NASA Tech Briefs

THE DIGEST OF NEW TECHNOLOGY

Official Publication of the National Aeronautics and Space Administration
April 1995 Vol.19 No. 4

Transferring Engineering Technology to Over 200,000 Qualified Readers Throughout Industry and Government

Dryden Pushes The Envelope

NASA's Invention Of The Year

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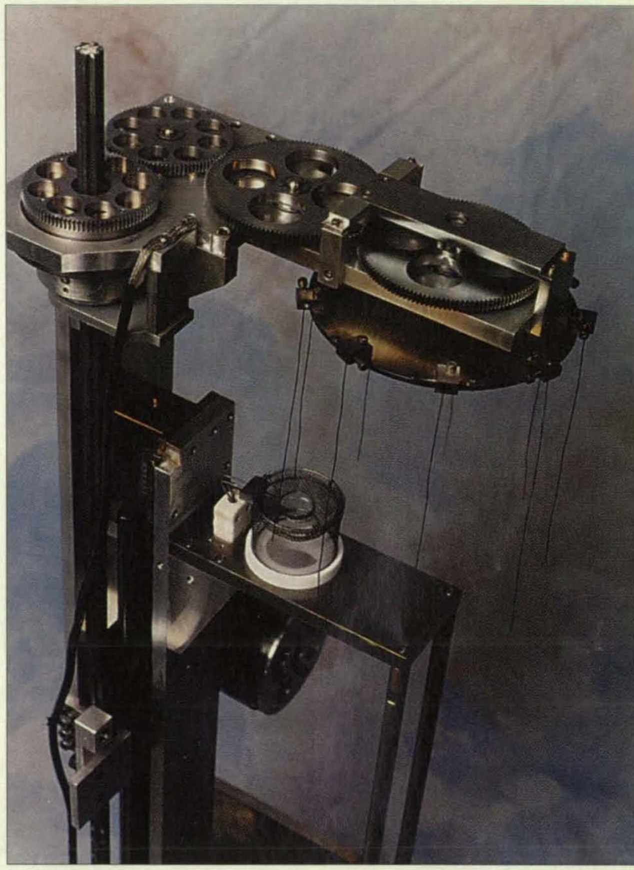
FEATURES

TECHNICAL SECTION



For Marshall Space Flight Center's Drop Tube Facility, an electron beam furnace has been redesigned to increase the number of experiments per loading. Both the electron source and the carousel mechanism are now mounted on the same plate, so they vibrate less and can be installed and aligned more quickly. The carousel diameter has also been changed to accommodate nine wire samples instead of four, increasing the number of experiments that can be performed. The furnace melts wires to make drops of molten metal for experiments on processing materials in a drop tube. See the brief on page 77.

Photo courtesy Goddard Space Flight Center

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Contents *(continued)*

On the cover:
The F-16XL is flown by NASA's Dryden Flight Research Center to investigate minimizing the sharp sound of sonic booms from supersonic aircraft. Sensors on the F-16-XL measure the distribution patterns of sonic booms generated by an SR-71 flying just above and ahead of the F-16-XL. This research could lead to altering aircraft shapes to reduce the startling factor of the sonic booms. For more resources available at Dryden, turn to page 16.

Photo courtesy of Dryden Flight Research Center

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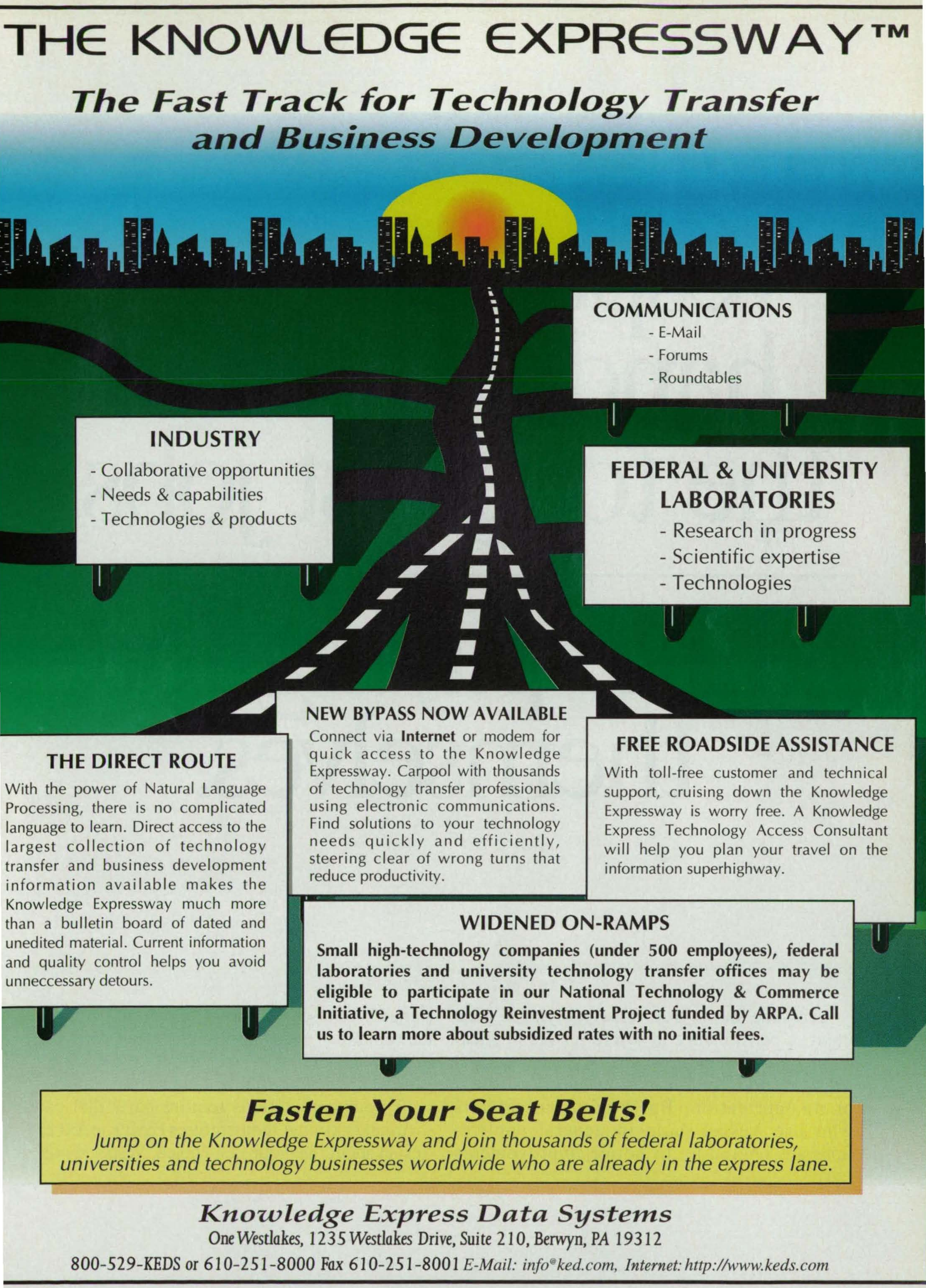
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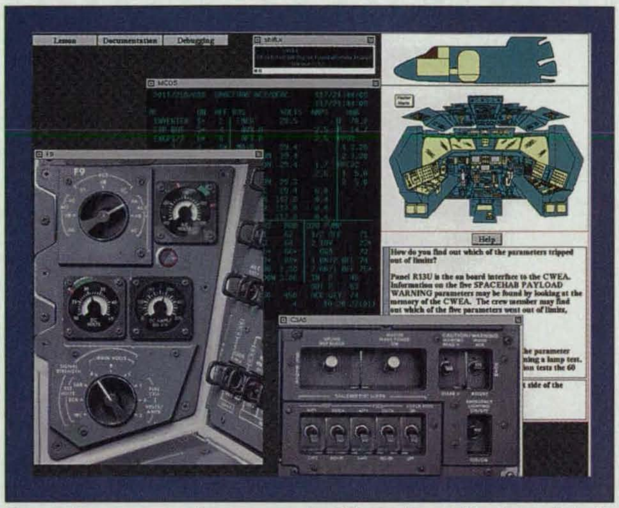
NASA's Invention of the Year:

The General-Purpose Architecture for Intelligent Computer-Aided Training

Inventors: R. Bowen Loftin, Lui Wang, Paul T. Baffes, and Grace T. Hua, Johnson Space Center

Training, as distinct from tutoring or teaching, often demands a high degree of flexibility or freedom in the way the trainee does a task. The most effective training methods, such as one-on-one and on-the-job, are labor-intensive and often impractical, especially when few experienced personnel can spare the time to train. To remedy this dilemma, a research team at Johnson Space Center designed computer software that can meet the needs of the trainee and fill in for the expertise of the human trainer.



Computer screen of a space shuttle trainer displays details from shuttle control panel.

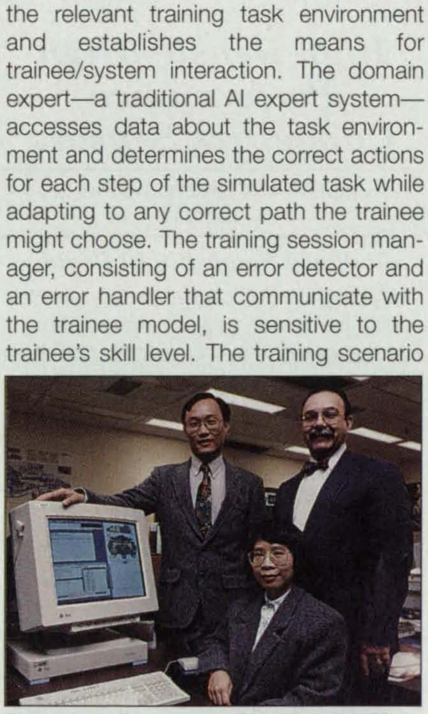
Rather than a training program in itself, the general-purpose architecture for intelligent computer-aided training (ICAT) is a computer system for forming specific training programs. Its basic concept is the emulation of the human expert in a given field who focuses full attention on the individual trainee, proposes training scenarios, monitors and evaluates the trainee, appropriately responds to trainee errors, and answers trainee requests for information.

"The best way to think of it is as a framework or an architecture upon which you can build a particular application," said Dr. F. Bowen Loftin, who developed the award-winning system with Lui Wang, Paul T. Baffes, and Grace C. Hua. "We tried to design an approach that preserves the parts of a system that don't have to change from application to application, enabling people to add on the things that are peculiar to their needs.

"Historically these systems have been built one at a time—uniquely—and that's a time-consuming process," Dr. Loftin said. "So our goal was to build a way to do it without having to reinvent the wheel every time."

The system consists of six modules, each fulfilling one of the expert-emulation goals: the user interface, the domain expert, the training session manager, the training scenario generator, the trainee model, and the blackboard module, an intermodule interface that relays messages directed from module to module; thus, the modules control themselves and eliminate the need for a central controller.

The user interface module simulates the relevant training task environment and establishes the means for trainee/system interaction. The domain expert—a traditional AI expert system—accesses data about the task environment and determines the correct actions for each step of the simulated task while adapting to any correct path the trainee might choose. The training session manager, consisting of an error detector and an error handler that communicate with the trainee model, is sensitive to the trainee's skill level. The training scenario generator module, with its database of parameters defining simulation scenarios, designs more and more complex training tasks according to the trainee's skill level. The trainee model communicates with the training session manager module about the trainee's correct actions and errors and compiles a trainee record; at the end of each session, it summarizes the errors and correct actions, the time taken by the trainee's session, and the assistance provided by the system.



Inventors of the general-purpose architecture for intelligent computer-aided training are (standing, left to right) Lui Wang and R. Bowen Loftin, (seated) Grace T. Hua, and (not pictured) Paul T. Baffes.

Initially developed for astronaut and flight controller training at Johnson, the ICAT system already has found numerous applications. "We sell it, if you will, as a procedural training device," Dr. Loftin said. "Procedural tasks are things like operating machinery, driving cars, and flying planes, where you can define specifically what one should do in a given circumstance".

The SpaceHab Intelligent Familiarization Trainer (SHIFT), a general purpose architecture ICAT system, replaced the Single System Trainer in astronaut training. Unlike traditional training systems, SHIFT could accommodate operational procedures daily and was made available in crew office workstations, providing ready access to training. Johnson designed the Instrument Pointing System/ICAT for Marshall Space Flight Center to train astronauts in the Astro Spacelab. The Center Information System Computer Operator (CISCO)/ICAT trains mainframe computer operators in infrequently performed operations such as power up, power down, and applications loads. Other applications include the Main Propulsion Pneumatics (MPP)/ICAT for Kennedy Space Center to train engineers in testing and troubleshooting the shuttle's MPP system, and the Active Thermal Control System (ATCS) ICAT for training flight controllers and astronauts in operating the space station ATCS.

Johnson also was commissioned to build ICAT systems to train US Army and National Guard tank crews. Moreover, Dr. Loftin led a team in developing the Intelligent Physics Tutor to help college and high school students acquire physics problem-solving skills; this software has been licensed to a Houston company, which will sell it to educational institutions.

Other developments in the works include an ICAT system for training software engineers in object-oriented programming methodology, as well as in training nurses and airline flight controllers.

Despite this wide range of applications, the general purpose architecture has its limits. "Humans work with incomplete data, and they [make] creative or intuitive leaps, and certainly we don't address those kinds of issues," Dr. Loftin said. However, "if you can write a manual that tells how to do something, we can probably train you through this system to do it."

1995 Award Finalists

Atomic Oxygen Resistant Polymers

John W. Connell, Paul M. Hergenrother, and Joseph G. Smith

Langley Research Center

At altitudes of low-Earth orbit, atomic oxygen (AO) reaches peak concentrations, wreaking havoc on the substrate commonly used in solar cell arrays and thermal blankets. Langley researchers developed an alternative, polymeric material that is resistant to AO and retains structural integrity.

In earlier attempts to solve the AO problem, engineers tried coating the substrate with a material such as silicon oxide that does not react significantly with AO. But these coatings are brittle and easily damaged by handling or micrometeorites; once an opening is made in the coating, the substrate is susceptible to rapid erosion by AO, about 0.001 inch in one 40-hour exposure experiment. By contrast, the new polymer, poly (arylene ether benzimidazole), or PAEBI, eroded only 0.00006-in. in the same 40-hour exposure experiment. Further, its erosion was not linear like that of the other substrate, so the rate decreased over time, whereas the standard substrate erodes until it disappears.

PAEBI's erosion resistance derives from the polymer's structure: when exposed to AO, it undergoes chemical reactions that form a thin, outer oxide layer. If this layer is damaged, it "self-heals" as the newly exposed polymer reacts with the AO to form more oxide layer.

PAEBI also can be extruded into threads or fibers and woven into multilayer thermal blankets. Compared to the two most common competing substrates, PAEBI saves 15-50% on weight and has 14-30% higher emissivity.

Triton Systems Inc., Chelmsford, MA, has licensed two PAEBI patents from Langley and soon will introduce its PAEBI film product, Aorimide. Target customers include Lockheed and Martin Marietta for NASA-funded projects such as the Earth Observation Satellite and space station Alpha, besides privately funded satellites.

Earth-bound applications of PAEBI include corona-resistant wire coatings, fire-resistant fibers for aircraft interiors, microelectronic applications that require direct adhesion to copper, and hollow fiber supports for high temperature/high pressure liquid separation modules used in industrial separation processes. IBM has tested the use of PAEBI in a process for making ceramic modules containing 60-90 layers of circuitry.

High Density/High Performance Capacitive Sensors

John M. Vranish and Robert L. McConnell

Goddard Space Flight Center

Offering unmatched accuracy and the ability to detect objects more than 12 inches away, the "Capaciflector" has found many commercial applications. Goddard researchers John Vranish and Robert L. McConnell developed the Capaciflector—a capacitive reflector sensor—to help keep robots in space from colliding with other objects. Its unusual range and sensitivity derives from an active reflector that reflects the electric field lines of the sensor capacitor away from a grounded robot arm toward an oncoming object.

Several Capaciflectors can be packed together in close proximity without crosstalk, opening new dimensions in capabilities. Goddard has developed an electrically scanned capacitive camera to provide 3D imaging to identify obstacles and mating interfaces and thus further improve control. A license has been signed with Computer Application Systems Inc. of Signal Mountain, TN, which will pursue such applications as a sensor for tower-painting robots for the Tennessee Valley Authority. Other applications include sensing fluid levels in pipes or vessels, determining fill-level in bulk packaging, and detecting motion.

The portable seat lift makes life easier for people with bad knees or hips.

Portable Seat Lift

Bruce Weddendorf

Marshall Space Flight Center

Bruce Weddendorf of Marshall Space Flight Center followed an orthopedic surgeon's suggestion and designed a portable seat lift for people with bad hips or knees. While sufferers may already have large stationary chairs at home, help under other circumstances is on the way.

Lightweight, briefcase-sized, capable of lifting 300 pounds, and powered by a dc motor with rechargeable batteries, the seat lift required careful CAD modeling to overcome structural problems. The challenge was to develop a mechanism that could provide stable lift over the large range of motion needed to raise a person to near-standing position, while folding flat enough to provide comfortable sitting.

The prototype demonstrated the concept and the mechanism's function. At least 16 companies have requested the licensing package for the patent. An estimated two million Americans are in need of such a device.

Catalyst for Carbon Monoxide Oxidation

Billy T. Upchurch, Irvina M. Miller, David R. Brown, Patricia P. Davis, David R. Schryer, Kenneth G. Brown, and John D. Van Norman (dec)

Langley Research Center

While finding a way to increase the power of spaceborne CO_2 lasers, a team at Langley Research Center also struck on something that can increase building safety and clean car exhaust. In CO_2 lasers, the dissociation products, CO and O_2, collect in the laser's discharge zone, the O_2 interfering with stable power output. One solution is to use catalysts that recombine CO and O_2 into CO_2, but this usually requires heating above the temperature of the laser envelope, calling for a pump and heating and cooling systems. These additions introduce more cost and weight to space-borne applications. Langley developed a catalyst that functions at the laser's operating temperature, making it feasible to increase the laser's power with little added weight.

The invention overcomes two main problems with previous catalysts: most of the stannic oxide catalyst, in the form of granules or pellets impregnated with colloidal particles, was below the surface and unavailable as active sites; further, the previous designs did not take advantage of chemiabsorbed moisture on the catalyst surface to enhance and prolong activity. The Langley design both increases the exposed surface area of the catalyst and incorporates chemiabsorbed water.

As studies have demonstrated, the presence of small amounts of water on the catalyst can help maintain catalytic activity at low temperatures as well as enhance sealed CO_2 laser output, while too much water vapor can decrease laser output. The new water-binding compound introduces just enough moisture to assist catalysis but not harm lasing. Very lightweight, with high efficiency and long life, the catalyst has allowed long-term CO_2 laser studies in space.

Langley and the Rochester (NY) Gas & Electric Co. jointly investigated using the catalyst for removing CO from residences and offices. Mantic Corporation, Salt Lake City, UT, has obtained a partially exclusive license to use the catalyst in personal CO removal masks. Other potential applications include CO removal from auto exhaust, CO sensors for alarm systems, and CO isotope separation.

Harsh Environment Strain Gauges

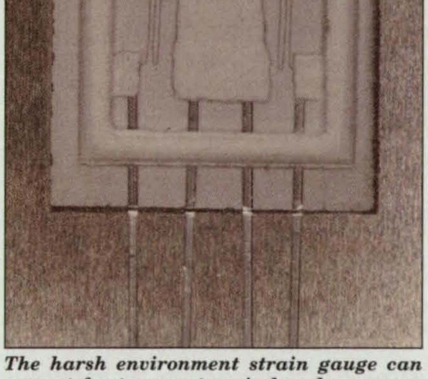
Thomas C. Moore

Langley Research Center

Designers of the National AeroSpace Plane (NASP) proposed titanium matrix composite (TMC) as the primary structural material. As in most structures designed to minimize weight for flight, joints are a major challenge for advanced composites such as TMC that are to operate at high temperatures, so measuring strain on these joints is particularly important. However, strain gauges at high temperatures often are subject to temperature-induced errors.

Thomas Moore invented compensating strain gauges that are effective over a range of temperatures up to 370 °C. As with earlier attempts to solve the temperature problem, Moore's solution involves two gauges, one active and one inactive. The inactive gauge, surrounding the active on three sides, gauges temperature effects.

The two gauge wires, made of the same alloy, are in thermal contact with the strain specimen and also are covered with nearly identical thermal insulation. Thus they should always be at about the same temperature and the thermal contributions of the two gauge wires should be about equal. These two wires are connected to adjacent arms of a wheatstone bridge, which cancels out the identical thermal components of the output, leaving only the net strain component. This system precludes the need for additional calculating circuitry or precise temperature measurement of the active gauge wire.



The harsh environment strain gauge can correct for temperature-induced errors up to 370 °C.

Toughened Uni-Piece Fibrous Insulation

Daniel B. Leiser, Marnell Smith, Rex A. Churchward, and Victor W. Katvala

Ames Research Center

Ames researchers have developed an insulation 20-100 times tougher than the original material used in the heat-shield tiles on the space shuttle, reducing tile patching and repairing between flights and making repairs easier, faster, and cheaper.

This toughened uni-piece fibrous insulation (TUFI) is a low-density composite thermal material that insulates effectively in environments convectively heated in excess of 1260 °C. With a high resistance to thermal shock, TUFI's surface layer has a lower modulus of elasticity—requiring greater strain before failure—than previous insulation materials.

