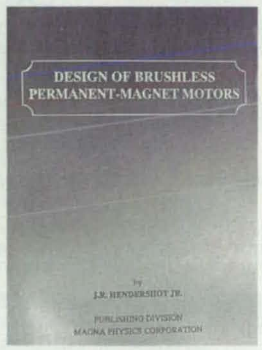
A product handbook from CONTEC Microelectronics USA Inc., San Jose, CA, features a wide range of **interface boards** for the IBM PC/XT/AT, PS/2, and compatibles that enable data acquisition and control in factory and laboratory environments. The 144-page catalog contains specifications for analog and digital I/O interfaces, timers/counters, communication interfaces, motor/machine control interfaces, and virtual memory boards. It also includes accessories, image processing equipment, and application and utility software.
Circle Reader Action Number 712.



A 952-page data book describes **discrete semiconductors** for surface mounting available from Siemens Components Inc., Iselin, NJ. The publication covers diodes, transistors, GaAs FETs, GaAs MMICs, and sensors. It provides thermal resistance data, package types, and mounting information.
Circle Reader Action Number 730.



Metra Martech Ltd., London, England, has compiled a directory of **European laser manufacturers**, as well as research, testing, and academic facilities. Covering 20 countries, the guide lists over 1500 European organizations active in the laser field. It includes contact names and details opportunities for collaborative R&D.
Circle Reader Action Number 714.



Design of Brushless Permanent-Magnet Motors, published by Magna Physics Corp., Hillsboro, OH, covers basic design decisions regarding magnet materials, lamination grades, rotor designs, and number of rotor poles, stator teeth, and phases for various applications. The 200-page illustrated handbook features previously unpublished design shortcuts for winding arrangements, a complete list of pole and slot combinations for 2-,4-,5-, and 6-phase motors, and details on cogging and detent torques.
Circle Reader Action Number 706.

The *Industrial Graphite Engineering Handbook*, prepared by products and materials engineers at UCAR Carbon Company Inc., Danbury, CT, provides information on graphite grades, properties, and manufacturing. It describes applications in the metallurgical, chemical, aerospace, nuclear, electrical, and electronics fields, including graphite's lastest use as high-temperature radiation shielding.
Circle Reader Action Number 736.

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Subject Index

A

AERODYNAMICS
Experiments to verify computed flows
page 80 ARC-12231

AIRCRAFT SPIN
Selectable-towline spin-chute system
page 84 LAR-14322

AIRFOILS
Pneumatic spoiler controls airfoil lift
page 71 ARC-11519

ALGORITHMS
Algorithm derives rules from data
page 96 NPO-18114
Removing ambiguities in remotely sensed winds
page 99 NPO-18079

ANTIFRICTION BEARINGS
Flexure bearing reduces startup friction
page 72 LAR-14348

APPLICATIONS PROGRAMS (COMPUTERS)
DOS batch files as control programs
page 101 MSC-21570

ARC WELDING
Automatic control of length of welding arc
page 91 MSC-21473
Jointed holder for welding electrodes
page 95 MFS-29739

ARCHITECTURE (COMPUTERS)
Study of candidate architectures for data processor
page 48 MSC-21690

ARTIFICIAL INTELLIGENCE
Valve- and switch-monitoring computer program
page 98 MSC-21720

B

BALL BEARINGS
Flexure bearing reduces startup friction
page 72 LAR-14348

BANDPASS FILTERS
Nonlinear dynamic compensation for feedback control
page 47 NPO-17993

BATCH PROCESSING
DOS batch files as control programs
page 101 MSC-21570

BEAMS (SUPPORTS)
Temperature, thermal stress, and creep in a structure
page 81 ARC-12213

BEARINGS
Servo reduces friction in flexure bearing
page 74 LAR-14349

BOLTS
Lockwasher strongly resists disassembly
page 93 MFS-29696

BRAZING
Uniform-dead-weight brazing
page 91 MSC-21627

C

CHEMISORPTION
Reversible chemisorption gas-gap thermal switch
page 54 NPO-17568

CIRCUITS
Driver circuit for high-power MOSFET's
page 28 LEW-15089

COMPUTATIONAL FLUID DYNAMICS
Experiments to verify computed flows
page 80 ARC-12231

COMPUTATIONAL GRIDS
Computation of flow in a turbine stage on a refined grid
page 90 ARC-12444

COMPUTERIZED SIMULATION
Program for parallel discrete-event simulation
page 69 NPO-18037

CONCURRENT PROCESSING
Program for parallel discrete-event simulation
page 69 NPO-18037

CONFIDENCE LIMITS
Developing confidence limits for reliability of software
page 102 LAR-14292

CONSTRAINTS
Solving constraint-satisfaction problems in prolog language
page 101 ARC-12460

CONTOUR SENSORS
Contact probe with pivoting tip
page 77 MFS-28536

CONVERGENT-DIVERGENT NOZZLES
Two-phase Hero turbine with curved nozzles
page 87 NPO-18059

CREEP ANALYSIS
Temperature, thermal stress, and creep in a structure
page 81 ARC-12213

CRYOGENIC FLUIDS
Improved ultrasonic transducer for measuring cryogenic flow
page 78 MFS-29687

D

DATA PROCESSING
Algorithm derives rules from data
page 96 NPO-18114
Study of candidate architectures for data processor
page 48 MSC-21690

DATA REDUCTION
Dynacounter electronic data-reduction system
page 46 MSC-21568

DATA RETRIEVAL
Video image communication and retrieval — updated
page 66 NPO-18076

DIAMONDS
Diamond-coated wire-feeding nozzle
page 93 MFS-29714

DIODES
Multiple integrated in-line diode lasers
page 34 LAR-14378

DISCONNECT DEVICES
Redundant toggle/hook release mechanism
page 71 MSC-21671

DOPPLER RADAR
Ambiguity of Doppler centroid in synthetic-aperture radar
page 48 NPO-17943

DROPS (LIQUIDS)
Vapor-screen-density controller
page 38 LAR-14099

E

ELASTIC WAVES
Software models impact stresses
page 65 MFS-29628

ELECTRICAL RESISTIVITY
Measuring electrical resistivity of compacted powder
page 58 NPO-18056

ELECTRODES
Jointed holder for welding electrodes
page 95 MFS-29739

EYE (ANATOMY)
Compensating for movement of eye in laser surgery
page 46 MSC-21509

F

FASTENERS
Lockwasher strongly resists disassembly
page 93 MFS-29696

FATIGUE (MATERIALS)
Alloy has high fatigue strength in hydrogen
page 62 MFS-28464
Dynacounter electronic data-reduction system
page 46 MSC-21568

FEEDBACK
Digital phase-locked loop with phase and frequency feedback
page 36 NPO-17722

FEEDBACK CONTROL
Nonlinear dynamic compensation for feedback control
page 47 NPO-17993

FEEDING (SUPPLYING)
Diamond-coated wire-feeding nozzle
page 93 MFS-29714

FIBERS
Effects of interference on scattering by parallel fibers
page 60 ARC-12530

FIELD EFFECT TRANSISTORS
Driver circuit for high-power MOSFET's
page 28 LEW-15089

FIXTURES
Magnetic-bearing test fixture
page 82 LAR-14312

FLOW EQUATIONS
Computation of flow in a turbine stage on a refined grid
page 90 ARC-12444

FLOW REGULATORS
Pressure-actuated flow-control valve
page 74 MFS-28513

FLOW VISUALIZATION
Digital image velocimetry
page 96 ARC-12474

FLOW VISUALIZATION
Vapor-screen-density controller
page 38 LAR-14099

FLUID DYNAMICS
Experiments to verify computed flows
page 80 ARC-12231

FLUID FLOW
Improved ultrasonic transducer for measuring cryogenic flow
page 78 MFS-29687