The material achieves its strength through its unique porous structure; it is the first heat-shield insulation to use porosity in the high-emittance surface layer to improve overall performance. The porous body of the fibrous, low-density silica-based material is impregnated with a reactive glass frit and fluxing and emittance agents. The large number of pores act as deflectors to a crack front. "If you have a crack going through a material, when it runs into a pore, the pore opens up the crack front," said Dr. Daniel Leiser, head of the TUFI development team, "and by doing that it stops the crack from going any further than the pore itself."

TUFI was tested on two flights of the shuttle Endeavor, with tiles placed at the bottom of the base heat shield. Compared to the standard reaction-cured glass-coated tiles, which showed pronounced re-entry damage, the TUFI tiles showed little damage. □

NASA's Invention of the Year competition is sponsored by the Office of General Counsel. For more information about the technologies described in this article, contact the NASA field center that sponsored the research (see page 20).

Dryden Flight Research Center

At Dryden Flight Research Center, technicians begin mounting the space shuttle Atlantis atop NASA's 747 Shuttle Carrier Aircraft for the ferry flight back.

As its name implies, Dryden Flight Research Center is the NASA center that concentrates on in-flight aeronautics research. With a fleet of aircraft—flying laboratories—from the X-29 to the SR-71, Dryden builds on a history of some of the nation's greatest advances in aviation.

Within mammoth Edwards Air Force Base and beside dry lake beds of the Mojave Desert, Dryden has access to the sort of natural playa useful for test operations, emergency landings, and other aeronautics research. The site has seen such breakthroughs as the X-1, the first aircraft to exceed the sound barrier, in 1947, and the X-15, which in the early 1960's flew faster than 4,500 mph at altitudes over 350,000 feet.

More recently, Dryden modified an F-8 aircraft and pioneered a flight control system called digital fly-by-wire (DFBW), which replaces mechanical linkages between control surface and cockpit, reducing weight and space for systems installation and allowing more efficient flight of complex, high-performance aircraft. Dryden sponsored the mission adaptive wing, on which leading and trailing edges are contoured in flight to form the optimal airfoil for altitude, speed, and maneuvers. The AD-1 aircraft was specially built to research pivoting a wing up to angles of 60° to reduce drag, both below and above the speed of sound.

Much of this research has benefitted aeronautics in general, and technology utilization is structured into most Dryden programs from the start. "We work with aircraft companies very often," said Lee Duke, acting technology commercialization officer at Dryden. "They're one of the big customers for our technology. It's an ongoing process. Since we're a flight research organization, almost everything we do, we do with a company, and there's a large amount of commercialization."

Currently Dryden has several ongoing projects involving specific aircraft. The F-18 High Angle of Attack Research Vehicle allows studies in airflow, aircraft control, and engine performance at high angles of attack. To study laminar flow at supersonic speeds, Dryden has been using F-16XL aircraft. Three mach-three SR-71s are used for high-speed, high-altitude aeronautics research for the development of high-speed military and civil aircraft.

But the center also has branched out beyond aeronautics, building on its accomplished strengths in aerodynamics and the sort of systems integration used in the DFBW. "We did some studies about ten years ago on drag on vehicles, and one of the things that we're pushing very hard [for commercialization] is a cattle-hauler design that one of our people came up with," Duke said. The design directs the airflow around the trailer so that air circulates through the interior and cattle arrive healthier than those in standard trailers. The same Dryden designer also invented a device that is installed on trucks to make them more aerodynamically efficient.

Another major Dryden program is the NASA-HOST (Health-care Open Systems Trials) collaboration in telemedicine with Johnson Space Center, Ames Research Center, and Sprint, V-Tel, and the University of Texas Health Science Center in San Antonio. The first trials of the project, in Texas, involve pediatric oncologists in a large city doing examinations, via electronic communications, of patients in distant, small towns, which often lack such specialists. For this project, Dryden's contribution is primarily systems technology of the type employed in DFBW and for flight control systems.

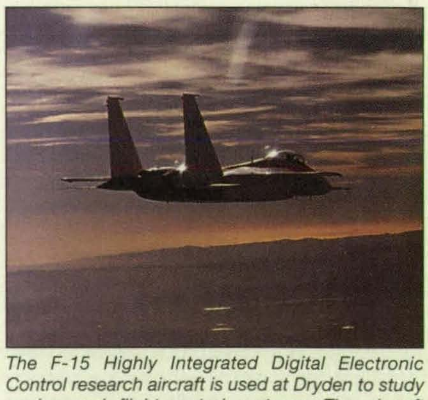
To help broaden technology transfer, Dryden developed an electronic workshop. "Instead of having people come out here for a workshop on a flight project, the way they would normally do, we put it all on the Internet," Duke said. Participants receive viewgraphs and text and can interact with the authors and other participants, while saving on time and money—particularly important in times of lean funding and for small businesses that cannot afford to send someone across the country. Duke said that Dryden is attempting to commercialize the electronic workshop through the SBIR process.

Dryden has a high temperature and loads calibration laboratory for ground-testing aircraft; a flight systems laboratory with capability for avionics development; and facilities for flow visualization, flight research with remotely piloted vehicles, and data analysis. The Integrated Test Facility, opened in 1992, is the only NASA facility of its type, designed to enhance and speed up systems integration and preflight checks on research aircraft.

Other research aircraft at Dryden include an F-18 Systems Research Aircraft for studying advanced technologies such as electric actuators and fiber optics; the F-15 ACTIVE for improving cruising and maneuvering capabilities; and two X-31s to study thrust vectoring for close-in combat. A B-52, CV-990, and an AFTI/F-16 used to research advanced fighter technology integration complete the Dryden research fleet. The center also serves the major space shuttle testing, refurbishing, and landing site.

The field center, founded in 1946 and made a part of Ames in 1981, separated from Ames in 1994. The Technology Commercialization Office, like the whole center, is undergoing reorganization and selecting staff.

For further information, contact Lee Duke, Technology Commercialization Officer, Mail Stop D-2131, Dryden Flight Research Center, PO Box 273, Edwards, CA 93523; Tel: 805-258-3892.



The F-15 Highly Integrated Digital Electronic Control research aircraft is used at Dryden to study engine and flight-control systems. The aircraft demonstrated the use of computer-assisted engine controls in landing an airplane safely with only engine power if the normal control surfaces, such as elevators, rudders, or ailerons, are disabled.

NASA PATENTS

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

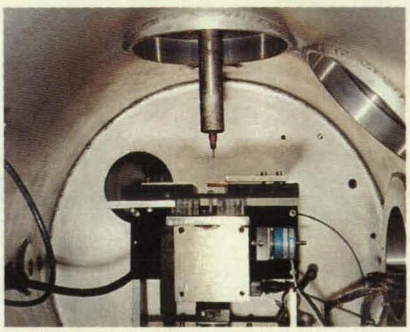
Method of Making a Membrane Having Hydrophilic and Hydrophobic Surfaces for Adhering Cells or Antibodies by Using Atomic Oxygen of Hydroxyl Radicals

(US Patent No. 5,369,012)

Inventors: **Steven L. Koontz** and **Glenn F. Spaulding**, Johnson Space Center

The use of polymeric materials for biomedical implants and in biotechnical manufacture is growing. An atomic oxygen treatment developed at Johnson produces a substantially uniform concentration of reactive atomic oxygen species. Polymer substrates so treated have a uniform distribution of hydrophilic functionality on the treated surface, a characteristic useful for biocompatibilizing polymer articles for biomedical applications.

For More Information Write In No. 730



Vacuum Vapor Deposition

(US Patent No. 5,380,415)

Inventors: **Richard M. Poorman** and **Jack L. Weeks**, Marshall Space Flight Center

A vapor deposition process for thin metallic films in a vacuum achieves a higher deposition rate than heretofore possible. An inert gas flows through a hollow tungsten electrode, so that an arc may be struck between the electrode and a target of the metal to be vaporized and deposited. Higher pressure near the target makes the vapor flow quickly toward the substrate, and a confining housing directs the vapor accurately toward it.

For More Information Write In No. 731

Adaptive Neuron Model--An Architecture for the Rapid Learning of Nonlinear Topological Transformations

(US Patent No. 5,371,834)

Inventor: **Raoul Tawel**, Langley Research Center

Mr. Tawel has developed the Adaptive Neuron Model (ANM) for rapid learning in fully-recurrent neural network architectures. The method actively involves the neuron processing elements in the learning procedures. Because of the ANM's ability to learn complex nonlinear transformations rapidly, it was trained on the highly-degenerative inverse kinematics problem in robotic control. Once trained, the resulting neuromorphic architecture was used in custom analog neural network hardware and the parameters capturing the functional transformation downloaded onto the system. This neuroprocessor, capable of 10^9 ops/sec, was interfaced directly to a three-degree-of-freedom Heathkit robotic manipulator.

For More Information Write In No. 732

Welding Nozzle Position Manipulator

(US Patent No. 5,360,157)

Inventors: **Jeffrey L. Gilbert** and **David A. Gutow**, Marshall Space Flight Center

A novel device enables precise adjustment by simple manual controls of the wire feed nozzle used on automatic welding apparatuses. Lightweight, compact, and robust, the manipulator is capable of accurately maintaining the nozzle tip's position within the severe environment surrounding the welding area.

For More Information Write In No. 733

Programmable High Voltage Power Supply With Regulation Confined to the High Voltage Section

(US Patent No. 5,363,288)

Inventors: **Karen D. Castell** and **Arthur P. Ruitberg**, Goddard Space Flight Center

A new configuration for a high voltage power supply in a dc-dc converter arrangement puts both the input and the output of the regulator on the high voltage side, averting isolation problems. This power supply is highly regulated, has low power consumption, a low parts count, and low manufacturing costs. A programmability feature permits selection of a large range of output voltages.

For More Information Write In No. 735

Method of Locating Ground Faults

(US Patent No. 5,365,175)

Inventors: **Richard L. Patterson**, **Allen H. Rose**, and **Ronald C. Cull**, Lewis Research Center

A novel device consists of a fiber optic cable coil through which pass hot and neutral wires of modern multiwire power systems. The wires carry equal and opposite currents whose magnetic fields thus cancel one another. If a ground fault occurs, the currents in the two wires are no longer in balance. Light transmitted through the coil responds to the unequal magnetic fields of the wires with the Faraday effect, causing a net rotation of the light's polarization that reveals the fault.

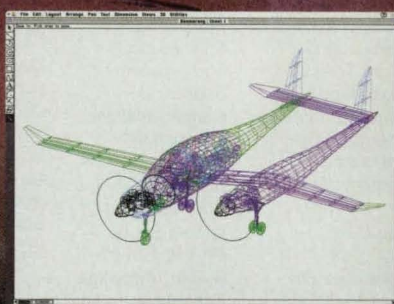
For More Information Write In No. 736

Burt Rutan Makes Vellum Fly

Two years after the Voyager completed its record-shattering around-the-world flight, you could still find its designer, Burt Rutan, working at a drafting table with pencil and paper.

Hardware wasn't the problem. He had computers. His company could buy any design system worth owning. What kept Burt grounded was software. CAD so clumsy, it squashed creativity. Or so weak, it simply couldn't do his job.

Maybe that's why the first time he sat down to design with Vellum®, Burt compared the experience to the exhilaration of flying. Vellum is the first CAD program with an autopilot.



Burt's creativity and willingness to explore uncharted territory is exemplified by this sneak peek at one of his latest designs produced (of course) in Vellum.

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NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC). We encourage all businesses with technical needs to contact the appropriate organizations for more information. For those who have access to the Internet, general information can be accessed with Mosaic software on the NASA Commercial Technology Home Page at URL: http://nctn.oact.hq.nasa.gov. Instructions regarding how to acquire the free Mosaic software can be obtained by sending an e-mail request to: innovation@oact.hq.nasa.gov.

NASA's Technology Sources

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

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

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

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

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

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

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

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

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

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Lon Miller
(601) 688-1632
lmiller@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

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

Lee Rivers
National Technology Transfer Center
(800) 678-6882

Robert Stark
Far-West Technology Transfer Center
University of Southern California
(800) 472-6785 or
(213) 743-6132

Dr. William Gasko
Center for Technology Commercialization
Massachusetts Technology Park
(800) 472-6785 or
(508) 870-0042

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

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

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(800) 472-6785 or
(412) 648-7000

Chris Coburn
Great Lakes Industrial Technology Center
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Easy Access To The FLC: Call (206) 683-1005 for the name of the Federal Laboratory Consortium Regional Coordinator in your area. The Regional Coordinator, working with the FLC Locator, can help you locate a specific laboratory to respond to your needs.

NASA Program Offices

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

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

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

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

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

Bill Smith
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(202) 358-2473
wsmith@sm.ms.ossa.hq.nasa.gov

Bert Hansen
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(202) 358-1958
bhansen@gm.olmsa.hq.nasa.gov

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

NASA's Business Facilitators

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

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

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

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

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

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

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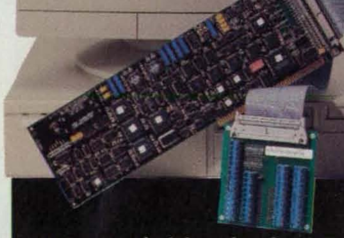

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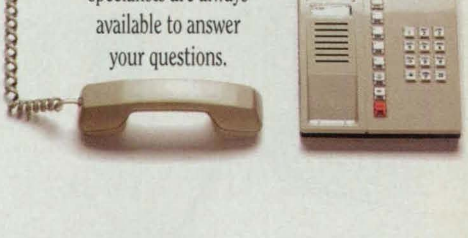

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For More Information Write In No. 508

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 in 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 contacting the Commercial Technology Office of the sponsoring NASA center (see page 20).

Ultracold-Atom Accelerometers

The primary advantage of these accelerometers is unsurpassed sensitivity over that of even the best currently available designs.
(See page 51.)

Measuring Thickness of Ice When Liquid Is Present

A proposed capacitive gauge would give reliable reading of the remaining ice thickness even when deicing fluids or heat are applied. This would be an extra safety measure in deicing airplane wings, for example, to ensure that all of ice has been melted.
(See page 47.)

Remote Neural Pendants in a Welding-Control System

Neural-network integrated circuits increase information flow of different welding parameters that are critical in controlling a large robotic welding facility. Data include such critical aspects as current, voltage, flow of gas, starting, and stopping.
(See page 42.)

Superacid-Based Lithium Salts for Polymer Electrolytes

These electrolytes are candidates for rechargeable lithium-based electrochemical cells and promise to increase achievable power and energy density.
(See page 58.)

Using Spider-Web Patterns To Determine Toxicity

A method of studying different web patterns woven by spiders subjected to toxic chemicals can replace significantly costlier laboratory experimentation with higher animals and avert potential conflicts with the recent animal-rights legislation issues.
(See page 82.)

Redesigned Electron-Beam Furnace Boosts Productivity

This furnace features a larger carousel to accommodate more experiments in one load, thus reducing the time needed for reloading and vacuum pump-down.
(See page 77.)

Programmable Switch Solutions.

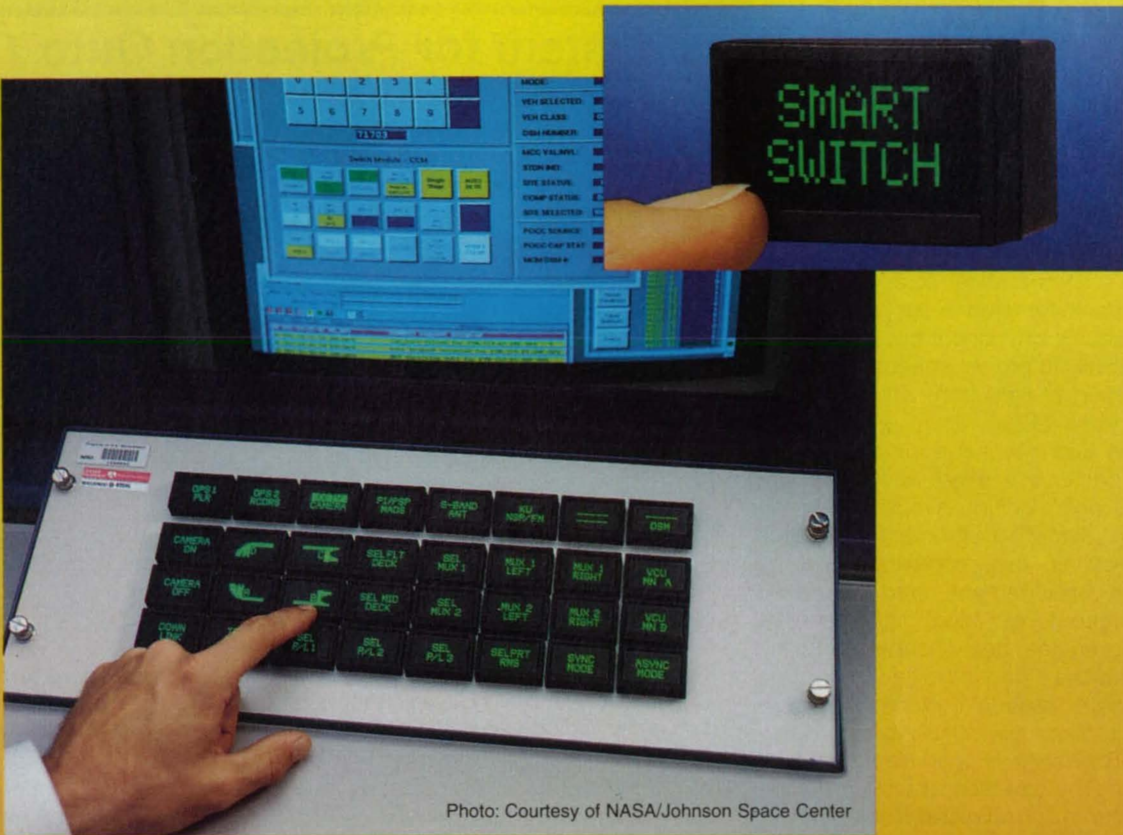

Photo: Courtesy of NASA/Johnson Space Center

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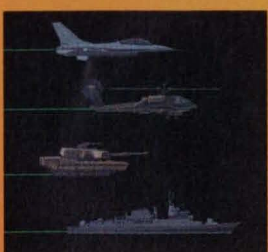

Each VIVISUN 5000 Programmable Switch has a matrix of 560 LED pixels that provide total legend flexibility for alphanumeric and graphic messages. In addition, these messages are software controlled to provide both sunlight readability (10,000 foot-candles) and NVIS compliance per MIL-L-85762A.

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For More Information Write In No. 516

Dual Telecentric Lens System for Projection Onto Tilted Toroidal Screen

One projection lens is optimized for the red and green spectral region; the other for the blue.

Lyndon B. Johnson Space Center, Houston, Texas

Figure 1 shows a system of two optical assemblies for projecting an image onto a tilted toroidal screen. The system could be used in conjunction with any source of imagery but is designed especially to project images formed by reflection of light from a liquid-crystal light valve (LCLV).

The dual-channel approach is chosen because it offers several advantages which include: simplified color filtering, simplified chromatic aberration corrections, less complex polarizing prism arrangement, and increased throughput of blue light energy. However, the dual-channel approach introduces an off-axis projection geometry making correction of geometric distortion much more challenging. The design is optimized, as is customary, by selection of unique combinations of optical glasses and configurations of lens elements. The design of one optical assembly is optimized for red and green light, and this assembly is used to project only the red and green components of the image; the design of the other optical assembly is optimized for blue light, and this assembly is used to project only the blue component of the image. The separate color components of the image are superimposed on the screen to obtain a full color image with minimal chromatic aberration and minimal geometric distortion.

Figure 2 shows the ray trace layouts of the two telecentric optical assemblies. In each assembly, image light reflects from the LCLV, passes through a fluid-filled, polarizing, beam-splitting prism, and is focused onto the tilted, curved screen by the projection lenses. An internal physical aperture stop helps to optimize performance. In the blue optical assembly, the projection lens includes an element that is decentered to compensate for the asymmetric aberrations which are induced by the off-axis geometry of the blue channel with respect to the optical axis of the red/green channel.

Each optical assembly includes a half-wave retarder for rotating the planes of polarization when used with a polarization-sensitive viewing apparatus such as the pancake window (in-line-infinity-view optical system). The half-wave retarders are not needed for mere projection of an image on the screen.

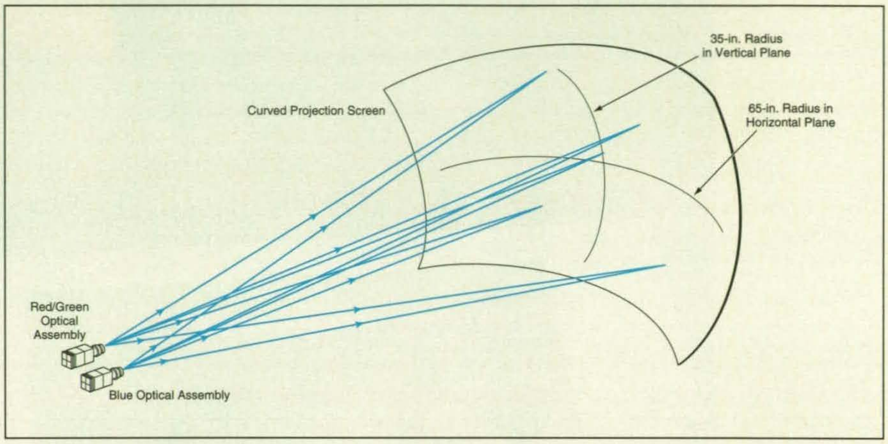

Figure 1. **Two Different Spectral Components of the Same Image** are projected onto a screen that is toroidally curved; its curvature in the horizontal plane differs from its curvature in the vertical plane. The screen is also tilted with respect to the optical axis of the red/green optical assembly.