FLUIDIZED BED PROCESSORS
Fluidized-bed silane-decomposition reactor
page 63 NPO-18014

FUEL FLOW REGULATORS
Pressure-actuated flow-control valve
page 74 MFS-28513

G

GAS TUNGSTEN ARC WELDING
Automatic control of length of welding arc
page 91 MSC-21473
Diamond-coated wire-feeding nozzle
page 93 MFS-29714
Jointed holder for welding electrodes
page 95 MFS-29739

GEODESY
Estimating baselines from constrained data on GPS orbits
page 40 NPO-18173

GIMBALS
Flexure bearing reduces startup friction
page 72 LAR-14348

GLOBAL POSITIONING SYSTEM
Estimating baselines from constrained data on GPS orbits
page 40 NPO-18173

H

HALL EFFECT
Magnet/Hall-effect random-access memory
page 28 NPO-17999

HEAT TRANSFER
Effects of interference on scattering by parallel fibers
page 60 ARC-12530

HYDROGEN EMBRITTLEMENT
Alloy has high fatigue strength in hydrogen
page 62 MFS-28464

I

IMAGE ANALYSIS
Digital image velocimetry
page 96 ARC-12474

IMAGE PROCESSING
Video image communication and retrieval — updated
page 66 NPO-18076

IMPACT LOADS
Software models impact stresses
page 65 MFS-29628

INFORMATION THEORY
Algorithm derives rules from data
page 96 NPO-18114

INFRARED DETECTORS
Proceedings of infrared-detector workshop
page 60 ARC-12851

INTEGRATED CIRCUITS
Addressable-matrix integrated-circuit test structure
page 32 NPO-18162

INTERFEROMETRY
Single-exposure long-equivalent-wavelength interferometry
page 52 NPO-17580

L

LANDING MODULES
Reusable manned lunar vehicle
page 89 MFS-28454

LASER APPLICATIONS
Compensating for movement of eye in laser surgery
page 46 MSC-21509

LASER INTERFEROMETRY
Single-exposure long-equivalent-wavelength interferometry
page 52 NPO-17580

LASERS
Multiple integrated in-line diode lasers
page 34 LAR-14378

LIFT
Pneumatic spoiler controls airfoil lift
page 71 ARC-11519

LOOPS
Digital phase-locked loop with phase and frequency feedback
page 36 NPO-17722

LUNAR SPACECRAFT
Reusable manned lunar vehicle
page 89 MFS-28454

M

MAGNETIC BEARINGS
Magnetic-bearing test fixture
page 82 LAR-14312

MAGNETIC STORAGE
Magnetic analog random-access memory
page 30 NPO-17998

MANNED SPACECRAFT
Reusable manned lunar vehicle
page 89 MFS-28454

MECHANICAL DEVICES
Redundant toggle/hook release mechanism
page 71 MSC-21671

MECHANICAL PROPERTIES
Layered plating specimens for mechanical tests
page 94 MFS-29718

MEMORY (COMPUTERS)
Magnet/Hall-effect random-access memory
page 28 NPO-17999
Magnetic analog random-access memory
page 30 NPO-17998

METAL PLATES
Uniform-dead-weight brazing
page 91 MSC-21627

MICROMETERS
Measuring electrical resistivity of compacted powder
page 58 NPO-18056

MIRRORS
Conical mirrors for quasi-retroreflection
page 54 NPO-18005

MIXING
Three-dimensional structure of a mixing layer
page 79 ARC-12506

N

NICKEL ALLOYS
Alloy has high fatigue strength in hydrogen
page 62 MFS-28464

NONLINEAR FEEDBACK
Nonlinear dynamic compensation for feedback control
page 47 NPO-17993

NOZZLE GEOMETRY
Two-phase Hero turbine with curved nozzles
page 87 NPO-18059

O

OCEAN SURFACE
Removing ambiguities in remotely sensed winds
page 99 NPO-18079

OPERATING SYSTEMS (COMPUTERS)
DOS batch files as control programs
page 101 MSC-21570