This work was done by Ronald S. Gold and Russell M. Hudyma of Hughes Aircraft for **Johnson Space Center**. *For further information,* ***write in 25*** *on the TSP Request Card.*
MSC-22443

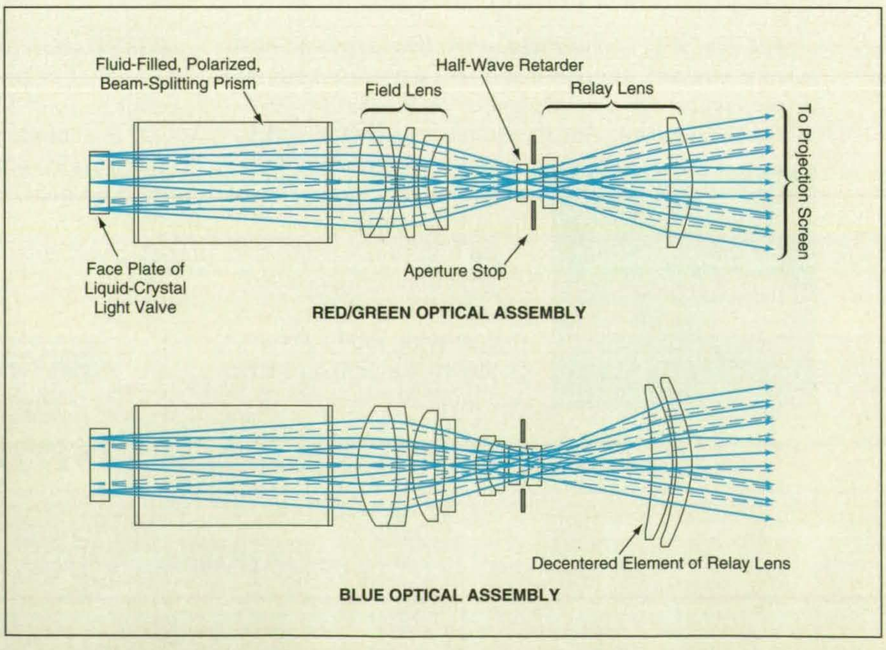

Figure 2. The **Two Optical Assemblies** have slightly different designs, each optimized for its region of the spectrum.

Chromatic Image Analysis for Quantitative Thermal Mapping

Temperature maps are computed from various sensing surfaces using color image data.

Langley Research Center, Hampton, Virginia

A chromatic image analysis system (CIAS) has been developed for use in noncontact measurements of temperatures on aerothermodynamic models in hypersonic wind tunnels. The CIAS is based on a concept of temperature coupled to a shift in color spectrum for an optical measurement — a concept that is straightforward for various sensing surfaces but heretofore has been difficult to implement in practice. Using a high-quality color video camera with multiple detectors and band-pass filters coupled to a powerful image-acquisition-and-processing computer, it is now possible to implement this concept efficiently. The CIAS eliminates the need for intrusive, time-consuming, contact temperature measurements by gauges, making it possible to map temperatures on complex surfaces in a timely manner and at reduced cost.

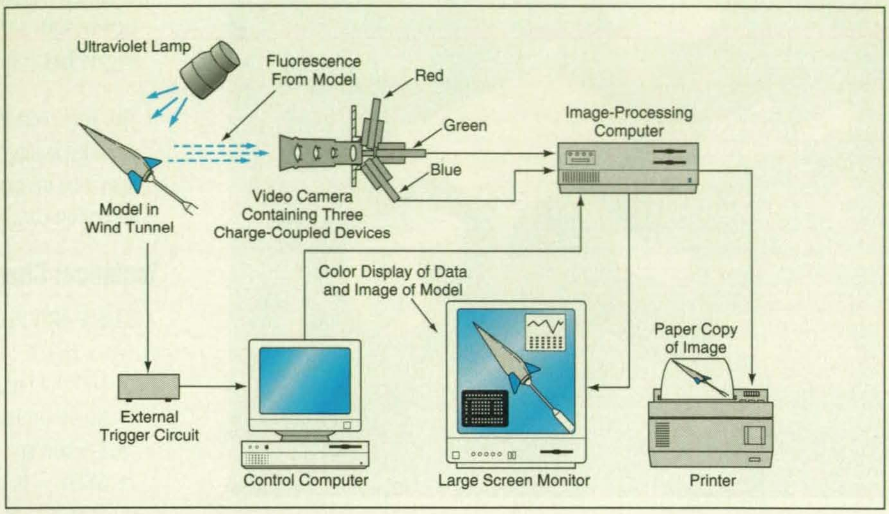

Figure 1. **The Video Camera Images Fluorescence** emitted by the phosphor-coated model at two wavelengths. The temperature map of the model is then computed from the relative brightnesses in the video images of the model at those wavelengths.

In preparation for temperature mapping by use of the CIAS, the surface of the wind-tunnel model is coated with a sensing material, which either emits or reflects light with a color that varies significantly with temperature in the range of interest. In the initial development of the CIAS, two-color thermographic phosphors were used as the sensing materials. The functioning of these phosphors as sensing materials involves transfers of energy via metallic ions. Other sensing materials that have also been useful in extracting temperature data include rare-earth-ion phosphors, phase-change paints, cholesteric liquid crystals, and a fluorescent dye used for simultaneous mapping of temperature and pressure. Whichever sensing material is used, the dependence of color on temperature (more precisely, ratios between brightnesses measured in different wavelength channels as functions of temperature) must be determined from calibration measurements on a similarly coated specimen at known temperatures.

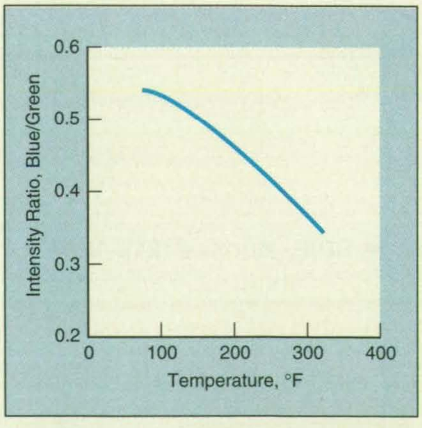

Figure 2. The **Ratio Between the Radiometric Brightnesses** of the band-pass-filtered light that reaches the blue and green camera tubes from the same location on the phosphor-coated surface is a function of temperature.

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Figure 1 illustrates the use of the CIAS in mapping the temperature on a model coated with a two-color thermographic phosphor made of zinc sulfide doped with copper (ZnS:Cu) During the wind-tunnel test, the model is illuminated with ultraviolet light at a wavelength of 365 nm. The ultraviolet illumination causes surface luminescence with temperature-dependent spectral peaks at 450 nm (blue) and 520 nm (green). The spatial variation in the color of the luminescence with temperature is imaged with a three-detector color video camera, using its blue-filtered (wavelength 450±20 nm) and green-filtered (wavelength 540±20 nm) detectors. Then by use of the calibration data (see Figure 2), the temperature at each location on the model can be computed from the ratio between the brightnesses of the same location in the blue and green images.

The present CIAS is both portable and capable of producing temperature maps immediately following a measurement sequence. As many as 64 512-by-512-pixel, 8-bit images are stored in each measurement sequence at programmable data-acquisition rates, with a maximum video rate of 30 frames per second.

This work was done by Gregory M. Buck of **Langley Research Center**. *For further information* ***write in 297*** *on the TSP Request Card.*
LAR-14386

Noise-Reduction Circuit for Imaging Photodetectors

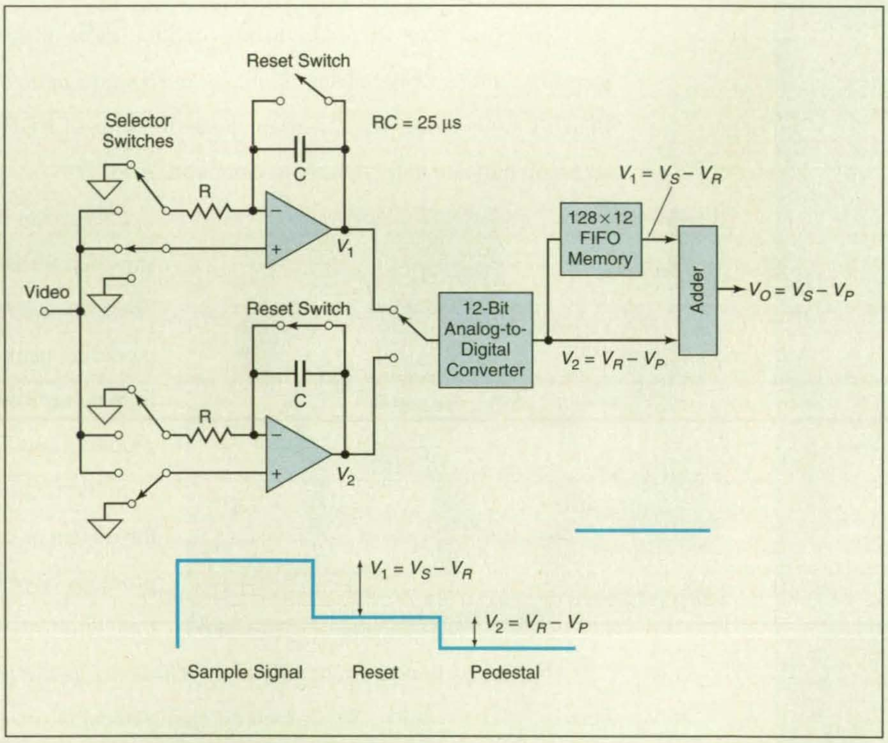
Correlated triple sampling eliminates reset noise and reduces 1/f noise.

NASA's Jet Propulsion Laboratory, Pasadena, California

A developmental correlated-triple-sampling circuit would suppress capacitor reset noise and attenuate low frequency noise in integrated-and-sampled circuits of multiplexed photodiode arrays. The noise reduction circuit is part of the Visible and Infrared Mapping Spectrometer (VIMS) instrument to be flown aboard the Cassini spacecraft to explore Saturn and its moons. Modified versions of the circuit might also be useful for reducing noise in terrestrial photosensor instruments.

The circuit is designed to eliminate the component of noise caused by resetting the voltage on a charge-integrating-and-sampling capacitor after taking each sample. This component is proportional to kTC, where k is Boltzmann's constant, T is the absolute temperature, and C is the integrating capacitance. The circuit is also designed to suppress a component of noise proportional to 1/f (where f = frequency) contributed during the times between integrations of photocharges.

The photodiode arrays are interfaced electrically with the signal processing electronics (SPE) which provide the appropriate bias voltages and control signals necessary to operate the array. The signal processing electronics includes a preamplifier, a clamp circuit, a gain-controlled amplifier that conditions the video signal for conversion from analog to 12-bit digital, and the correlated-triple-sampling circuit. The timing and control logic in the SPE command the photodiodes to provide three signal levels [(1) integrated video signal, VS, (2) reset level, VR, and (3) pedestal level due to switch feedthrough, VP] to be of the same duration (25 µs).



The **Correlated-Triple-Sampling Circuit** produces an output signal equal to VS – VR from the present video frame period plus VR – VP from the previous video frame period; the sum is nominally equal to the present value of VS – VP.

The correlated-triple-sampling circuit (see figure) contains an analog subtractor/integrator, an analog-to-digital converter, and a first-in/first-out (FIFO) memory. The difference between the digitized reset and pedestal voltages, V2 = VR – VP, is stored in the FIFO memory for one video frame time. The difference between the digitized video signal and the reset voltages, V1 = VS – VR, is then summed with V2 in real time to obtain the correlated output voltage. In principle, the three video voltages could be digitized and processed (subtracting, storing, and adding) digitally. In practice, this cannot be done in the initial intended application because the additional digital circuitry needed to accomplish all-digital processing would cause an unacceptably large increase in the overall size and mass of the spectrometer.

This work was done by Luis J. Ramirez, Bedabrata Pain, Craig Staller, and Roger W. Hickok of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 275*** *on the TSP Request Card.*
NPO-18897

Two-Diffraction-Order, Beam-Splitting, Imaging Spectrometer

Spectral images would be made in two wavelength bands.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed imaging spectrometer would generate spectral images of a line target in two adjacent, harmonically related wavelength bands; 0.45 to 0.90 μm and 0.90 to 1.8 μm. The conceptual design of the spectrometer calls for a minimum number of optical elements to achieve coverage of the required visible and near-infrared wavelengths in an instrument of reduced size, weight, and cost.

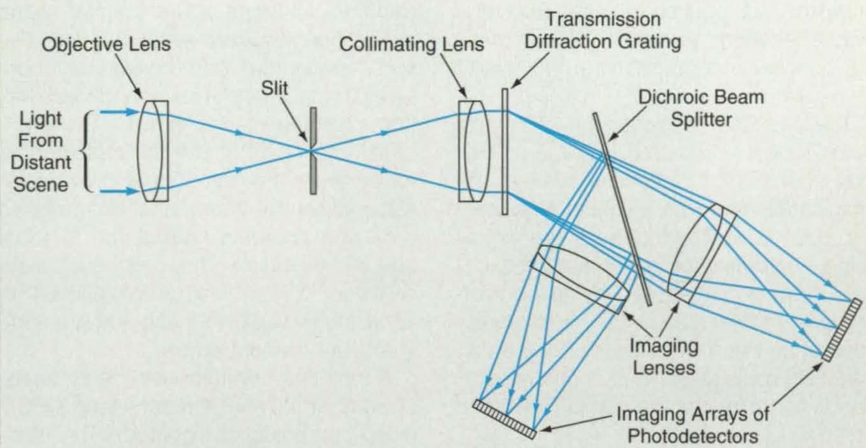
The instrument (see figure) has a single objective lens, which images the scene under observation onto a slit. As in other imaging spectrometers, the slit defines the line-target portion of the scene. A second lens collimates the slit image onto a transmission diffraction grating, which will spectrally disperse the beam. The extent of dispersion would depend on wavelength: For example, 0.9-μm light would be deflected at an angle of 19.67°, while 1.8-μm light would be deflected at 45.28°.

In typical spectrometers, light diffracted to higher orders is regarded as spurious and is reflected and/or absorbed to keep it from the photodetectors. In this instrument, however, the second diffraction order would be utilized. The design of the instrument would exploit the fact that the angle of first-order diffraction of light of a given wavelength equals the angle of second-order diffraction of light of half that wavelength.

A dichroic, 50-percent transmitting, 50-percent reflecting beam splitter would intercept the diffracted light, separating it into its two component wavelength bands and the corresponding diffraction orders. A separate lens for each band would focus the light onto an imaging array of photodetectors sensitive to the light in that band. Thus, the spectral images would be formed in two octaves covering the required wavelength range.

This work was done by Clayton C. LaBaw and Ronald N. Burns of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 276*** *on the TSP Request Card.*

NPO-19086



The **Two-Octave Imaging Spectrometer** would utilize light of two harmonically related wavelengths diffracted to harmonically related orders at the same angles, followed by separation via a dichroic beam splitter before final imaging.

Real-Time Compression of Digital Video

Images are reconstructed without noticeable degradation.

Lewis Research Center, Cleveland, Ohio

A digital video compression algorithm was developed to process 8-bit samples of composite color NTSC video signals taken at four times the color subcarrier frequency. After compression, the amount of digital data required for video transmission is reduced by over 75 percent without noticeable degradation in the quality of the picture.

The algorithm is based on differential pulse code modulation (DPCM), a predictive compression technique where the anticipated value (prediction) of an incoming pixel is subtracted from the actual value. This difference is then assigned to a level from a limited set of quantization groups. For this implementation, all predictions of an incoming pixel are done on an intra-field basis to eliminate motion degradation and minimize the complexity of the processing circuits.

To improve on DPCM, the compression algorithm additionally utilizes a non-uniform quantizer, nonadaptive predictor, and multi-level Huffman coder. The non-uniform quantizer improves resolution of the reconstructed video, the non-adaptive predictor increases edge preservation, and the multi-level Huffman coder provides additional data rate reduction.

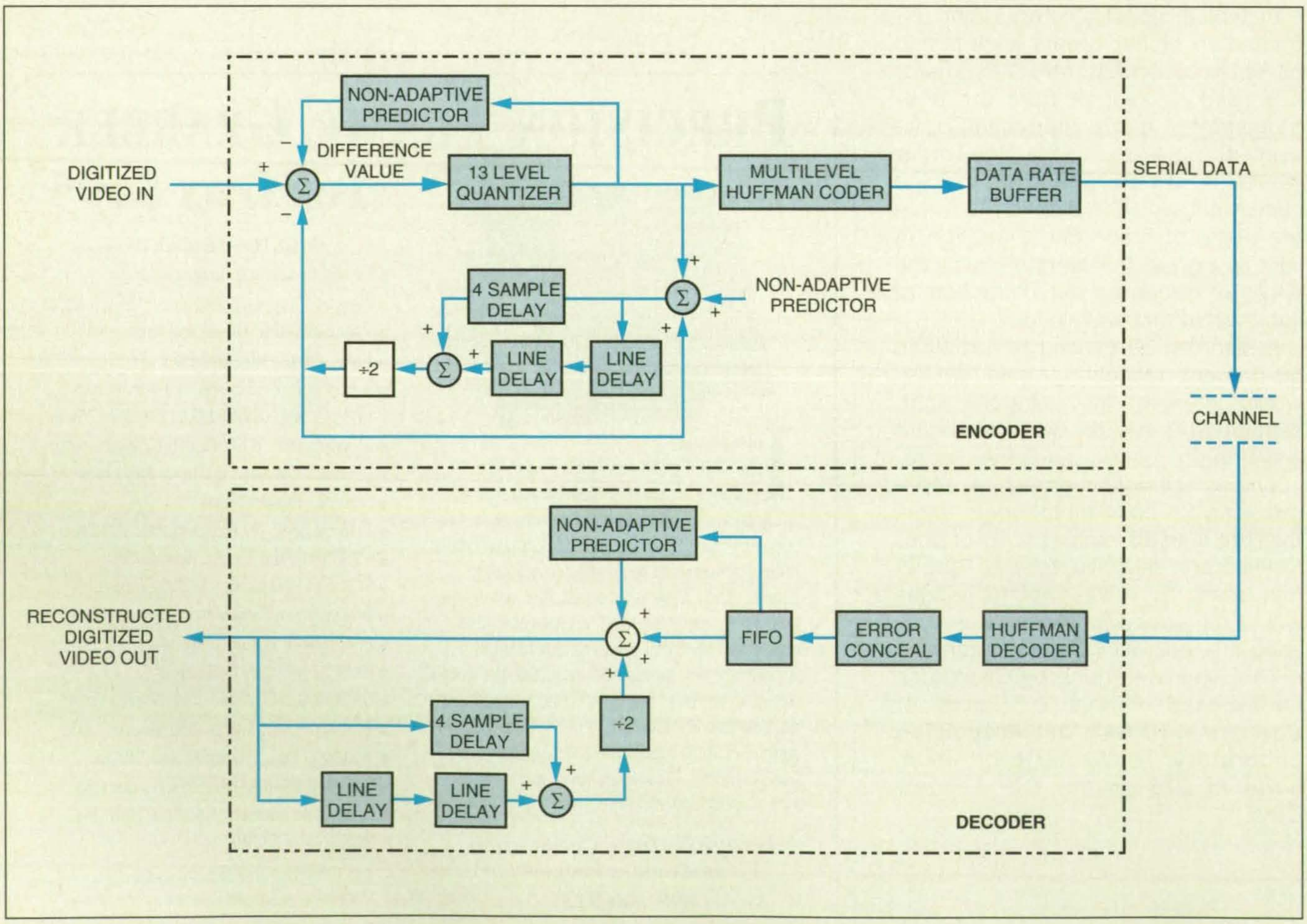
Several issues must be resolved to transmit Huffman-coded digital video over a constant-rate serial channel. Two such issues are rate conversion (from variable to a fixed rate) and recovery from communication errors. An intelligent data rate buffer was implemented to perform the rate conversion, while also efficiently storing the compressed data and guarding against the memory underflow and overflow. An error concealment circuit was implemented to allow the decoder to mask and gracefully recover from bit errors.

A real-time system has been developed to implement the enhanced DPCM video compression algorithm. The hardware reduces the digital video information from 114 Mbps to 26 Mbps (approximately 1.8 bits per pixel). Quality of the reconstructed video is excellent with no motion degradation.

This work was done by Thomas P. Bizon, Wayne A. Whyte, Jr., and Mary Jo Shalkhauser of **Lewis Research Center** *and Vincent R. Marcopoli of Case Western Reserve University. Further information may be found in NASA TM-105616 (N92-19700/TB), "Real-Time Demonstration Hardware for Enhanced DPCM Video Compression Algorithm" and NASA TM-106092 [N93-22483/TB], "Real-Time Transmission of Digital Video Using Variable-Length Coding."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, Linthicum Heights, Maryland, Telephone No. (301) 621-0390. Rush orders may be placed for an extra fee by calling the same number.

This invention has been patented by NASA (U.S. Patent No. 5,057,917). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 20]. Refer to LEW- 15866.



The **Enhanced DPCM Video Compression Algorithm** utilizes a non-uniform quantizer, non-adaptive predictor, and multi-level Huffman coder to substantially reduce the data rate below that achievable with conventional DPCM.

Automated Selection of Pictures in Sequences

Motion-picture frames to be stored or examined are culled by computer.

Lyndon B. Johnson Space Center, Houston, Texas

A method of automated selection of film or video motion-picture frames for storage or examination is undergoing development. Automated selection could be beneficial in situations in which (1) the quantity of visual information available exceeds the amount that can be stored or that can be examined by humans in a reasonable amount of time, and/or (2) it is necessary to reduce a large number of motion-picture frames to a few that convey significantly different information in a manner intermediate between that of a movie and that of a comic book or storyboard. For example, a computerized vision system that monitors an industrial process could be programmed to sound an alarm when changes in the scene exceed normal limits.

The method of automated selection involves preliminary sampling at regular intervals (e.g., the use of the first or last frame in each successive group of a few hundred frames). Each preliminarily sampled frame is digitized, then processed to extract a number of general, primitive features in histogram form. The quantities in the histogram can include hue, saturation, chroma, and grey levels; slopes and intensities of edges; lengths and slopes of lines; and distances of lines from the center of the picture. The data in the histograms are reduced to small sets of numbers, wherein each number is regarded as representing a structural attribute of the entire frame.

To render these numbers to common units of measurement, the mean and standard deviation of each such number over the entire set of preliminarily selected frames is computed so that each such number can be recomputed as a unit normal deviate from a normal curve. Then all the resulting numbers for each frame are added to obtain a single value that is regarded as representative of the entire structure of the frame. The set of such single values derived from all the preliminarily selected images is then regarded as constituting a training set, and the training set is processed to extract its mean and standard deviation. Then the automated selection process is based on a simple selection rule: retain those frames, the single representative values of which lie at a specified number of standard deviations from the mean.

Presently, there is no way to guarantee an optimal automatic selection: choices of sampling interval, the primitive features to be analyzed statistically, the statistical techniques used to summarize the image data, and the selection rule are all arbitrary. Despite this nonoptimality, a prototype automated-selection algorithm applied to video records of astronaut activity was partly successful in selecting frames that indicated sequences of motions clearly.

Notably, the frequency of selection within a given sequence was found to be inversely proportional to the number of scenes of the same type, where "type" denotes an average image composition in terms of light levels, edges, and other primitive features. This result is consistent with the fact that this approach to automated selection is based on a model of human attentiveness: at all times, we create mental running distributions of scenes, the distributions change with the addition and deletion of visible objects, and we attend to outliers in the distributions.

This work was done by Mark E. Rorvig and Robert O. Shelton of **Johnson Space Center**. *For further information,* ***write in 87*** *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 NASA Patent Counsel, Johnson Space Center, [see page 20]. Refer to MSC- 22093.

Tunnel-Junction Mixers Perform Well at 205 GHz

NbN/MgO/NbN and NbN/AlO_x/Nb junctions have been tested.

NASA's Jet Propulsion Laboratory, Pasadena, California

Superconductor-Insulator Superconductor (SIS) tunnel junctions made of NbN/MgO/NbN and Nb/AlO_x/Nb, with cross-sectional areas of about 0.30 and 0.25 μm^2 respectively, have been fabricated and tested for use as mixers at frequencies near 205 GHz. The cross sections must be as small as they are to make the capacitances of the devices acceptably small for operation at this frequency. NbN and Nb are good materials choices as the superconductors because of their high energy gap, and they are mechanically and electrically rugged and chemically stable.

The NbNMgO/NbN tunnel junctions were fabricated by dc sputtering of NbN films 1,500 to 2,000 Å thick, radio-frequency sputtering of MgO tunnel barriers 10 Å thick, and photolithographic techniques. The small cross sections were obtained by use of an edge geometry (with an associated fabrication sequence) that has been described previously in *NASA Tech Briefs*. Some estimated parameters of a typical NbN/MgO/NbN junction include a capacitance of 28 f F, current density of 10^4 to 2.5 x 10^4 A/cm^2, and a normal-state resistance of 40 to 70 Ω. The upper part of Figure 1 shows a typical current-vs.-voltage curve measured at a temperature of 4.2 K.

The Nb/AlO_x/Nb junctions were fabricated by dc sputtering of Nb films 2,000 to 3,000 Å thick, formation of an AlO_x barrier 10 to 20 Å thick, electron-beam lithography to define the junctions, and conventional photolithography to make the junction leads and the associated radio-frequency-filter structure. Estimated parameters of a typical junction of this type include capacitance of 15 f F, current density of 10^4 A/cm^2, and normal-state resistance of 80 to 100 Ω. The lower part of the figure shows a typical current-vs.-voltage curve measured at 4.2 K; the width of the quasi-particle current rise in this case is 0.3 mV, which is less than hf/e = 0.85 mV at 205 GHz (where h is Planck's constant, f is the frequency, and e is the fundamental unit of electrical charge).

Figure 2 is a block diagram of the specially designed cryogenic system used to test the devices as mixers. Each device to be tested was placed in a waveguide mount with an adjustable backshort and electric-field-plane tuner. "Hot" (300 K) and "cold" (77 K) loads were placed in the beam at the radio-frequency input port of the cryostat to provide a source temperature, T_{rf}. A specially designed variable temperature load was used to determine the temperature T_{if} at the output of the intermediate-frequency (IF) matching transformer of the mixer. A bidirectional coupler was used to measure the return loss of the mixer at an IF of 1.4 GHz. Analysis of the T_{rf}-vs.-T_{if} data yielded the gain and noise of the mixer to an accuracy of ±10 percent. The gain thus computed was corrected for the IF mismatch to obtain the available gain.

Devices of both types performed well. The Nb devices exhibited a noise temperature of 60 K (SSB), which is the best

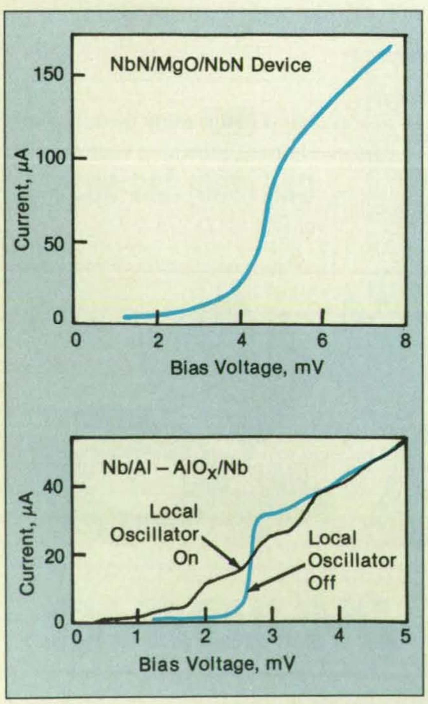


Figure 1. These **Current-vs.-Voltage** curves of tunnel-junction devices were measured at a temperature of 4.2 K.

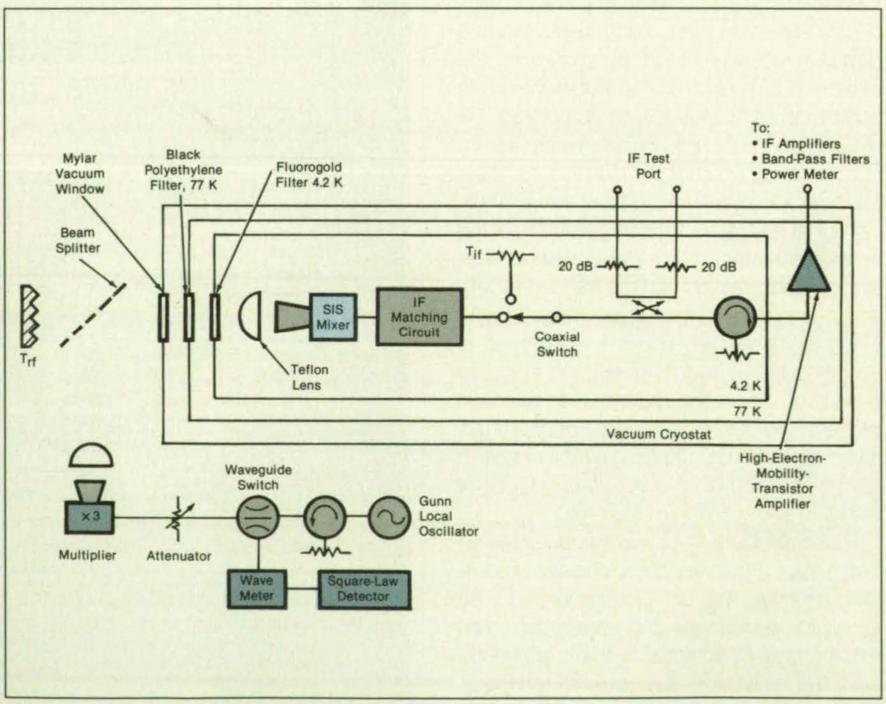


Figure 2. The performance of **Tunnel-Junction Devices** as mixers was measured at about 205 GHz in this specially designed cryogenic rf system.

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ever reported for such a mixer near 200 GHz. Other parameters of Nb devices include a sideband ratio of 19 dB, an IF return loss of –7.6 dB, and an available gain of –2.0 dB, which suggests good coupling of the rf signal.

The NbN devices exhibited a noise temperature of 145 K (DSB), which is comparable to that of prior NbN junctions with integrated tuning elements. However, the gain of the NbN devices was very low (–10.7 dB), suggesting that the radio-frequency matching of this device may not have been optimal.

This work was done by Hamid H. S. Javadi, William R. McGrath, Scott R. Cypher, Bruce Bumble, Henry G. LeDuc, and Brian D. Hunt of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 141*** *on the TSP Request Card.*

NPO-18419

Measuring Speed of Rotation With Two Brushless Resolvers

The measurement principle exploits a simple trigonometric identity.

Marshall Space Flight Center, Alabama

The speed of rotation of a shaft can be measured by use of two brushless shaft-angle resolvers aligned so that they are electrically and mechanically in phase with each other. In some older tachometer systems, speeds of rotation are determined by electronically differentiating shaft-angle signals with respect to time. Unfortunately, electronic differentiation introduces noise. The present system does not rely on differentiation; instead, it involves electronic multiplication and addition, and exploits the trigonometric identity $[\sin\theta]^2 + [\cos\theta]^2 = 1$, where θ in this case denotes the instantaneous shaft angle.

One of the resolvers is excited with a direct current proportional to k_1; the other resolver is excited by a sinusoidal alternating current with amplitude proportional to k_2 and frequency $\omega_2/2\pi$. Let ω_2 be much greater than ω, which is the angular speed to be measured. Then the output voltages of resolver 1 are given by

$$v_{1a}(t) = k_1\omega \sin(\theta)$$

$$v_{1b}(t) = k_1\omega \cos(\theta)$$

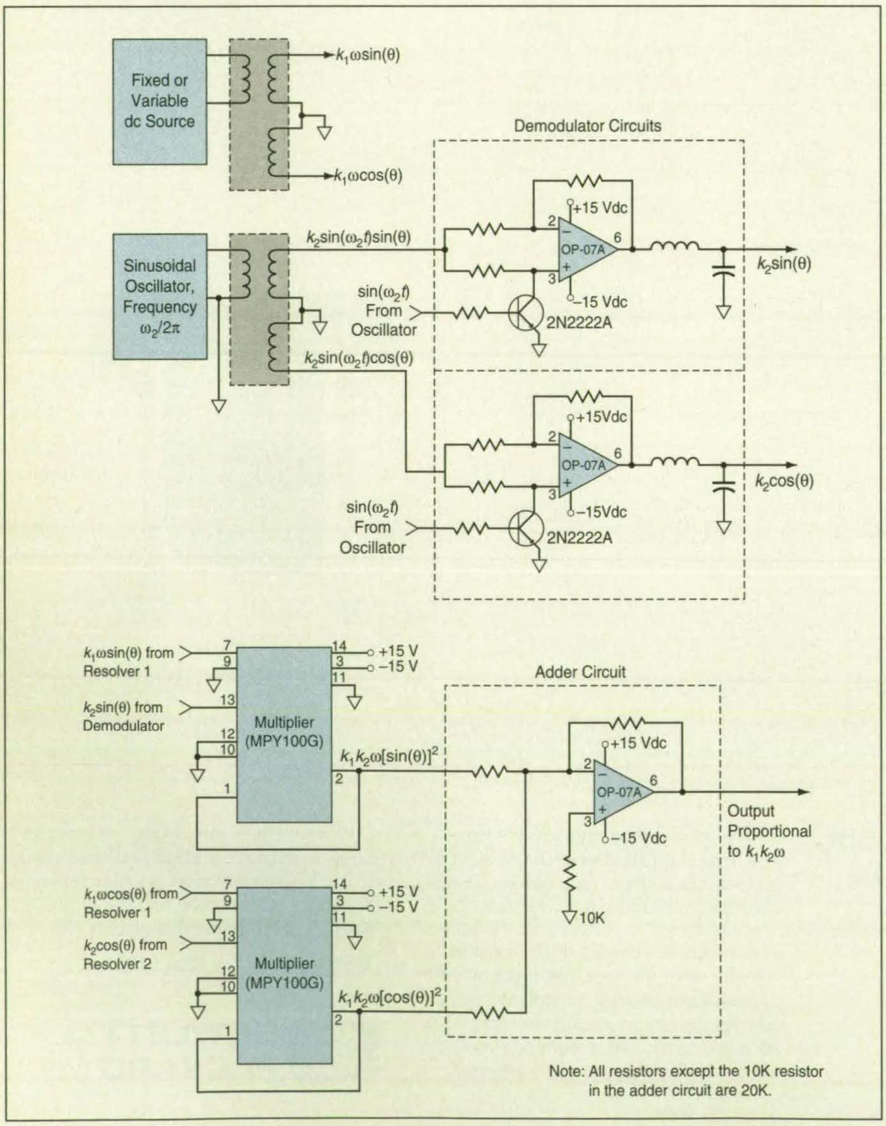
while the output voltages of resolver 2 are given by

$$v_{2a}(t) = k_2 \sin(\theta)\sin(\omega_2 t)$$

$$v_{2b}(t) = k_2 \cos(\theta)\sin(\omega_2 t)$$

where t is time.

As shown in the figure, the output voltages of resolver 2 are demodulated to obtain amplitudes proportional to k_2 sin (θ) and k_2 cos (θ). Then each of these amplitudes is multiplied by the corresponding output of resolver 1 to obtain voltages proportional to $v_a = k_1k_2\omega[\sin(\theta)]^2$ and $v_b = k_1k_2\omega[\cos(\theta)]^2$. Then using the aforementioned trigonometric identity, these voltages are added to obtain an output voltage proportional to $k_1k_2\omega$; that is, the output voltage is directly proportional to the speed to be measured. The dc excitation current can be adjusted to increase or decrease k_1 and thereby increase or decrease the sensitivity of the measurement.



Two Brushless Shaft-Angle Resolvers and associated circuits generate a voltage proportional to the speed of rotation (ω) in both magnitude and sign.

This work was done by David E. Howard of **Marshall Space Flight Center.** *For further information,* ***write in 242*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-28793.

Wavelength-Division Multiplexing With Integrated Optics

One integrated-circuit multiplexer/demultiplexer would communicate digital data at ≥ Gb/s.

NASA's Jet Propulsion Laboratory, Pasadena, California

High-density wavelength-division-multiplexed optoelectronic integrated circuits would be developed for use as transceivers in fiber-optic communications between computers, according to a proposal. The best wavelength-division multiplexer available at present supports only four channels (at a rate of 2 Gb/s each), and conventional time-division-multiplexing computer communication links introduce delays at the points of conversion between serial and parallel transmission. When fully developed, one of the proposed multiplexer/demultiplexer units would provide simultaneous communication on 32 wavelength channels at an overall data rate > 40 Gb/s, thereby (1) increasing the channel capacity and (2) simplifying the transmitting and receiving electronics and reducing the delay by eliminating the serial-to-parallel and parallel-to-serial "bottlenecks."

Development efforts are expected to focus on the integration of waveguide structures, surface and vertical diffraction gratings, lasers, photodetectors, and the associated signal-processing electronic circuits into monolithic devices in the InGaAs/InP material system. The devices would operate in the 1.3- and 1.55-μ m wavelength bands. In a transmitter, the outputs of parallel integrated lasers, each at a different wavelength in the band, would be coupled into a single-mode optical fiber via a vertical diffraction grating. The multiple-wavelength beam entering a receiver from a single-mode optical fiber would be dispersed by a similar vertical diffraction grating into an array of parallel integrated positive/intrinsic/negative photodiodes — one photodiode for each wavelength (see Figure 1).

The vertical diffraction grating is so named because it would function similarly to a conventional diffraction grating oriented with its lines vertical with respect to devices illustrated in Figure 1. Two grating configurations would be investigated: a wide-band configuration for discrimination between 1.55 and 1.3 μm, and a narrow-band configuration for discrimination among closely spaced wavelengths in the 1.33-μm band.

Figure 2 is a schematic illustration of a proposed fiber-optic-communication switch node. Wavelength-multiplexed inputs would enter the node from two fibers, then be separated into 1.3-μm and 1.55-μm bands by wide-band vertical diffraction gratings. Each 1.55-μm band, which contains a data channel, would be sent through a fiber-optic delay line to integrated control, routing, and signal-regeneration circuitry. Control channels in the 1.3-μm bands would be separated by narrow-band vertical diffraction gratings. The control signals would be detected and fed without delay to the control, routing, and signal-regeneration circuitry. Additional electronic control signals would be fed into and out of the node via electrical contacts. After processing the control and data signals, the node would recombine each data signal with modified control signals by wavelength multiplexing onto one of the output optical fibers.

This work was done by Robert J. Lang and Siamak Forouhar of Caltech for

NASA's Jet Propulsion Laboratory. *For further information, **write in 162** on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office — JPL [see page 20]. Refer to NPO-18357.

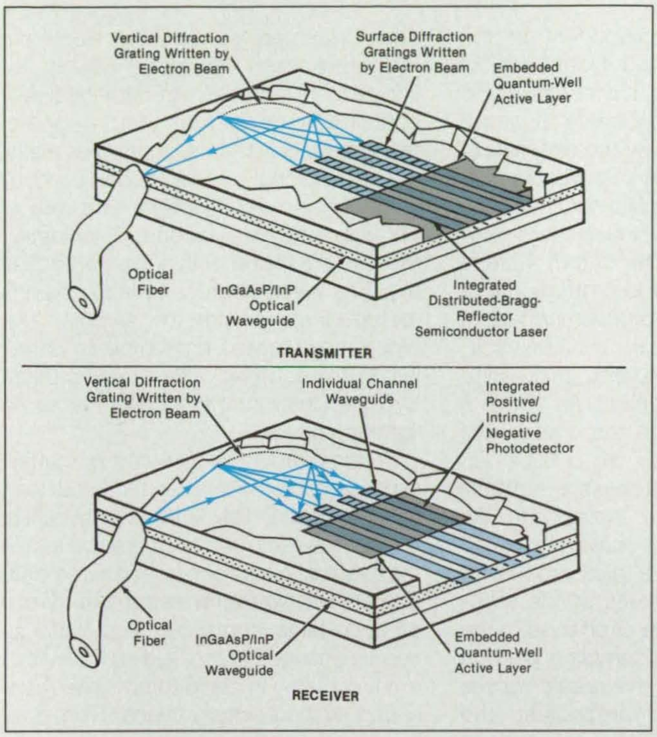


Figure 1. **Single-Chip Transmitters and Receivers** would include arrays of integrated single-frequency semiconductor lasers (in transmitters) and integrated photodiodes (in receivers) coupled via integrated vertical diffraction gratings to single-mode optical fibers. Although only 4 lasers and 4 diodes are shown here, the fully developed devices would contain 32 of each.

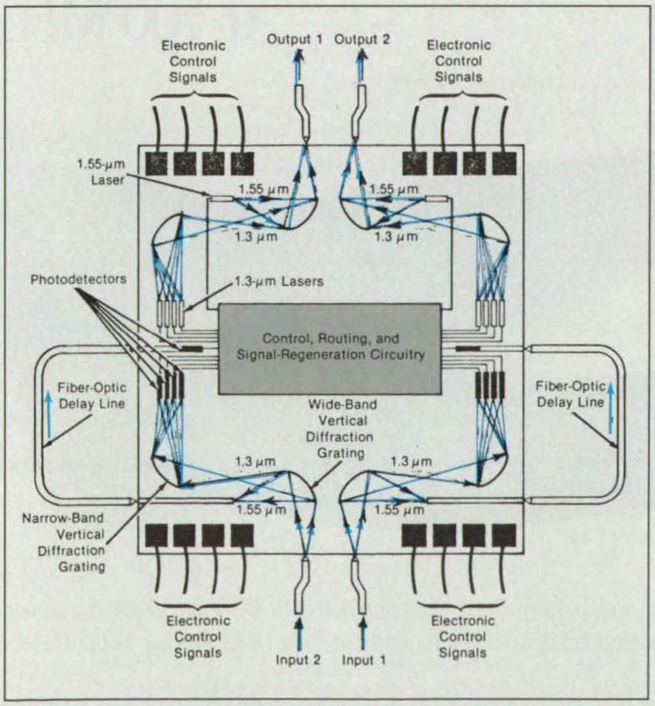


Figure 2. This **Switch Node** would process wavelength-multiplexed data and control signals from two input optical fibers and retransmit the data signals with modified control signals on two output optical fibers.

Instrument Records Magnetic Fields Generated by Lightning

Measurements aid in assessment of potential for damage to sensitive equipment.