OPERATORS (PERSONNEL)
Valve- and switch-monitoring computer program
page 98 MSC-21720

P

PARACHUTES
Selectable-towline spin-chute system
page 84 LAR-14322

PARALLEL PROCESSING (COMPUTERS)
Program for parallel discrete-event simulation
page 69 NPO-18037

PHASE LOCKED SYSTEMS
Digital phase-locked loop with phase and frequency feedback
page 36 NPO-17722

PIVOTS
Contact probe with pivoting tip
page 77 MFS-28536

PLATES (STRUCTURAL MEMBERS)
Fully-stressed-design algorithm for plate/shell structures
page 75 ARC-12687

PLATING
Layered plating specimens for mechanical tests
page 94 MFS-29718

POWDER (PARTICLES)
Measuring electrical resistivity of compacted powder
page 58 NPO-18056

PROBES
Contact probe with pivoting tip
page 77 MFS-28536

PROBLEM SOLVING
Solving constraint-satisfaction problems in prolog language
page 101 ARC-12460

PROLOG (PROGRAMMING LANGUAGE)
Solving constraint-satisfaction problems in prolog language
page 101 ARC-12460

PYROLYSIS
Fluidized-bed silane-decomposition reactor
page 63 NPO-18014

Q

QUALITY CONTROL
Addressable-matrix integrated-circuit test structure
page 32 NPO-18162

R

RADAR IMAGERY
Ambiguity of Doppler centroid in synthetic-aperture radar
page 48 NPO-17943

RADIATIVE TRANSFER
Effects of interference on scattering by parallel fibers
page 60 ARC-12530

RADIOMETERS
Proceedings of infrared-detector workshop
page 60 ARC-12851

RANDOM ACCESS MEMORY
Magnet/Hall-effect random-access memory
page 28 NPO-17999
Magnetic analog random-access memory
page 30 NPO-17998

RECOVERY PARACHUTES
Selectable-towline spin-chute system
page 84 LAR-14322

REFLECTORS
Conical mirrors for quasi-retroreflection
page 54 NPO-18005

REFRIGERATING
Reversible chemisorption gas-gap thermal switch
page 54 NPO-17568

RELEASING
Redundant toggle/hook release mechanism
page 71 MSC-21671

RELIABILITY ANALYSIS
Computing availability and reliability for a system
page 70 NPO-18051
Developing confidence limits for reliability of software
page 102 LAR-14292

REMOTE SENSING
Removing ambiguities in remotely sensed winds
page 99 NPO-18079

RETINA
Compensating for movement of eye in laser surgery
page 46 MSC-21509

RETROREFLECTION
Conical mirrors for quasi-retroreflection
page 54 NPO-18005

RULES
Algorithm derives rules from data
page 96 NPO-18114

S

SCREWS
Lockwasher strongly resists disassembly
page 93 MFS-29696

SEMICONDUCTOR DEVICES
Proceedings of infrared-detector workshop
page 60 ARC-12851

SEMICONDUCTOR LASERS
Multiple integrated in-line diode lasers
page 34 LAR-14378

SERVOCONTROL
Servo reduces friction in flexure bearing
page 74 LAR-14349

SHELLS (STRUCTURAL FORMS)
Fully-stressed-design algorithm for plate/shell structures
page 75 ARC-12687

SILICON
Fluidized-bed silane-decomposition reactor
page 63 NPO-18014

SOFTWARE TOOLS
Computing availability and reliability for a system
page 70 NPO-18051
Developing confidence limits for reliability of software
page 102 LAR-14292

SORPTION
Reversible chemisorption gas-gap thermal switch
page 54 NPO-17568

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SPACECRAFT COMMUNICATION
Study of candidate architectures for data processor
page 48 MSC-21690

SPATIAL FILTERING
Single-exposure long-equivalent-wavelength interferometry
page 52 NPO-17580