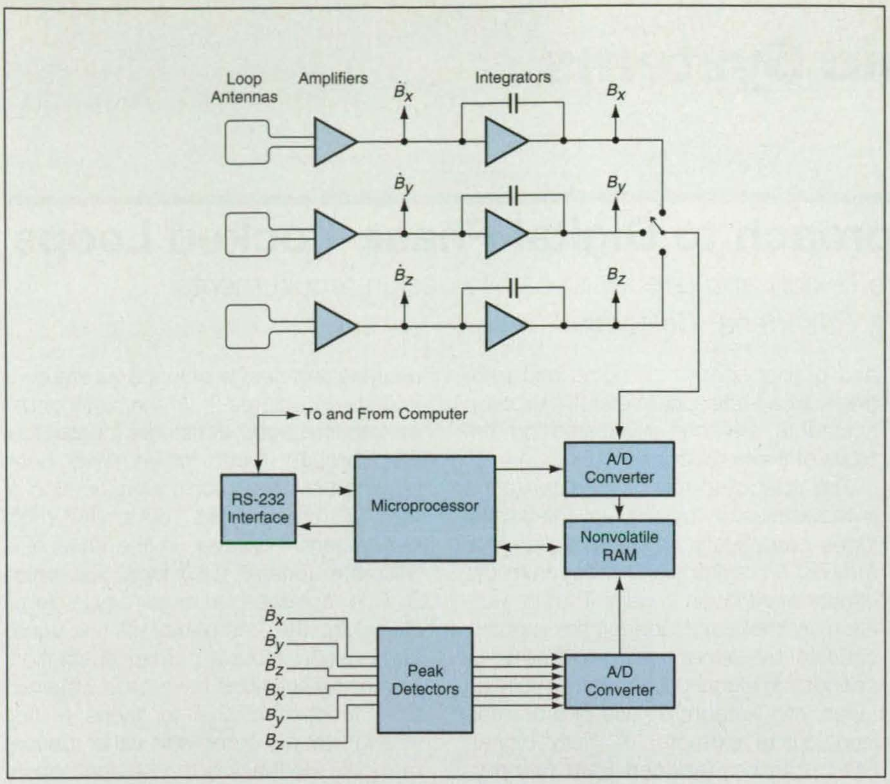
John F. Kennedy Space Center, Florida

A portable, self-contained, compact instrument measures and records transient magnetic fields — particularly those generated by nearby lightning strikes. The instrument is designed to be placed near sensitive electronic equipment in anticipation of thunderstorms. The data recorded by the instrument during thunderstorms can be analyzed afterward to determine whether the magnetic effects of the lightning were strong enough that they might have damaged and/or affected the operation of the sensitive equipment. Thus, the instrument provides data that help engineers decide whether the sensitive equipment should be tested for damage and/or other effects caused by lightning. Typical installations in which this instrument could prove beneficial include outdoor sensing equipment, computer rooms, broadcasting stations, and powerplant control rooms.

The instrument (see figure) includes three orthogonal loop antennas, each of which senses the component of the transient magnetic field along one of three orthogonal axes. It is necessary to sense all three components because there is no way to know the direction of arrival of the magnetic field in advance. The three loops are placed far enough from each other to minimize cross-coupling among them. The output voltage of each loop antenna is proportional to the rate of change of one component of the magnetic field ($\dot{B}_x, \dot{B}_y$, or $\dot{B}_z$)This voltage is sampled; it is also processed through an integrator circuit to obtain a voltage proportional to the component of the magnetic field (B_x, B_y, or B_z).

An internal microprocessor controls the operation of the instrument. An analog-to-digital (A/D) converter, acting in conjunction with the microprocessor, samples the peak values of the magnetic field and the rate of change of the magnetic field during sampling periods 1 ms long. When the peak values exceed predefined thresholds, the peak values are stored in an electronic random-access memory (RAM) for subsequent retrieval. An additional A/D converter samples the output of one of the integrators (that is, it samples a signal proportional to one chosen component of the magnetic field) at a rate of 10^7 samples per second. The instrument is equipped with a clock, so that the time when each sample is taken is recorded along with the sample. The time record makes it possible to correlate these samples with samples taken by other instruments during the same lightning strike.

The instrument is powered by batteries; it can operate unattended for as long as two weeks. The RAM is nonvolatile, so that the recorded data are not lost in the event of a loss of power. Stored data are retrieved from the instrument by use of a portable computer. The batteries can be changed in the field so the instrument can stay in place to continue measuring without interruptions. The data



Three Loop Antennas sense the three orthogonal components of the rate of change of magnetic-flux density. These components and their time integrals (proportional to the magnetic field) are sampled and recorded for subsequent analysis.

retrieved include the date and time of each occurrence, the peak positive and negative values of both the magnetic field and rate of change of its derivative (for all three axes), and a string of samples representing a 50-μs-long waveform of the chosen component of the magnetic field.

With its 10-MHz sampling rate, this instrument records lightning waveforms more accurately than do portable commercial magnetic-field meters. Lightning waveforms typically include frequencies up to tens of megahertz, while the commercial meters, which are designed to measure magnetic fields of high-voltage power lines, are usually limited in frequency response to a few hundred hertz.

This work was done by Pedro J. Medelius and Howard James Simpson of I-NET, Inc., for **Kennedy Space Center**. *For further information,* ***write in 1*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center [see page 20]. Refer to KSC-11769.

Controlled-Root Approach to Digital Phase-Locked Loops

Performance can be tailored more flexibly and directly to satisfy design requirements.

NASA's Jet Propulsion Laboratory, Pasadena, California

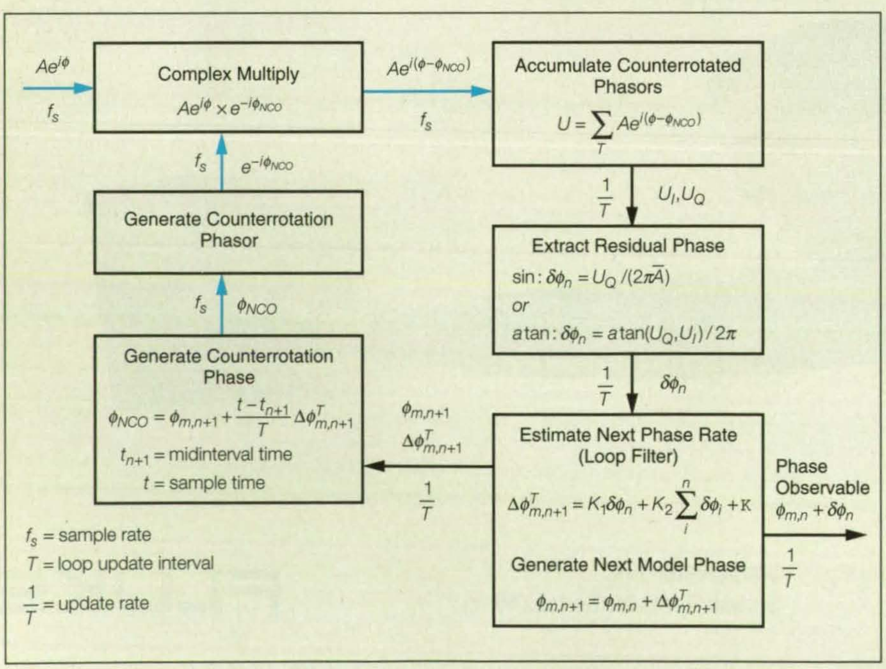
The controlled-root approach is an improved method for analysis and design of digital phase-locked loops (DPLLs). Heretofore, DPLLs (see figure) have been designed and analyzed partly by reliance on analog-circuit traditions, which has made such analysis unnecessarily cumbersome. In contrast, the controlled-root approach has been developed rigorously from first principles for fully digital loops, making DPLL theory and design simpler and more straightforward (particularly for a third- or fourth-order DPLL) and controlling performance more accurately in the case of high gain. The formalism, which can be systematically extended to loops of arbitrary order, provides an easy flexibility by directly placing roots in the s-plane (where s is the Laplace-transform complex frequency).

In the controlled-root approach, the transient response and noise bandwidth of the loop can be selected directly. The roots of the transfer function of the loop are first placed in the s plane on the basis of a loop-bandwidth parameter and of root-specific damping and transient-decay-rate parameters. The loop constants are then calculated on the basis of these roots.

The controlled-root parameterization is made feasible by the fact that digital loops can usually be designed so that they do not suffer significantly from the effects of variation in gain. That is, variation in the amplitude of the signals, caused by either gain instability or changes in signal power, can usually be taken into account by use of a normalized phase extractor. A "fully digital" DPLL can be designed from this perspective, without the analysis or precautions that are needed in older design methods to cope with potential variation in gain.

Previous analyses have been begun with the closed-loop equation in the "continuous-update" (CU) limit in which $B_L T \rightarrow 0$, where B_L is the loop noise bandwidth and T is the loop update interval. For sufficiently small $B_L T$ (e.g., $B_L T \leq 0.02$), the CU approximation can provide an adequate starting point for analysis and design of loops via the controlled-root approach. In the continuous-update limit, loop constants for loops of first through fourth order have been obtained in closed form as a function of the aforementioned controlled-root-parameters. However, in the case of a "discrete-update" (DU) loop, for which $B_L T$ is assigned a larger value (e.g., $B_L T$=0.5), the complexity of the equations necessitates a numerical solution. Numerical solutions have been obtained as a function of $B_L T$ for loops of first through fourth order with either phase-rate-only feedback or phase and phase-rate feedback, with supercritical damping or standard underdamping, and with zero computation delay or a computation delay equal to one update interval. With the controlled-root parameterization, the bandwidth and damping behavior of a high-order loop can be implemented simply and accurately, even when $B_L T$ is large.

Based on the controlled-root parameterization, loops of first through fourth order were simulated and characterized in terms of mean time to first cycle slip. The simulated loops have phase and phase-rate feedback, supercritical damping and zero computation delay. For a given B_L, loops with larger $B_L T$ exhibited considerably better (longer) mean time to first cycle slip than did those of smaller $B_L T$. Performance of loops with respect to steady-state phase error has also been assessed. For a given value of B_L, steady-state phase error remains essentially constant for $B_L T \leq 0.02$, but increases at larger values of $B_L T$.



A Phase-Locked Loop with phase and phase-rate updates and zero computation delay is illustrated schematically.

This work was done by Scott A. Stephens and J. Brooks Thomas of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 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, NASA Resident Office–JPL [see page 20]. Refer to NPO-18757.

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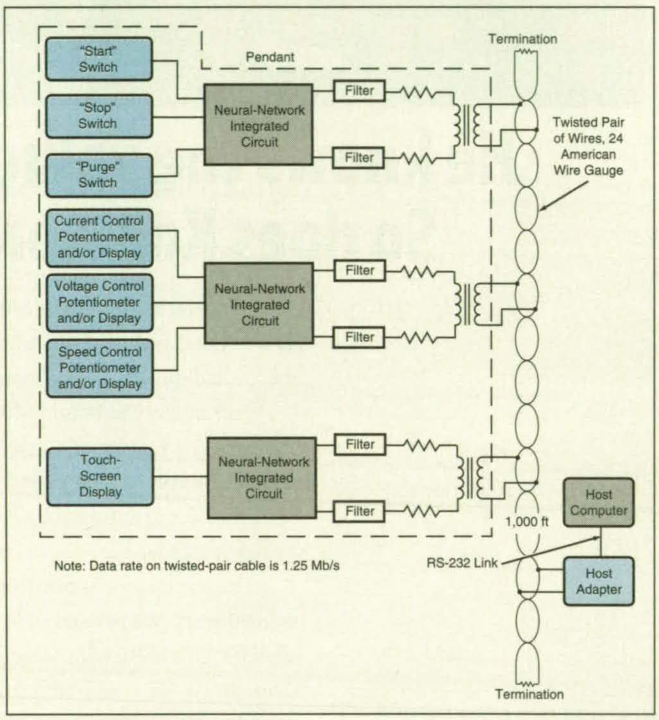
Remote Neural Pendants in a Welding-Control System

Neural-network circuits enhance functionality.

Marshall Space Flight Center, Alabama

Neural-network integrated circuits are used to increase the information capacities of remote terminals and of the communication links between those terminals and a host computer in the electronic control system of a large robotic welding facility. The neural-network integrated circuits enhance the functionalities of both the remote terminals (which are called "pendants" in the industry) and the communication links, without necessitating the installation of additional wires in the links. A neural-network integrated circuit makes it possible to incorporate many features into a pendant, including a real-time display of critical welding parameters and other process information, a capability for communication between a technician at the pendant and the host computer or a technician elsewhere in the system, and switches and potentiometers through which a technician at the pendant exerts remote control over such critical aspects of the welding process as current, voltage, rate of travel, flow of gas, starting, and stopping.



Neural-Network Integrated Circuits control the flow of information over a twisted-pair cable for communication with a host computer. Despite the high electromagnetic interference in a factory environment, the host computer can be positioned a large distance from the pendant.

Heretofore, a separate microprocessor would probably have been needed for each of these features. Furthermore, communication links included double-shielded cables containing 50 twisted-wire pairs, which could handle only basic remote-control functions, and the addition of video displays in the electrically noisy welding environment was prohibitively expensive.

The pendants equipped with the neural-network integrated circuits are all transformer-coupled to a single twisted-pair cable, which thus constitutes the trunk line of a local-area network of neural-network terminals and the host computer (see

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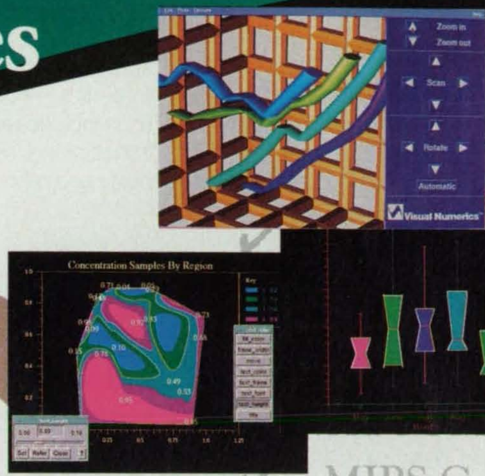

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figure). Each neural-network integrated circuit in a pendant is a commercial unit (Neuron 143150) that can handle as many as 11 input/output functions. Each display device (cathode-ray tube, liquid-crystal display, light-emitting diode, or meter) and each control switch in a pendant is connected to one of the input/output ports of its neural-network integrated circuit(s). The twisted-pair cable can be as long as 1,000 ft (about 300 m), and is connected to a host adapter that is, in turn, coupled to the host computer via standard equipment.

Other potential manufacturing applications of pendants and communication links like these could include control of spray coating and of curing of composite materials. Potential nonmanufacturing uses include remote control of heating, air conditioning, and lighting in electrically noisy and otherwise hostile environments.

This work was done by Richard A. Venable and Joseph H. Bucher of Martin Marietta 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 20]. Refer to MFS-28903.

Tilt/Integral/Derivative Compensators for Controllers

The responses of the controllers can be made to approximate the optimal responses more closely.

NASA's Jet Propulsion Laboratory, Pasadena, California

Tilt/integral/derivative compensators for tunable feedback control systems offer advantages over proportional/integral/derivative compensators, which until now have been the standard compensators in such controllers. In comparison with the proportional/integral/derivative (PID) compensator that would otherwise be used in a given controller, a tilt/integral/derivative (TID) compensator can be designed and adjusted more easily, and can be made to reject disturbances more strongly and be less sensitive to variations in the parameters of the controlled system.

Figure 1 shows a PID controller and the corresponding TID controller. The command input is fed to the controller through a prefilter that has a transfer function R(s) (where s is the complex-frequency independent variable of the Laplace transforms). The prefiltered input is fed through the compensator into the controlled system. Feedback from the output of the controlled system is also filtered through the compensator. The transfer function of the PID compensator is

$$P + Is^{-1} + Ds$$

whereas that of the TID compensator is

$$Ts^{-1/n} + Is^{-1} + Ds/\left(1+\frac{s}{s_o}\right)$$

where P, I, D, n, T, and s_o are constants to be selected by design and/or adjustment, and typical values of n lie between 2 and 3. The prefilter corrects for some of the effects of the compensator on the command input in such a way as to provide the desired overall frequency response to the command input.

Bode calculated the optimal frequency response of a control loop that rejects disturbances strongly and is relatively insensitive to changes in parameters of the controlled system. Figure 2 shows a simplified, slightly suboptimal version of the Bode frequency response that is adequate for industrial control, along with the frequency response of a PID controller. The frequency response of a TID controller can be made to approximate the Bode response more closely. In practice, the irrational $s^{-1/n}$ term in the TID transfer function is approximated by a rational transfer function that can be implemented in analog circuitry by use of resistors, capacitors, and an amplifier, or can be implemented digitally in software.

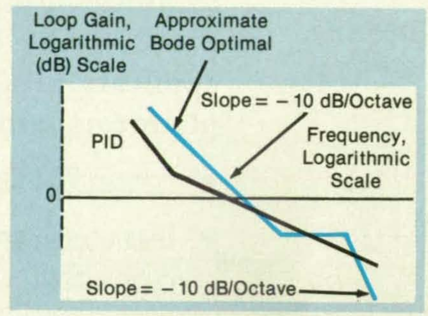

Figure 2. The **Optimal Bode Response** can be approximated in a TID controller by selection of the parameters of the TID transfer function.

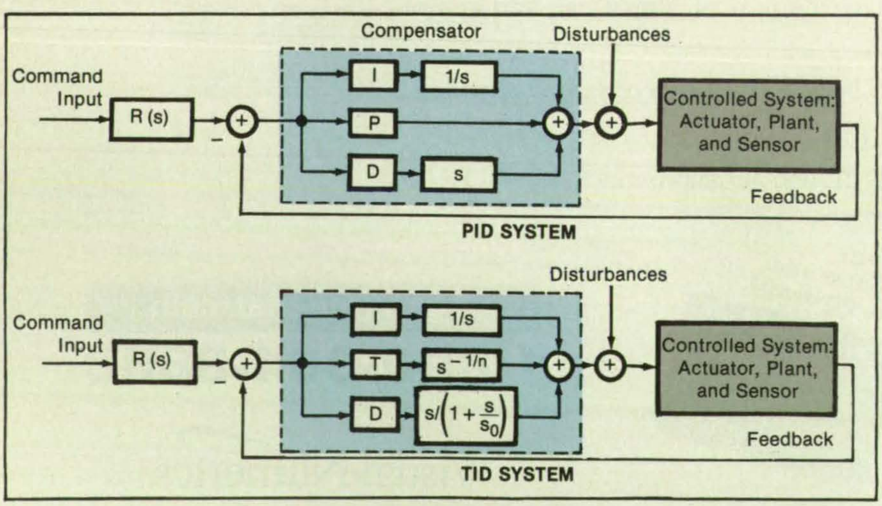

Figure 1. The **TID Controller Resembles the PID Controller** superficially, but offers better performance. The "T" (for "tilt") signifies a tilt in the gain-frequency response in the middle frequency range, where the T term dominates. In the PID controller, the P term dominates in this frequency range, and the gain-frequency plot there is horizontal.

This work was done by Boris J. Lurie of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 60*** *on the TSP Request Card.*

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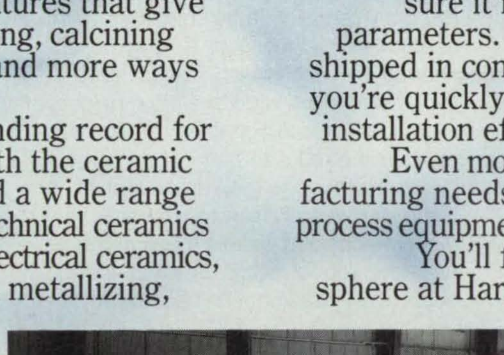

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Physical Sciences

Microsensor Hot-Film Anemometer

Features include low thermal inertia, ruggedness, and reduced perturbation of flow.

Langley Research Center, Hampton, Virginia

An improved hot-film anemometer has been developed for making high-bandwidth turbulence measurements in moderate-enthalpy supersonic and hypersonic flows (e.g., NASP inlets and control surfaces, HSCT jet exhaust). Traditional measurement techniques (e.g., hot-wires, LDV) are insufficient to meet the requirements of moderate-enthalpy flows, which include elevated stagnation temperatures and high dynamic pressures. In addition, existing hot-film designs are not well suited for this purpose, most notably because they lack the bandwidth necessary to resolve the energy-containing portion of such flows.

The development of the improved hot-film anemometer involved the use of advanced materials and state-of-the-art fabrication techniques to achieve a combination of ruggedness and high-frequency response, while minimizing flow perturbation. The hot-film substrate is a 14-degree half wedge (see figure) 0.5 in. (12.7 mm) long by 0.125 in. (3.175 mm) wide, diamond-tooled out of sapphire. The narrow end of the wedge, which faces upstream, is rounded to a radius of 0.2 mm and polished to a surface finish of less than 1 μin. (0.03 μm).

In hot-film anemometry, the fragile wire sensing element used in hot-wire anemometry is replaced with a thin metallic film deposited along the stagnation line of the upstream edge of the substrate, thus increasing mechanical strength. To achieve the low thermal inertia necessary for high frequency response, the sensor strip is made significantly smaller than older hot-film anemometer strips: it is a "dog-bone"-shaped strip of iridium about 3,000 Å thick by 12.5 μm wide by 0.25 mm long. High spatial resolution is an added benefit of this small size.