SPOILERS
Pneumatic spoiler controls airfoil lift
page 71 ARC-11519

STAINLESS STEELS
Uniform-dead-weight brazing
page 91 MSC-21627

STATISTICAL ANALYSIS
Dynacounter electronic data-reduction system
page 46 MSC-21568

STRESS ANALYSIS
Software models impact stresses
page 65 MFS-29628

STRESS RATIO
Fully-stressed-design algorithm for plate/shell structures
page 75 ARC-12687

SWITCHES
Valve- and switch-monitoring computer program
page 98 MSC-21720

SWITCHING CIRCUITS
Driver circuit for high-power MOSFET's
page 28 LEW-15089

SYNTHETIC APERTURE RADAR
Ambiguity of Doppler centroid in synthetic-aperture radar
page 48 NPO-17943

SYSTEMS ANALYSIS
Computing availability and reliability for a system
page 70 NPO-18051

T

TENSILE TESTS
Layered plating specimens for mechanical tests
page 94 MFS-29718

TEST EQUIPMENT
Magnetic-bearing test fixture
page 82 LAR-14312

TESTERS
Addressable-matrix integrated-circuit test structure
page 32 NPO-18162

THERMAL STRESSES
Temperature, thermal stress, and creep in a structure
page 81 ARC-12213

THIN FILMS
Diamond-coated wire-feeding nozzle
page 93 MFS-29714

TORQUERS
Servo reduces friction in flexure bearing
page 74 LAR-14349

TURBINES
Computation of flow in a turbine stage on a refined grid
page 90 ARC-12444

Two-phase Hero turbine with curved nozzles
page 87 NPO-18059

TURBULENT MIXING
Three-dimensional structure of a mixing layer
page 79 ARC-12506

U

ULTRASONIC WAVE TRANSDUCERS
Improved ultrasonic transducer for measuring cryogenic flow
page 78 MFS-29687

V

VALVES
Pressure-actuated flow-control valve
page 74 MFS-28513

Valve- and switch-monitoring computer program
page 98 MSC-21720

VELOCITY MEASUREMENT
Digital image velocimetry
page 96 ARC-12474

VERY LONG BASE INTERFEROMETRY
Estimating baselines from constrained data on GPS orbits
page 40 NPO-18173

VIDEO DATA
Video image communication and retrieval — updated
page 66 NPO-18076

VORTICES
Three-dimensional structure of a mixing layer
page 79 ARC-12506

W

WASHERS (SPACERS)
Lockwasher strongly resists disassembly
page 93 MFS-29696

WAVE SCATTERING
Effects of interference on scattering by parallel fibers
page 60 ARC-12530

WELDING
Automatic control of length of welding arc
page 91 MSC-21473

WIND TUNNEL MODELS
Vapor-screen-density controller
page 38 LAR-14099

WIND (METEOROLOGY)
Removing ambiguities in remotely sensed winds
page 99 NPO-18079