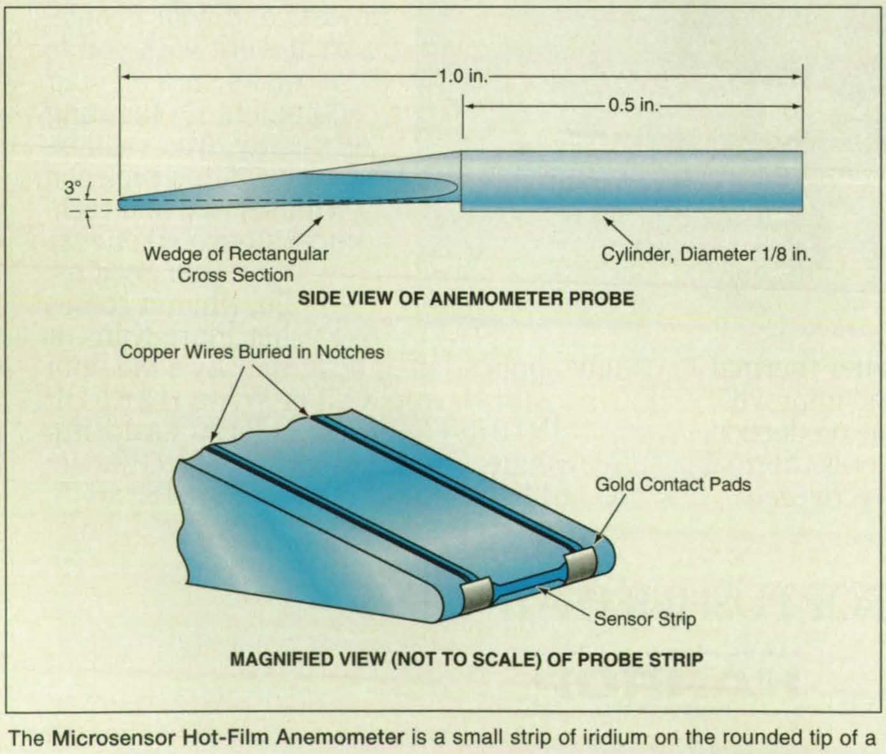
The half-wedge geometry shown in the figure was chosen to minimize flow disturbances and enable measurements near the model body. The half-wedge angle of 14° was chosen because it prevents the wedge from generating a detached shock through much of a hypersonic boundary layer. The 3° angle of one side of the wedge is intended to relieve shock-induced disturbances created by the finite curvature of the upstream edge: this will decrease any boundary-layer disturbance that can propagate upstream, improving the accuracy of the measurement.

The iridium sensor strip is formed on the rounded edge of the wedge substrate by a microphotolithographic process. Gold contact pads are formed on the ends of the sensor strip by painting and baking a gold organometallic solution. Thin copper wires for connection to external circuitry are buried in notches and attached to the gold contact pads by use of a silver-filled polyimide adhesive.

The use of iridium as the hot-film material helps to increase thermoelectric stability at high temperatures, since it is the most corrosion-resistant element known. The use of sapphire not only enables the fabrication of a small, precisely shaped and finished anemometer substrate but also enables the anemometer to withstand severe temperatures without mechanical failure and without significant changes in dielectric properties. Preliminary testing at mach 6 in air has indicated a frequency response which extends out to over 800 kHz, which represents a five-fold increase over previous designs.

This work was done by Catherine B. McGinley, Ralph Stephens, Purnell Hopson, and James E. Bartlett of **Langley Research Center** *and Mark Sheplak and Eric F. Spina of Syracuse University. For further information,* ***write in 36*** *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, Langley Research Center [see page 20]. Refer to LAR-15112.



The **Microsensor Hot-Film Anemometer** is a small strip of iridium on the rounded tip of a sapphire wedge.

Measuring Thickness of Ice When Liquid Is Present

Capacitances are measured at two frequencies.

Langley Research Center, Hampton, Virginia

A proposed capacitive ice-thickness gauge would give a reliable measurement even when water or other liquid was present within or over the layer of ice. This capability is important for measuring the thickness of ice on an airplane wing or other surface because (1) some liquid water is often present during the formation of ice and (2) even when deicing fluid or heat is applied, there is still a need to measure the thickness of the remaining ice.

Heretofore, dual-geometry capacitive ice-thickness gauges have been used. A gauge of this type comprises two gauges with different electrode spacings to measure the thickness of a layer of ice, independent of the temperature and dirtiness of the ice. The gauge works well if the ice is reasonably homogeneous and no water or other liquid is mixed into or lying over the ice. In the presence of liquid, the apparent electric permeability and conductivity may vary considerably with position from near the electrodes to the outer surface of the ice. Such variations can cause large errors in the gauge readings, making the readings unusable.

The proposed gauge would correct for the effects of liquids by utilizing the known variations of the relative electric permeabilities (popularly called "dielectric constants" even though they are not constants) of ice and liquids. Because of the mobility of their molecules, liquids respond very rapidly to changes in electric fields. Ice, on the other hand, responds relatively slowly to variations in electric fields because of the constraints of its crystal lattice. Moreover, ice and liquid water both have strong molecular dipole moments. As a result, the relative electric permeability of liquid water remains nearly constant ($\approx$80) throughout the range of frequencies (up to more than 10^8 Hz) used to measure it, whereas the relative electric permeability of ice varies from 3.1 at frequencies $\geq$ about 10^4 Hz to more than 80 at frequencies $\leq$ 50 Hz. The exact values of relative electric permeability and the frequency ranges in which the values change sharply with frequency are functions of temperature. In addition, polarization and conductivity affect capacitive measurements and are characterized by rapid responses in both ice and liquids.

In the proposed gauge, the capacitive effects of ice and water (or other liquid) would be measured at two frequencies — for example, 50 Hz and 10 kHz. The capacitance measured at the higher frequency would be subtracted from that measured at the lower frequency. The difference would be related only to the difference between the corresponding values of the relative electric permeability of ice. The other effects, which would be independent of frequency in the range that includes these two frequencies, would be common to both readings and therefore would be canceled in the subtraction. The absolute level of the difference would vary with temperature and composition, but a correction for this variation would be provided by the dual geometry retained from the previous gauge concept.

The common portion of the signal would be an indication of those parameters that are independent of frequency. The amount of the signal subtracted out would be at least partially indicative of liquid content. The frequencies used in a given case could differ from those mentioned above, as long as the result of the subtraction was reasonably large. Measurements at more than two frequencies might provide more accuracy, but would entail greater effort.

This work was done by Leonard M. Weinstein of **Langley Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-15061.

Vapor Degreasing of a Large Tank

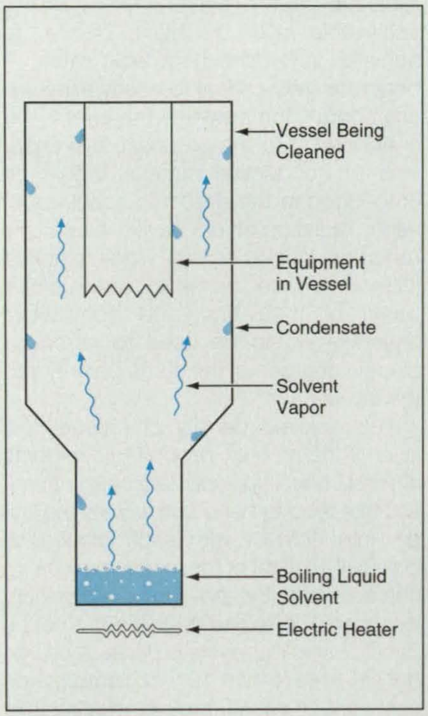
Solvent is refluxed to concentrate less volatile contaminants at the bottom.

NASA's Jet Propulsion Laboratory, Pasadena, California

A vapor degreasing procedure provides for the removal of relatively nonvolatile oils and greases from the insides of large vessels. The procedure can ensure the required degrees of cleanliness in high-purity chemical processing and high-vacuum processing vessels. The procedure was devised for, and proved successful in, cleaning a complexly-shaped stainless-steel vacuum chamber that contains numerous difficult-to-clean features like screw holes and abutting surfaces.

The procedure begins with the attachment of plumbing to handle the flows of degreasing solvent into and out of the bottom of the vessel. Electric-heating tapes are applied to the bottom of the vessel, which is thus converted temporarily into a solvent boiler. The bottom of the vessel is filled with solvent to a suitable depth and the heat is turned on.

As the solvent boils, heated vapor moves to the upper levels of the tank, where the vapor condenses and dissolves greasy contaminants. The solvent refluxes to the boiler, carrying the dissolved contaminants with it. The procedure can be carried out at a moderate temperature (below 100 °C) if a low-boiling-temperature solvent is used. The



Solvent Is Refluxed in a vessel to dissolve oil and grease.

vessel need not be pressurized because the vapor is condensed and returned to the boiler. The solvent is removed after refluxing for a suitable time. To achieve a higher degree of cleanliness, the procedure can be repeated.

The solvent can be a chlorofluorocarbon, provided that means are provided to recover most of it and minimize the portion that escapes into the air. Alternatively, a hydrocarbon or other flammable solvent can be used, provided that flammability is tolerable in the particular application.

This work was done by Robert E. Frazer of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 89*** *on the TSP Request Card.*
NPO-19258

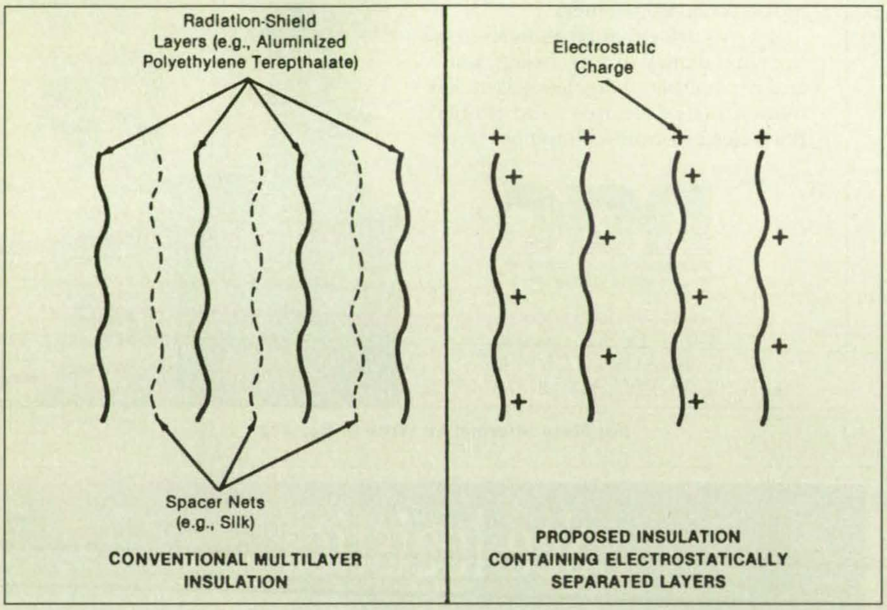
Electrostatic Separation of Layers in Thermal Insulation

Conduction between layers would be eliminated (except at the edges).

NASA's Jet Propulsion Laboratory, Pasadena, California

The layers of multilayer thermal insulation would be kept apart by electrostatic repulsion, according to a proposal. The insulation in question is of the type used to slow the leakage of heat into Dewar flasks that contain liquid helium. The proposal was originally meant to apply to insulation in cryogenic cooling subsystems of infrared-detector systems in outer space, but it also appears to be applicable to small panels of insulation for terrestrial cryogenic equipment, provided that the layers are contained in evacuated spaces and that the weight of each layer is a small fraction of the electrostatic force upon it.

Typically, a layer consists of a thin sheet of Mylar (or equivalent) polyethylene terephthalate coated with aluminum or gold. The metal coats provide the high reflectivity needed to minimize the radiative transfer of heat through a stack of such sheets. Heretofore, to prevent the conductive transfer of heat that would occur if the radiation-shield layers were allowed to touch, spacer nets made of Dacron (or equivalent) polyethylene terephthalate or silk have been placed between the radiation-shield layers to keep them apart (see figure). Unfortunately, there is some small residual conduction through the spacer nets. At temperatures lower than about 40 K, this residual conduction dominates over radiative-heat transfer for typically achievable layer densities. Hence, to achieve very low heat-leak rates, it becomes very critical to nearly eliminate any conduction between the layers.



Layers in Multilayer Insulation would be charged to keep them separated by electrostatic repulsion, eliminating the need for spacer nets. Removal of the spacer nets would reduce conduction of heat between layers.

According to the proposal, thin channels of conductive material would be embedded in the dielectric substrate of each radiation-shield layer. Once the radiation-shield layers were stacked (without spacer nets) to assemble a panel of insulation, the conductive channels would be used to introduce electric charges of the same polarity into the layers.

The required density of charge in a layer is the amount needed to overcome internal, handling, and fabrication stresses that tend to bend and wrinkle the layers into contact with each other. The cumulative effect of these stresses can be characterized by the pressure (typically less than 1 kPa) that is applied to hold a panel of stacked layers in place. A charge density of less than 10^{-4} coulumb/m^2 on each sheet would provide electrostatic repulsion equal to this pressure.

This work was done by Pradeep Bhandari of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 243*** *on the TSP Request Card.*
NPO-18559

Ultracold-Atom Accelerometers

These accelerometers would be essentially frictionless.

Marshall Space Flight Center, Alabama

A proposed class of accelerometers and related motion sensors would be based on the use of ultracold atoms as the inertial components of motion transducers. The ultracold atoms would supplant the spring-and-mass components of older accelerometers. As used here, "ultracold atoms" means atoms with kinetic energies equivalent to temperatures ≤ 20 mK.

The atoms would be trapped and cooled by use of laser beams. The motions of the atoms would be sensed via their radiative interactions with laser beams, using Doppler shifts of characteristic absorption and emission spectral lines as measures of the motions of the atoms with respect to the lasers and photosensors. An accelerometer of the proposed type could be designed to focus on a single atom, possibly with the help of an electromagnetic feedback subsystem that would respond to and regulate the position of the atom relative to an observation window.

The ultracold-atom accelerometers would be essentially frictionless. The primary advantage over other accelerometers would be high sensitivity — even greater than the sensitivity of the best currently available accelerometers based on electromagnetic interactions with superconducting inertial masses.

This work was done by David A. Noever of **Marshall Space Flight Center.** *To obtain a copy of the report, "Frictionless Accelerometer Technology for Motion Detection Using Ultracold Single Atoms,"* ***write in 115*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-28979.

Sorbents Remove Oxygen at High Temperatures

Cobalt-exchanged, platinized zeolites lower equilibrium oxygen levels to < 1 part per trillion.

NASA's Jet Propulsion Laboratory, Pasadena, California

Cobalt-exchanged, platinized zeolites 13X and L have been found to be conveniently reducible in a hot gaseous mixture of hydrogen and nitrogen and to be thereafter useful as sorbents of trace amounts of oxygen at high temperatures. Aided by the catalytic action of the platinum, the sorbents exhibit rapid oxygen-sorption kinetics and, according to the thermodynamic properties of the O_2/CoO system, should be capable of lowering the level of oxygen in an otherwise inert gaseous atmosphere to < 1 part per trillion in the temperature range of 400 to 800 °C. Inert atmospheres with these oxygen levels, which cannot be achieved by use of prior copper-exchanged zeolites, are required for the processing of certain materials in the semiconductor industry.

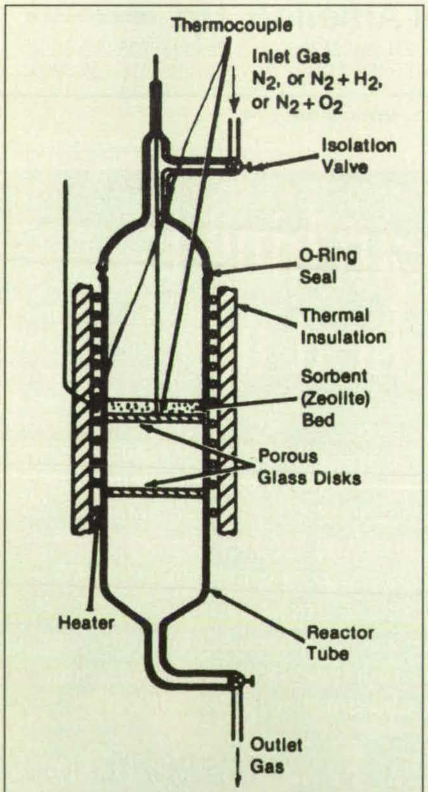


Figure 1. This **Reactor Assembly** was used to reduce the sorbents, then to test them for ability to chemisorb oxygen.

In experiments, beads of zeolites 13X and L were first treated with a 1-molar aqueous solution of ammonium nitrate to replace Na^+ in the zeolite by NH_4^+. The ammonium-exchanged zeolites were then treated with 0.1 molar cobalt nitrate to replace the NH_4^+ with Co_2^+. After rinsing in distilled water and drying in air at 250 °C, the cobalt-treated zeolites were further treated with an aqueous solution of chloroplatinic acid, H_2PtCl_6, such that the amount of platinum introduced into each zeolite was approximately 0.1 percent of its weight. Each platinum-treated zeolite was then dried in air at 250 °C.

The dried, cobalt-exchanged, platinized zeolites were reduced by heating them in a mixture of nitrogen and hydrogen at a temperature of 600 °C in the system shown schematically in Figure 1. The concentration of hydrogen was gradually increased from 1 percent to 20 percent during 24 hours. At the end of this time, the zeolite beads were found to be fully black in color, indicating that extensive reduction had occurred. (In contrast, when cobalt-exchanged zeolites that did not contain platinum were subjected to the same reducing conditions, there was no appreciable change in color, indicating a general lack of reduction.)

The uptake of oxygen by the reduced sorbents was investigated in the same apparatus as that used for reduction. Before exposing each sorbent to oxygen, a thermocouple was placed in the middle of the sorbent bed to measure the increase in temperature caused by the exothermic oxidation reaction. The sorbent bed was heated to about 625 °C in a flow of highly pure nitrogen through the sorbent at a rate of 100 mL/min. When steady-state conditions were achieved, oxygen was introduced into the flow at a rate of 10 mL/min, so that a gas mixture consisting of 10 percent oxygen and 90 percent nitrogen flowed through the sorbent bed.

Figure 2 shows the exothermic increases in temperature, as functions of time, for cobalt-exchanged, reduced zeolites 13X and L, with and without platinum. The increase in temperature upon contact with oxygen is taken to be a measure of reactivity to oxygen, the area under the curve being proportional to the total oxygen uptake. By this measure, the sorbents that contained platinum absorbed much more oxygen than did the corresponding sorbents that did not contain platinum.

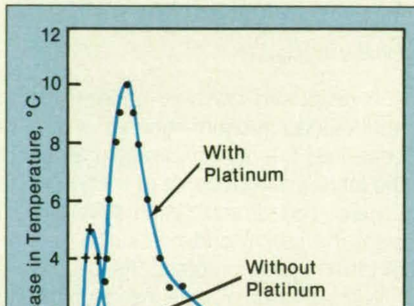


Figure 2. The **Increase in Temperature** caused by chemisorption of oxygen was measured in reduced sorbents with and without platinum.

This work was done by Pramod K. Sharma of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 150*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 20]. Refer to NPO-18409.

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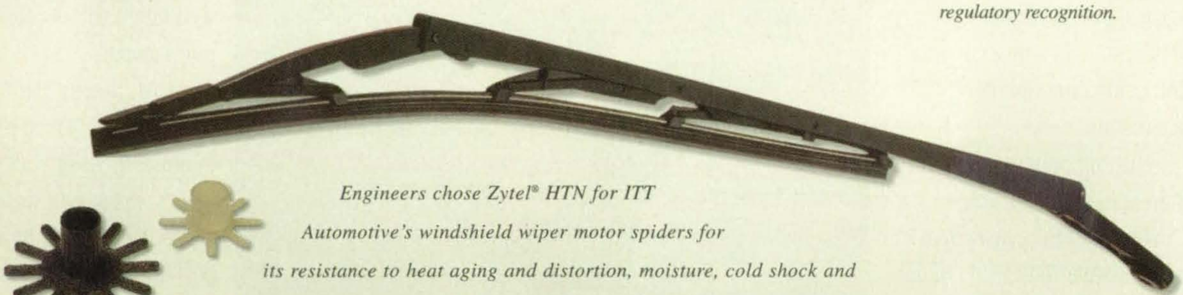

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Films Composed of Diamond and Diamondlike Carbon

These films would be used as self-lubricating and protective coats at extreme temperatures.

NASA's Jet Propulsion Laboratory, Pasadena, California

Proposed films composed of diamond and diamondlike carbon are expected to be useful as wear-resistant and self-lubricating protective and tribological coats at extreme temperatures (from -269 to +600 °C) and in corrosive and oxidizing environments. These films could have a wide variety of industrial applications.

Because of its chemical inertness, extreme mechanical hardness, and high thermal conductivity (the highest of all solid materials), diamond is the ideal material to provide resistance to wear in tribological and protective coats. On the other hand, the characteristics of diamondlike carbon — an amorphous carbon material with a mixture of diamond and graphite molecular bonding configurations — enable it to act as a solid, self-lubricating agent. Therefore, it should be possible to design and fabricate films that are composed of both materials and that exhibit the desired wear-resisting and self-lubricating characteristics.

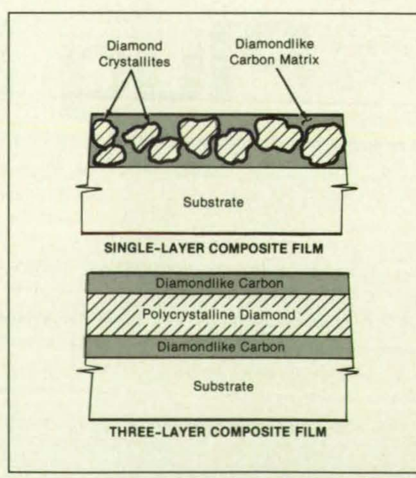
According to the proposal, two versions of films composed of diamond and diamondlike carbon could be made by chemical-vapor deposition. The upper part of the figure shows a version in which diamond crystallites would be embedded in a matrix of diamondlike carbon. The lower part of the figure shows the other version, in which a layer of polycrystalline diamond would lie between two layers of diamondlike carbon.

Polycrystalline diamond and amorphous diamondlike carbon can be deposited by use of high-pressure microwave plasmas and electron-cyclotron-resonance (ECR) microwave plasmas. High-pressure microwave plasma depositions can be performed at pressures from about 1 to 100 torr (about 0.13 to 13 kPa); ECR microwave plasma depositions can be performed at pressures of about 1 to 100 mtorr (about 0.13 to 13 Pa).

A microwave plasma deposition system has been constructed to test the concept. It operates in both high-pressure and ECR plasma modes. This system has been used to deposit polycrystalline diamond and diamondlike carbon films separately. Future efforts will be directed toward the deposition of composites of both materials.

This work was done by Yuh-Han Shing of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 51*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office — JPL [see page 20]. Refer to NPO-18501.



Composite Films of Diamond and Diamondlike Carbon could be used as protective and/or tribological coats at extreme temperatures and/or in corrosive environments.

Superacid-Based Lithium Salts for Polymer Electrolytes

Performances of solid-polymer-electrolyte/lithium batteries could be enhanced by greater ionic conductivities.

NASA's Jet Propulsion Laboratory, Pasadena, California

Solid polymer electrolytes that exhibit high lithium-ion conductivities have been made by incorporating salts of superacids into thin films of polyethylene oxide (PEO). These and other solid-polymer electrolytes are candidates for use in rechargeable lithium-based electrochemical cells, wherein increases in the room-temperature lithium-ion conductivities of the solid electrolytes are desirable because they would increase the achievable power and energy densities.

Previously, research on solid polymer electrolytes for lithium batteries had centered around PEO and other organic polymers complexed with lithium salts, which provide the lithium-ion conductivity. The lithium salts that have been used for this purpose include LiI, $LiAsF_6$, $LiCF_3SO_3$, $LiBF_4$ and $LiClO_4$. Of these salts, only $LiCF_3SO_3$ is derived from a superacid. ("Superacid" as used here denotes an acid with at least 1,000 times the strength of concentrated sulfuric acid.) Each of the solid polymer electrolytes tested in the previous research either (a) exhibited increased room-temperature conductivity but was made with a polymer that lacked mechanical integrity or (b) was made with PEO, which is mechanically robust, but was insufficiently conductive.

Solid Polymer Electrolyte	Conductivity (S/cm)
PEO/CF_3SO_3Li	2.09×10^{-8}
$PEO/C_4F_9SO_3Li$	1.22×10^{-6}
$PEO/C_8F_{17}SO_3Li$	8.84×10^{-7}
$PEO/C_{10}F_{21}SO_3Li$	1.12×10^{-6}

The Room-Temperature Conductivities of solid electrolytes that contained recently developed salts of superacids were greater than that of the first-listed solid electrolyte, which contained a previously known salt of a superacid.

Accordingly, the present PEO/salt-of-superacid solid polymer electrolytes were conceived in an effort to take advantage of the mechanical robustness of PEO while increasing the lithium-ion conductivity. Lithium salts of superacids were chosen in the hope of increasing the concentrations of free lithium ions while loading the PEO with the same proportions of salts as in the previous research.

In experiments, thin films of PEO containing lithium salts of superacids were fabricated by solution casting, in preparation for electrochemical evaluation. The salts used were $LiCF_3SO_3$ and three recently developed analogs of $LiCF_3SO_3$. As shown in the table, the room-temperature bulk electrical conductivities of the films (except the one that contained $LiCF_3SO_3$) ranged from about 43 to about 58 times that of the film that contained $LiCF_3SO_3$.

This work was done by Ganesan Nagasubramanian, Surya Prakash, David H. Shen, Subbarao Surampudi, and George Olah of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 35*** *on the TSP Request Card.*
NPO-19286

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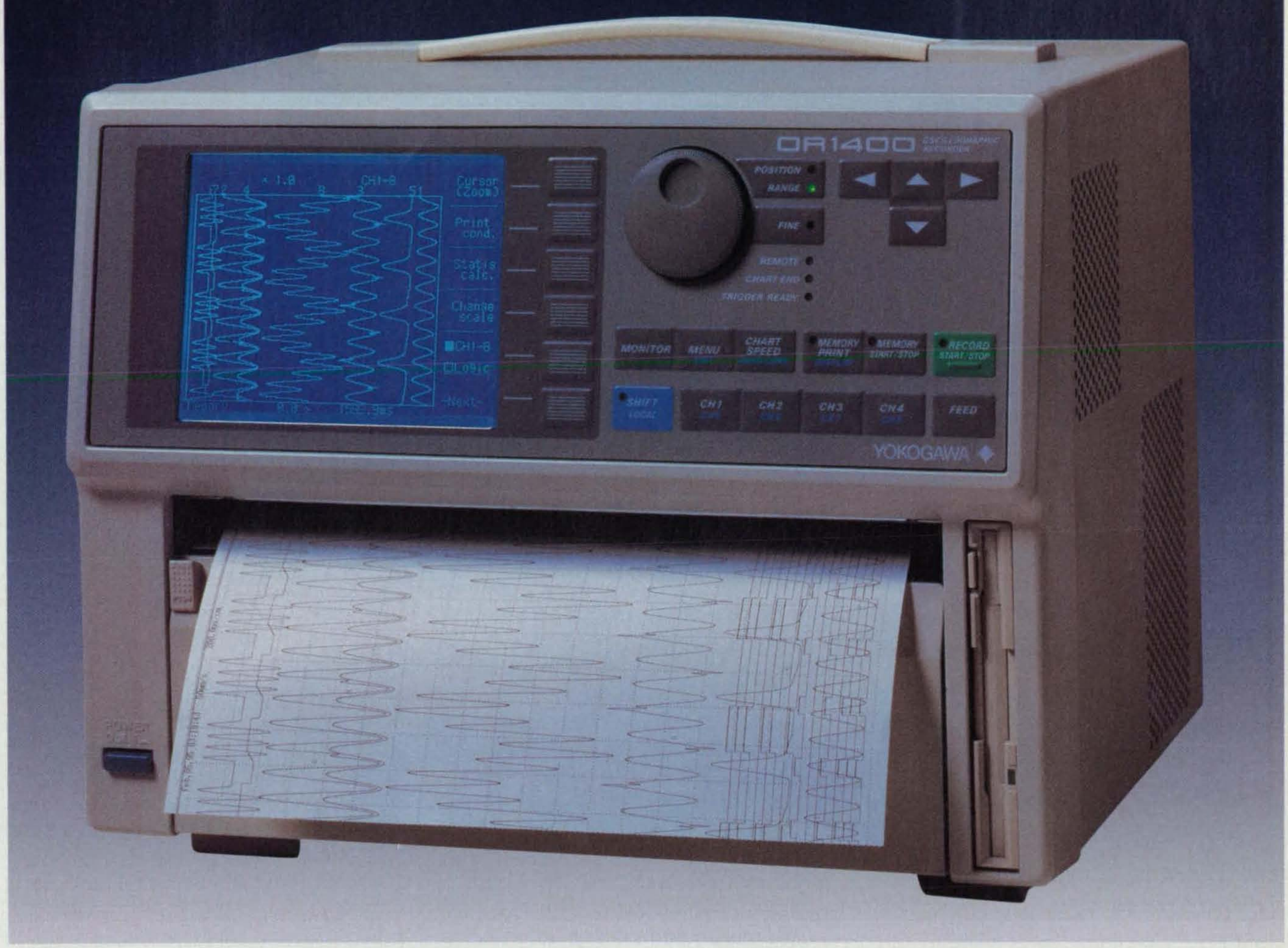

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Physical Sciences

Computing Fluxes of Molecules on and Near a Spacecraft

A free-molecular-flow mathematical model with perturbations accounts for nearly free flow.

The Molecular Flux (MOLFLUX) computer code is a versatile program that can be used to compute the following environmental effects induced by a spacecraft: (1) fluxes of molecules to, and deposition of molecules on, surfaces; (2) densities and column densities of molecules in surrounding space, and (3) return fluxes of molecules to surfaces caused by both collisions of the molecules with the ambient atmosphere and by self-scattering. MOLFLUX includes the capability to predict the buildup in the density of ambient gas in front of surfaces exposed to ram conditions by specifying the ambient flux rates for all species impinging on the surfaces. Surface chemical reactions can be represented as rates of emission from surfaces. The user has the option to modify spacecraft configurations and sources of contamination, and to choose which critical surfaces to examine.

MOLFLUX implements a free-molecular-flow mathematical model with perturbations to account for nearly free flow, and therefore appears to be adequate to deal with most applications related to outer space. "Nearly free flow" as used here includes the mass flow in a thruster plume, with the exception of a small plume volume of viscous and transition flow close to the nozzle from which the plume issues.

The transport function for all species can include a small perturbation (due to molecular collisions) from the free-molecular-flow case, and can be used to calculate backscattering return flux and attenuation of flux. The perturbation applied to the prediction of the basic model is based on a numerical integration of the Bhatnagar, Gross, Krook (BGK)-model approximation of the Boltzmann kinetic equation for a mixture of gases. As a result, MOLFLUX is a program of reasonable size and accuracy with maximum flexibility. To enhance flexibility of application, the capability to introduce input data as well as to evaluate output data is left very general and adaptable to the needs of the user.

Mathematical modeling of contamination generally requires addressing the following concerns: (1) the geometry of the spacecraft or other structure, (2) the processes of emission from all sources of contamination, (3) the transport of emitted contaminants, and (4) the induced effects of the contaminants upon critical surfaces and scientific objectives. The first three of these concerns are handled analytically in MOLFLUX. Once contamination levels have been established, other computer programs and analytical techniques can be used to determine the induced effects.

In general, the input of a new spacecraft configuration involves development of the necessary geometric relationships and mass-transport factors for that configuration. The most common approach is to use a thermal-radiation program like the Thermal Radiation Analyzer System (TRASYS) program to generate new mass-transport-factor input data for MOLFLUX. Configurations can be geometrically synthesized with TRASYS by use of basic geometrical surfaces and shapes; for example, cones, cylinders, and spheres. The level of detail is selected to assure accurate surface shadowing and to establish adequate surface resolution for compatibility with the various spacecraft-surface materials and available thermal-profile data. It is not necessary to run TRASYS to use MOLFLUX if the mass-transport-factor data have been precalculated and are available as permanent input data files. These input files must be regenerated only when new configurations are to be evaluated or existing configurations are to be modified.

MOLFLUX is written in FORTRAN and C language for DEC VAX-series computers running VMS. It requires up to 256MB of disk space and 120K of random-access memory for execution. The MOLFLUX software package includes sample executable codes, which were compiled by use of VMS FORTRAN 5.5.1. Sample input and output data files and sample batch files for compiling and linking are also included. The standard medium for distribution of this program is a 1,600-bit/in. (≈630-bit/cm), 9-track magnetic tape in DEC VAX BACKUP format. The program is also available on a TK50 tape cartridge in DEC VAX BACKUP format. This version of MOLFLUX, which includes interactive menus, was developed between 1989 and 1992.

This program was written by H. K. Ehlers of **Johnson Space Center** *and E. R. Rios, C. L. Hakes, and R. T. Rodriguez of Lockheed Engineering & Sciences Co. For further information,* ***write in 11*** *on the TSP Request Card. MSC-22260*

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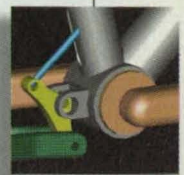

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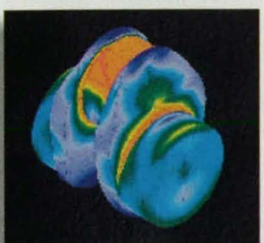

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Mathematics and Information Sciences

Application Portable Parallel Library

Program facilitates transport of application programs between computers.

The Application Portable Parallel Library (APPL) computer program is a subroutine-based message-passing software library intended to provide a consistent interface to a variety of multiprocessor computers on the market today. The objective of APPL is to minimize the effort needed to move an application program from one computer to another. A user can develop an application program once and then easily move the application program from a parallel computer on which it was created to another parallel computer. ("Parallel computer" may also include a heterogeneous collection of networked computers.)

APPL enables a programmer to think of an application program in terms of communicating processes, without the need to consider the underlying architecture of a computer during the development of the program. The application program can be mapped onto a particular computer architecture at run time. With APPL, this is accomplished by use of an initiator process, with a process-definition file as input.

The primitives in APPL enable a programmer to synchronously or asynchronously send and receive messages between processes. Among other APPL functions are the following: barrier, broadcast, probe, global operations, and other miscellaneous operations common to programming libraries of commercial distributed memory computers.

APPL is written in C language with one FORTRAN 77 subroutine for UNIX-based computers and it is callable from application programs written in C language or FORTRAN 77. The FORTRAN section of code could easily be rewritten in C language, but some FORTRAN vector compilers make this section of code more efficient than a C compiler would. APPL has been successfully implemented on a Sun4 computer running SunOS 4.1, an SGI computer running IRIX4.0.1, an Alliant FX/80-series computer running Concentrix 5.7.00, an IBM RS6000-series computer running AIX 3.1.6, an nCUBE2 computer running release 3.0 of the operating system, and a DEC Alpha computer running OSF/1. APPL requires a minimum of 1MB of random-access memory for execution. The standard distribution medium for APPL is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media and formats are available upon request. The distribution medium for APPL includes both UNIX man pages and an electronic copy of the documentation in PostScript format. The development of APPL began in 1990 and it was released for distribution through COSMIC in 1993.

This program was written by Gary L. Cole and Richard A. Blech of **Lewis Research Center**, *and Angela Quealy and Scott Townsend of Sverdrup Technology, Inc. For further information,* ***write in 222*** *on the TSP Request Card.*
LEW-15572

Electric Components and Circuits

Computing Radiation From Multiple-Circular-Aperture Antennas

Electromagnetic fields are computed in terms of superpositions of circular-waveguide modes.

The Mutual Coupling Program for Circular Waveguide-fed Aperture Array (CWG) computer program was developed to calculate the electromagnetic interactions among elements of antenna arrays with circular apertures with specified distributions of electromagnetic fields in the apertures. The distributions are assumed to be superpositions of the electromagnetic modes that can exist in a circular waveguide. Various external media are included to provide flexibility of use; for example, the flexibility to determine the effects of dielectric covers upon the impedances of aperture-type antennas.

The impedance and radiation characteristics of an antenna that contains a planar array of elements depend upon the mutual interactions among all the elements. These interactions are influenced by several parameters, (e.g., the parameters of the grid on which the array is laid out, the geometry and excitation of each element, the medium outside the array, and the internal network that feeds the array).

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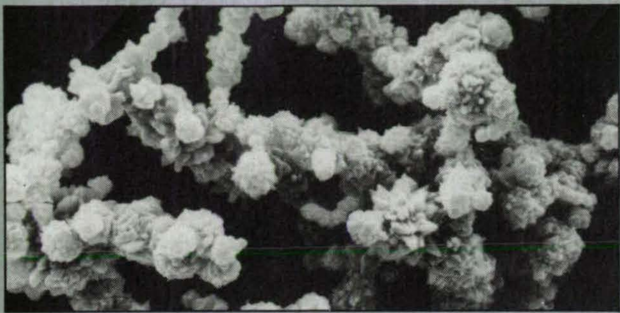

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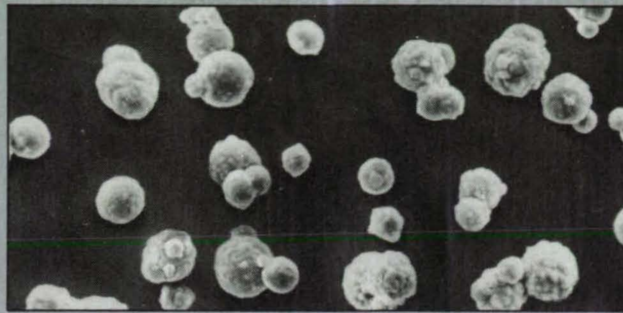
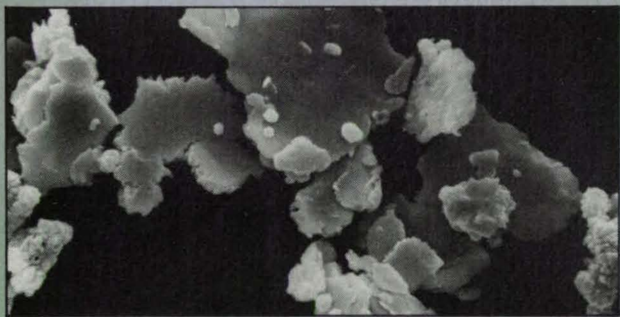


Novamet Silver Coated Nickel Spheres, 15% Ag, 2.5 g/cc apparent density, particle size 10 microns, screen mesh 99%-250, surface resistivity 0.03 Ω/□.



Novamet HCA-1 Flake, screen mesh 98% minus 400, apparent density 0.90 g/cc, thickness 1.0-1.1 microns, surface resistivity 0.25 Ω/□.

Novamet Nickel Coated Graphite, 60% fully encapsulated Ni, apparent density 1.6 g/cc, particle size (FSSS) 100 microns, screen mesh 63% −150/+250, surface resistivity 0.3 Ω/□.

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which the radiating elements are small holes in a flat conducting plate, the electromagnetic problem can be divided into an internal part and an external part. In solving the external part of the problem, CWG computes the mutual interactions among various combinations of circular apertures and distributions of circular-waveguide modes.

CWG computes the mutual coupling among various modes assumed to exist in circular apertures that are located in a flat conducting plane of infinite dimensions. The apertures can radiate into free space, into a homogeneous medium, into a multilayered region or onto a reflecting surface. These apertures are assumed to be excited by one or more modes that correspond to the distributions of modes in circular waveguides of the same cross sections as those of the apertures. The apertures can be of different sizes and different polarizations. However, the program implements the assumption that the fields in all the apertures contain the same distribution of modes, and it calculates a complex scattering matrix that summarizes the interactions among all modes and apertures. The scattering matrix can then be used to determine the complex modal field amplitudes for each aperture in the presence of a specified excitation of the array.

CWG is written in VAX FORTRAN for DEC VAX-series computers running VMS (LAR-15236) and IBM PC-series and compatible computers running MS-DOS (LAR-15226). It requires 360K of random-access memory for execution. To compile the source code for the PC version, the NDP Fortran compiler and linker are necessary; however, the medium for distribution of the PC version of CWG includes a sample MS-DOS executable code that was created by use of NDP Fortran with the -VMS compiler option. The standard medium for distribution of the PC version of CWG is a 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskette. The standard medium for distribution of the VAX version of CWG is a 1,600-bit/in. (≈630-bit/cm), 9-track magnetic tape in DEC VAX BACKUP format. The VAX version is also available on a TK50 tape cartridge in DEC VAX BACKUP format. Both machine versions of CWG include an electronic version of the documentation in Microsoft Word for Windows format. CWG was developed in 1993 and is a copyrighted work with all copyright vested in NASA.

This program was written by M. C. Bailey of **Langley Research Center.**

For further information on LAR-15226 ***write in 28*** *on the TSP Request Card.*

For further information on LAR-15236 ***write in 29*** *on the TSP Request Card.*
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Element drawings, solid models
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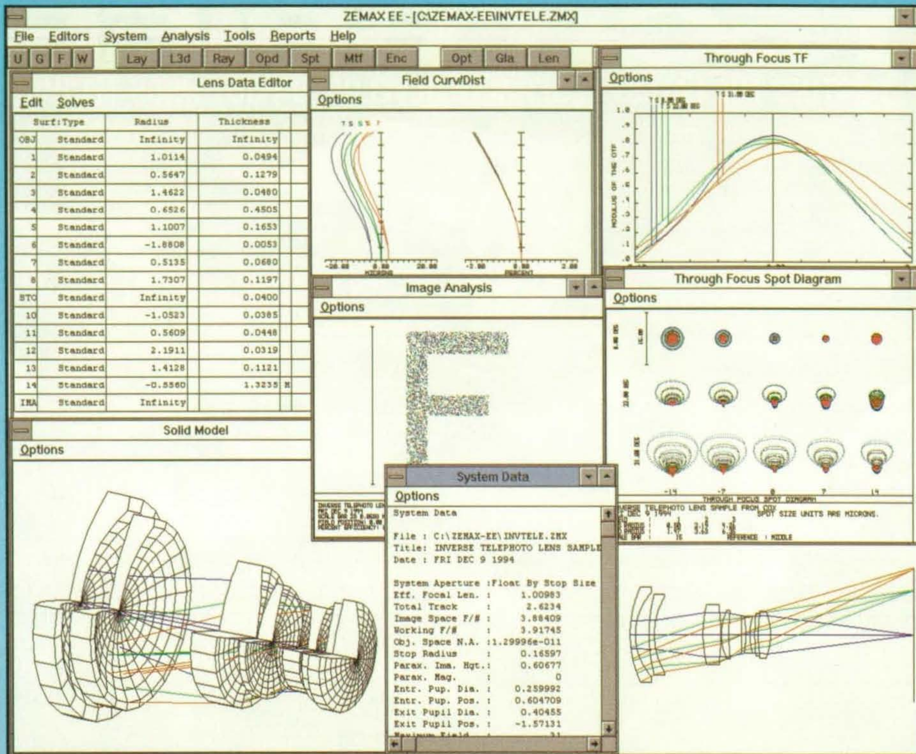

This sample ZEMAX screen shows just a few of the graphic and text displays available. Shown are a solid model, layout, extended source image, field curvature & distortion, spot diagram, and through focus MTF plot. The lens data editor and system data are also displayed.