WIRE
Diamond-coated wire-feeding nozzle
page 93 MFS-29714

ADVERTISERS INDEX

Advertiser	RAC	Page
3-D Visions	(RAC 669)*	9
Aerospace Optics, Inc.	(RAC 309)	35
Aerospatiale, Inc.	(RAC 530)	57
Aerospex Corporation	(RAC 591)	106
Agema Infrared Systems	(RAC 603)	19
Albany International, Inc.	(RAC 417)	12
Algor Interactive Systems, Inc.	(RAC 361)	66
Amco Engineering Co.	(RAC 500)	58
AMP	(RAC 657)	53
Ampex Data Systems Corp.	(RAC 595)	21
Apple Computer, Inc.		COV II-1
Anvil Cases	(RAC 528)	88
AZ-USA, Inc.	(RAC 478)	75
Ballard Technology	(RAC 619)	107
Bancomm	(RAC 658)	69
BTM Corporation	(RAC 522)	93
CAJON Company	(RAC 380)	73
Cole-Parmer Instrument Co.	(RAC 638, 533)	11, 49-51
Contempory Cybernetics Group	(RAC 411)	7
Crystal Mark, Inc.	(RAC 490)	24
Dataq Instruments, Inc.	(RAC 505)	106
Data Translation	(RAC 449)	56
Datum, Inc.	(RAC 549)	92
DGH Corporation	(RAC 491)	106
Dolphin Scientific, Inc.	(RAC 510)	48
DSP Development Corp.	(RAC 652)	COV IV
Dynamics Research Corp.	(RAC 601)	3
Electronic Imagery, Inc.	(RAC 356)	65
Elmo Manufacturing Corp.	(RAC 509)	76
Evergreen Systems International	(RAC 559)	106
Fenner	(RAC 383)	90
Flight	(RAC 413)	109
FLIR Systems, Inc.	(RAC 419)	17
Fluoramics, Inc.	(RAC 364)	70
Folsom Research	(RAC 648)	74
Frequency Electronics, Inc.	(RAC 640)	37
Galaxy Applied Engineering, Inc.	(RAC 406)	102
Gould Test & Measurement	(RAC 484)	29,31
Hardigg Cases	(RAC 492)	47
Houston Instrument	(RAC 550)	55
IBM Corporation		27
Information Handling Services	(RAC 546,616)	13,61
Integra Furniture, Inc.	(RAC 485)	110
International Light, Inc.	(RAC 645)	100
John Fluke Mfg. Co., Inc.	(RAC 667)	97
Kevex X-Ray	(RAC 531)	23
Laser Technology, Inc.	(RAC 629)	77
Lincoln Laser Company	(RAC 593)	78
Magnetic Instrumentation, Inc.	(RAC 348)	107
Magnetic Shield Corp.	(RAC 370)	60
MathSoft, Inc.	(RAC 682)	33
Maxwell Laboratories, Inc.	(RAC 460)	40
Mechanical Dynamics, Inc.	(RAC 548)	2
Meridian Laboratory	(RAC 377)	87
Merlin	(RAC 339)	106
Microstar Laboratories	(RAC 552)	100
Midwest Research Technologies	(RAC 390)	110
Minco Products, Inc.	(RAC 308)	88
Moritex U.S.A., Inc.	(RAC 317)	80
MTI Instruments	(RAC 365)	84
NAC Visual Systems	(RAC 639)	39
NASA Calendars		104
National Instruments	(RAC 681)	83
Nicolet Instruments	(RAC 697)	25
Numerical Algorithms Group, Inc.	(RAC 477)	18
Odetics	(RAC 347)	104
Patton & Patton Software Corp.	(RAC 499)	16
Penn Engineering & Mfg. Corp.	(RAC 340)	99
Polaroid Corporation	(RAC 685)	89
Precision Filters, Inc.	(RAC 306)	79
Quantitative Technology Corp.	(RAC 633)	75
Ramco Electric Company	(RAC 447)	106
Rexham Industrial	(RAC 369)	95
RGB Spectrum	(RAC 467)	8
Rolyn Optics Co.	(RAC 551)	107
Scientific Programming Enterprises	(RAC 408)	101
Scientific Solutions, Inc.	(RAC 573)	COV III
Seikosha America, Inc.	(RAC 462)	5
Servometer Corporation	(RAC 490)	97
Specac Analytical, Inc.	(RAC 621)	106
Spiral Software	(RAC 563)	94
Structural Research & Analysis Corporation	(RAC 676)	81
Syntex Rubber Corporation	(RAC 515)	72
Technology 2001		41-45
The MathWorks, Inc.	(RAC 503)	59
The Recorder Company	(RAC 519)	106
The Soundcoat Company	(RAC 438)	63
Tiodize Company, Inc.	(RAC 422)	64
Tucker-Davis Technologies	(RAC 444)	106
U.S. Department of Energy	(RAC 416)	108
Valco Instrument Co., Inc.	(RAC 498)	4
W.H. Brady Company	(RAC 637)	87
Zero East	(RAC 314, 315)	98
Zero Plastics	(RAC 614)	64

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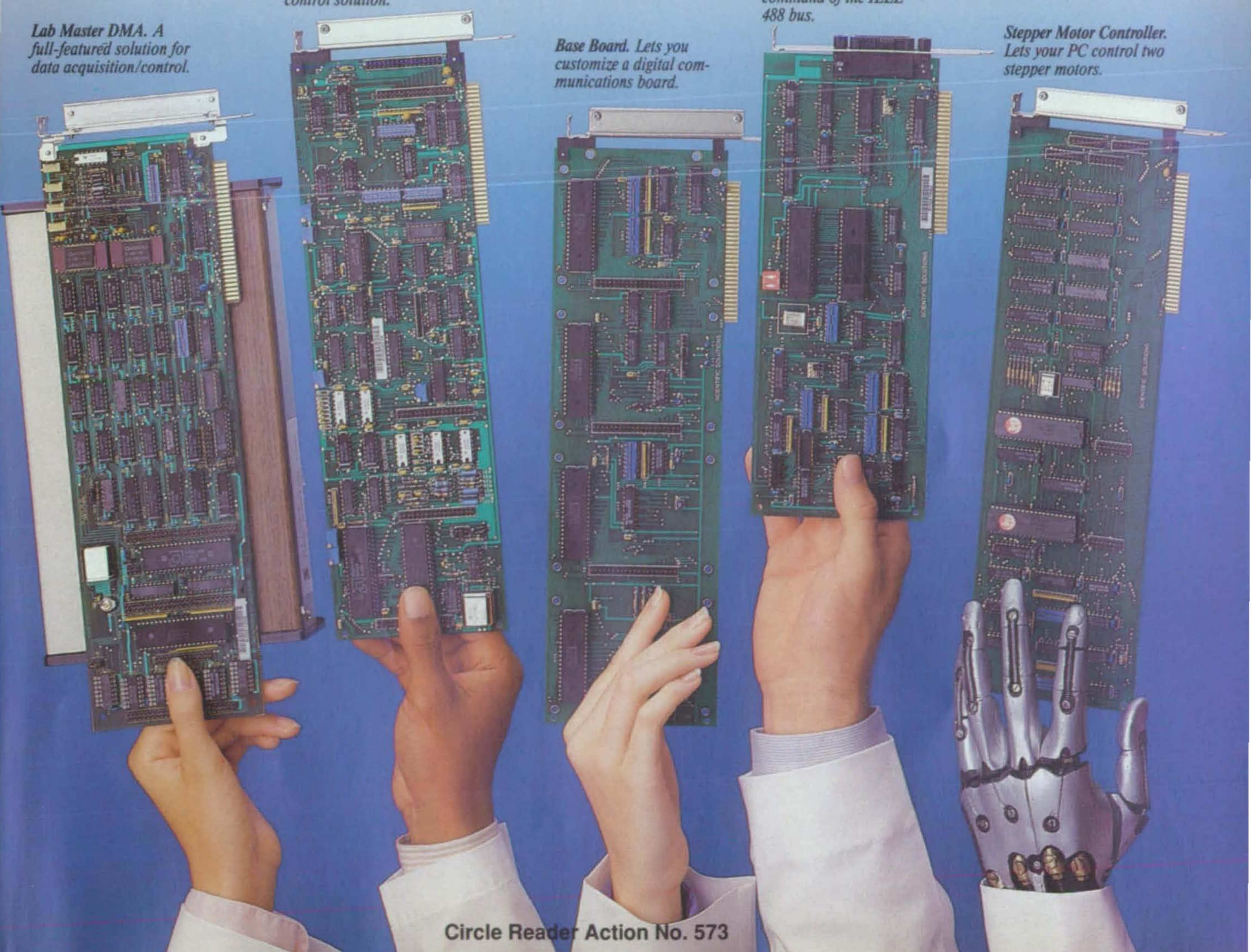

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