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Federal Lab Laser Tech Briefs
Supplement to *NASA Tech Briefs* April 1995 Issue
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FEATURES

On the cover:
Femtosecond spectroscopy measurement facility at the Army Research Laboratory, Adelphi, MD. Photo courtesy Army Research Laboratory.

LASER TECH BRIEFS

DEPARTMENTS

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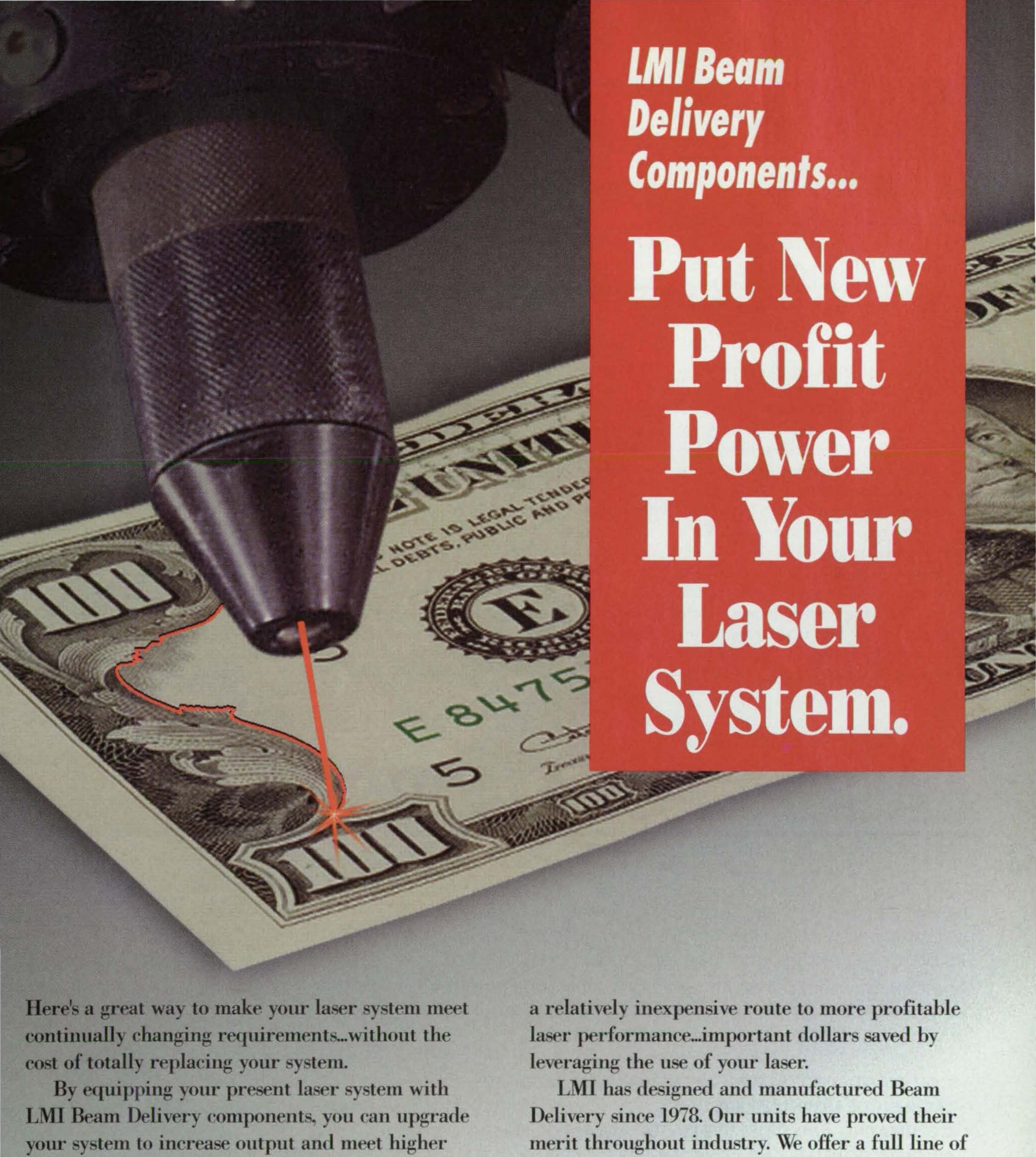

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EDITORIAL NOTEBOOK

News of the Industry and Federal Labs

• The National Institute of Standards and Technology (NIST) selected a partnership headed by the Optoelectronics Industry Development Association (OIDA) to be the broker on the US end of the Joint Optoelectronics Project. Joining OIDA in the partnership are George Mason University, Microelectronics and Computer Corporation, and MOSIS, a component of the Information Sciences Institute at the University of Southern California. The brokers here and in Japan will bring together designers of advanced computer systems and fabricators of optoelectronic components from both countries. The Project is part of Japan's Real World Computing Partnership, a 10-year, $700-million initiative to develop the next generation of information-processing technologies (see *LTB*, Fall 1994). Information: Judson French, Electronics and Electrical Engineering Laboratory, Metrology B358, NIST, Gaithersburg, MD 20899-0001; (301) 975-2220.

• Scientific Spectrum has initiated the Laser and Electro-Optic Network (LEO Net), a computer bulletin board intended exclusively for the photonics industry. Through LEO Net, vendors can provide product information and applications notes to potential buyers, and obtain marketing information straight from users. LEO Net is accessed free of charge by users, and can send mail and binary files to and from Internet. Information: Craig Goldberg, Scientific Spectrum, Laguna Hills, CA; (714) 770-1251; FAX (714) 859-5074.

• Coherent Inc. will offer royalty-free licenses to its patent "Measuring the Mode Quality of a Laser Beam" (US #5,267,012, November 1993) if an ISO draft standard for beam quality measurement is adopted that requires the use of the patented M^2 technology. According to Robert M. Gelber, Vice President and General Manager of Coherent Auburn Group (Auburn, CA), the standard had not been formally adopted as of this writing, but was expected to be. In an earlier statement Gelber said that the company was "uncomfortable in the position of promoting an international standard and thereafter being granted patent rights to a method that is necessary to implement the standard." The method in question involves Coherent's ModeMaster™ beam propagation analyzer.

• 3M (St. Paul, MN) is leading a consortium pursuing new low-cost methods of manufacturing diamond film for cooling high-density computer chips and laser circuits. 3M's partners are Research Triangle Institute (RTI), Research Triangle Park, NC, and Applied Science and Technology Inc. (ASTeX), Woburn, MA. 3M and ASTeX are cofunding the consortium, and BMDO is supporting separate but complementary R&D at RTI and the Naval Research Laboratory. 3M and RTI have done initial development of radio-frequency-stimulated chemical vapor deposition of diamond films. ASTeX is working on reactors for their commercial production, and NRL on diamond growth and plasma modelling. Also involved is Honeywell, focusing on sensing and controlling reaction conditions.

• Deltronic Crystal Industries (Dover, NJ) has received a Phase I Small Business Innovation Research (SBIR) contract from the US Dept. of Energy for the development of lutetium orthophosphate, a scintillator material that promises higher resolution and greater sensitivity for positron emission tomography cameras. $LuPO_4$ crystals as currently produced are too small to fabricate detectors from. Deltronic aims to produce the crystals from a less environmentally sensitive compound, and one that would provide large crystals.

NATIONAL IGNITION FACILITY

By producing a miniature star, a planned inertial confinement fusion site could point the way to an inexhaustible energy supply.

With the cancellation of the Superconducting Supercollider and the scaling back of plans for the Space Station setting the tone, "big science" seems increasingly to encounter difficulty in finding support among lawmakers and the public whose attitudes guide them. A prominent exception to this trend is the National Ignition Facility (NIF), which was endorsed last fall by Energy Secretary Hazel O'Leary despite her drive to cut large sums from the department's budget in the coming years.

NIF is a proposed multipurpose national center, to be built around the world's largest optical instrument. As the centerpiece of a national research facility for the study of inertial confinement fusion (ICF), the laser will aim 192 beams at a tiny fuel capsule called a target, compressing it to a small fraction of its original size. As a result the fusion reaction will "ignite" and produce more energy than was delivered by the laser beams to the target.

But NIF's strategic missions reach beyond this achievement, known as "scientific breakeven." In addition to demonstrating thermonuclear ignition and burn in the laboratory for the first time, and enabling optimization of ICF targets, the DOE sees a critical role for NIF in national security, fusion energy resources, basic science, and even, perhaps, advanced space propulsion.

With its ICF program, NIF will spearhead the worldwide quest for the scientific underpinnings of an environmentally clean, inexhaustible source of electrical power generation. Fusion is the process that powers the sun and other stars. The heavy isotopes of hydrogen that are fusion's basic fuels are derived from water and lithium, both naturally plentiful. Unlike fission, the waste produced would not require deep geologic disposal, and in contrast to coal, oil, and natural gas, no greenhouse gases would result from fusion.

Congress's 1992 National Energy Policy Act set a goal for the fusion energy program, which has two parallel scientific tracks, ICF and magnetic confinement fusion. That goal is the operation of a demonstration power plant capable of net electric power production by 2025. It is too early to choose scientifically between the two techniques, and NIF will provide information to aid in that selection. To meet the 2025 goal, fusion ignition must be demonstrated by about 2005, and calculations indicate that design of NIF must begin next year if it is to meet that deadline.

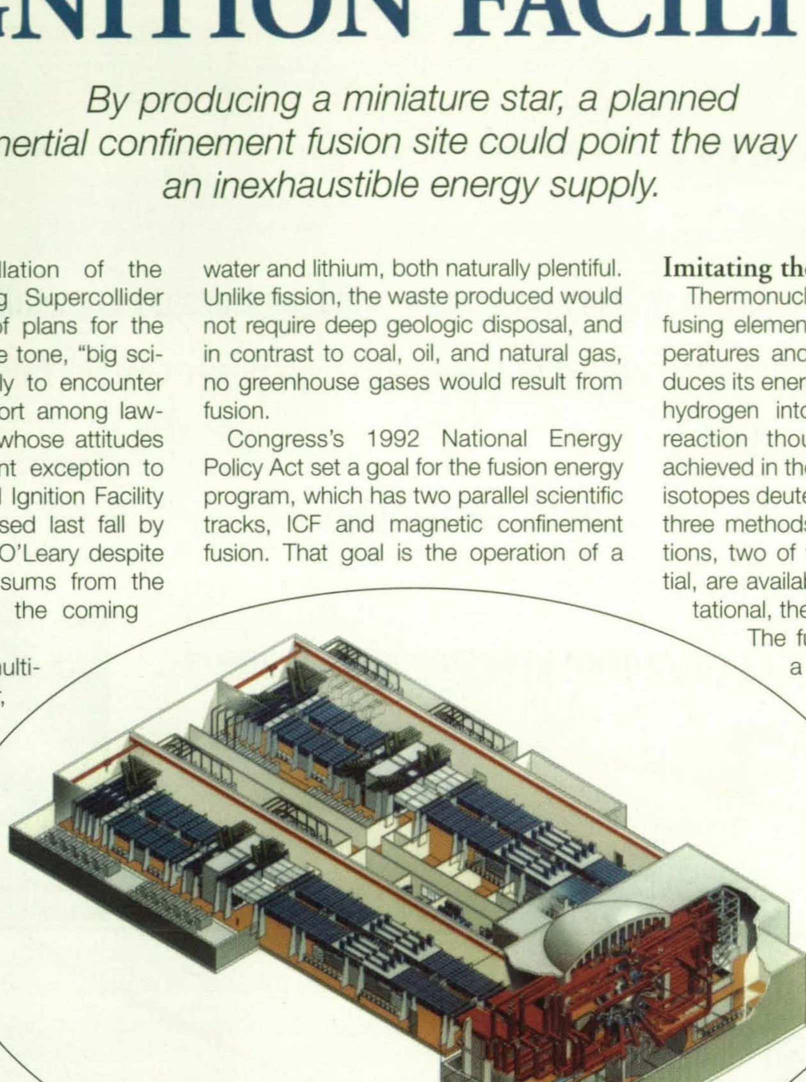


Illustration Above: *Schematic layout of the National Ignition Facility laser system. The laser system is colored blue. The beams start in the optical pulse generation system, just beneath the blue area at lower center. After oscillation back and forth four times inside the laser cavity, Pockels cells (white boxlike structures flanked by green assemblies) switch the beams out and send them through optical spatial filters and into the beam transport system (red), which directs them toward the target chamber (silver sphere amid the red assembly).*

Imitating the Sun

Thermonuclear fusion is the process of fusing elements by means of high temperatures and pressures. The sun produces its energy by the fusion of ordinary hydrogen into helium. But the fusion reaction thought to be most easily achieved in the laboratory is between the isotopes deuterium and tritium. There are three methods of confining fusion reactions, two of which, magnetic and inertial, are available in the laboratory (gravitational, the third, occurs inside stars).

The fuel for ICF is contained in a small capsule. Current experiments use one approximately 0.5 mm in diameter; the next generation of designs will employ one 2 mm in diameter, and ultimately a 5-mm capsule will be used for full-scale energy applications.

NIF will illuminate its fuel capsules both directly and indirectly. If illuminated indirectly, the fuel sphere is centered in a target cylinder a few millimeters wide. Entering the cylinder at the ends, the laser photons are absorbed at the inside wall. The heated surface then reradiates the energy as x-rays, which are absorbed by the capsule. Its surface explosively ablates, producing a rocket-like effect that in turn causes a uniform inward pressure on the deuterium-tritium fuel. The fuel's compression creates high densities and temperatures that result in a fusion reaction, releasing energy. The entire process takes place in approximately three billionths of a second.

In an operating inertial fusion energy (IFE) power plant, a series of fusion energy pulses would heat low-activation coolants, such as ceramic beads, surrounding the targets. These, in turn, would transfer the fusion heat to steam-turbine generators to make electricity.

Lawrence Livermore National Laboratory (LLNL) in Livermore, CA, has been chosen as the preferred site for NIF because its personnel have been responsible for designing five consecutive large laser systems, culminating in Nova, the world's largest. Along with LLNL, Los Alamos National Laboratory, Sandia National Laboratories, and the Laboratory for Laser Energetics at the University of Rochester make up the design team. Final site selection will take place after an environmental impact review, expected to last one to two years.

NIF's laser system will produce 1.8 million joules of near-ultraviolet energy, approximately 500 trillion watts for 3 billionths of a second. This is far greater than LLNL's Nova laser, currently the world's largest, which can produce 45,000 joules. Each of the 192 beams will be optically independent.

A full-scale prototype of a NIF arm was recently tested. Incorporating high-damage-threshold coatings and crystals, it serves to validate NIF optics and the laser architecture.

The light from NIF's beams will focus on the tiny target located inside a spherical chamber 10 meters in diameter that will house the most advanced diagnostic equipment. With pressures greater than 100 billion times that of the Earth's atmosphere, the fusion reaction is expected to yield up to 10 times the laser energy delivered to the target.

NIF's total project cost is estimated at $1.1 billion, spread over a seven-year period. With engineering design set for 1996, construction would begin the following year, and system startup would take place in 2002. Once built, the facility would have a lifetime of more than 15 years, with annual operating costs of about $60 million.

Of the total project cost, 75 percent will go to US industrial partners for equipment, materials, and design and construction services. Low-cost large-scale precision optics manufacturing techniques would get a hefty boost. Other companies that would feel the impact of NIF are those involved in plasma coating of materials, microfabrication, optical coatings, ultrapure glass, computer controls, power-system components, advanced welding and cutting, high-voltage technology, high explosives, and high-speed digital transmission.

DOE points out that spin-off projects already extend beyond the requirements of the project itself. The laboratories currently involved in NIF have participated in 24 cooperative research and development agreements totalling more than $160 million and advancing process and product development in such areas as microelectronics, microphotonics, precision manufacturing, biotechnology, precision optics, environmental sensors, and information storage.

An area of especially significant commercial development is the manufacture of semiconductors with the advanced x-ray optical components and systems designed for ICF. Similar effects may be felt in other fields. In optics manufacturing, DOE expects NIF to reduce production costs for America's crystal-growth industries and improve manufacturers' capability to produce precision optical components such as flat-panel displays. For the target chamber, diagnostics, and various other components, NIF is expected to advance particle imaging technologies, high-speed detectors, and the capabilities of companies involved in micromachining.

A Stewardship for Security

DOE envisions an important role for NIF in national security; in fact, NIF's funding would come from the office of the Assistant Secretary for Defense Programs. The end of the cold war has meant a significant reduction in the nation's stockpile of nuclear weapons as well as its commitment to a comprehensive test ban treaty. Without a program of underground testing, the reliability, safety, and effectiveness of the remaining weapons can be assured, DOE says, only through advanced computational capabilities and aboveground experimental facilities.

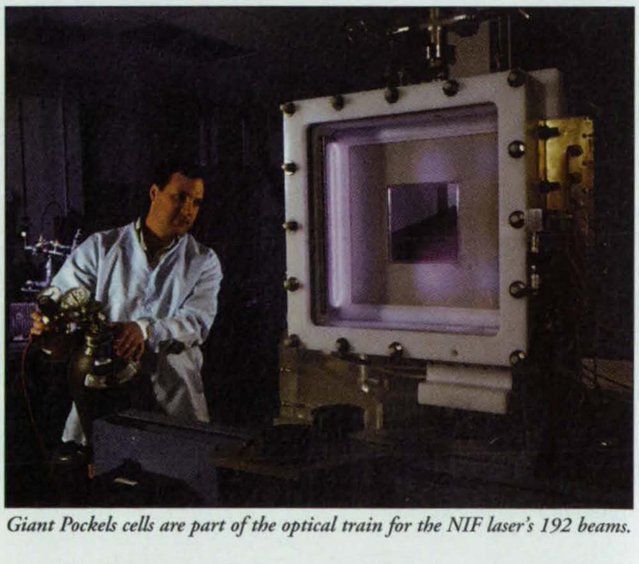
NIF will be a cornerstone of the Science-Based Stockpile Stewardship program. It will help maintain a core group of scientists who understand the complex physics of nuclear weapons. Such a cadre is needed to maintain the US stockpile, support arms control treaty efforts, and interpret information on nuclear proliferation. Although US policy does not permit design of new nuclear weapons, it does support maintenance of the capacity to resume design and development if necessary. NIF would be the only facility capable of examining the fusion aspects of nuclear weapons.

Basic science too will profit from NIF. For many areas, such as astrophysics, NIF's ability to create conditions of high temperature and density like those within a star would make possible previously unattainable laboratory research. This could lead to increased understanding of such phenomena as nucleosynthesis during the "Big Bang," fluid instabilities that may occur in supernovas, and even the solar flares that cause disruption of radio communications and pose a hazard to astronauts.

Though NIF is primarily a national undertaking, there is strong international interest. Sizable inertial confinement fusion programs exist in Japan, Russia, and France, and smaller ones in the UK, Germany, Italy, Spain, China, and other countries. Russia, France, and the UK have formally proposed cooperation with the US in ICF technologies for the NIF and other aspects of fusion energy.

Interest by the academic and research communities in many of these same countries runs high. DOE believes the recent declassification of virtually all the concepts behind ICF will foster an enhanced participation by the general scientific community. The department estimates that several thousand scientists worldwide will benefit from NIF data either for basic science or for applications of NIF technology such as fusion energy.

NIF technology may also make possible ICF-powered space flight. A study conducted jointly by LLNL, NASA's Jet Propulsion Laboratory, and Rockwell Rocketdyne concluded that an ICF-driven spacecraft called VISTA would be advantageous for self-contained single-stage manned spacecraft missions within the solar system. The study's baseline was a manned trips to Mars with a 100-ton payload. Using ICF allowed round trips of approximately 100 days with a total spacecraft mass of about 6000 tons, considerably faster than missions accomplished with chemical or nuclear-electric-propulsion technologies and minimum-mass vehicle configurations.



Giant Pockels cells are part of the optical train for the NIF laser's 192 beams.

LASER TECH BRIEFS

Advanced Electronic Imaging of High-Speed Phenomena

Electronic instrumentation provides instantaneous display, lower acquisition costs, and faster turn-around times for test data.

Army Combat Systems Test Activity, Aberdeen Proving Ground, Maryland

Aberdeen's Combat Systems Test Activity (CSTA) has used traditional forms of high-speed visual instrumentation to document test phenomena such as ballistic projectiles in flight and target interaction. Conventional instrumentation such as 35-mm and 16-mm film cameras running at 128-40,000 frames per second (fps) offer high-resolution color photographs of test results.

These cameras are rugged and can be placed close to the gun. There are several limitations, however. Film development is costly and time-consuming, and an environmentally burdensome technology. Processing cannot take place until after the test is complete and the range is clear. This delay hinders diagnosis of potential problems with experimental projectiles and test projects. Customers requested technology that would allow real-time display of results so that on-site test decision could be made without delay.

Now several high-speed electronic systems have been adapted for the test site, allowing the flexibility to choose the appropriate recording tool for each unique test. The Kodak EM high-speed system with electronic digital memory is a versatile diagnostic tool capable of continuously monitoring test operations at a rate of 1000 full fps to 6000 split fps. Electronic gating or shutter speeds of 10 microseconds are possible. Images are stored on dynamic random access memory (DRAM) until they are downloaded to magnetic tape or computer memory.

The Kodak 4540 high-speed video system permits much faster framing rates of 4500 fps to 40,500 fps. These exceptionally fast framing rates close the gap normally filled by high-speed film cameras.

The black-and-white (B&W) ballistic range camera produced by Hadland is capable of single-shot imaging from 200 ns to 1 ms. It is also capable of multiple pulsed imaging with up to sixteen independent exposures. All of these are capable of being superimposed on a single screen. Captured as 1134 X 486 pixels, this high-density image results in

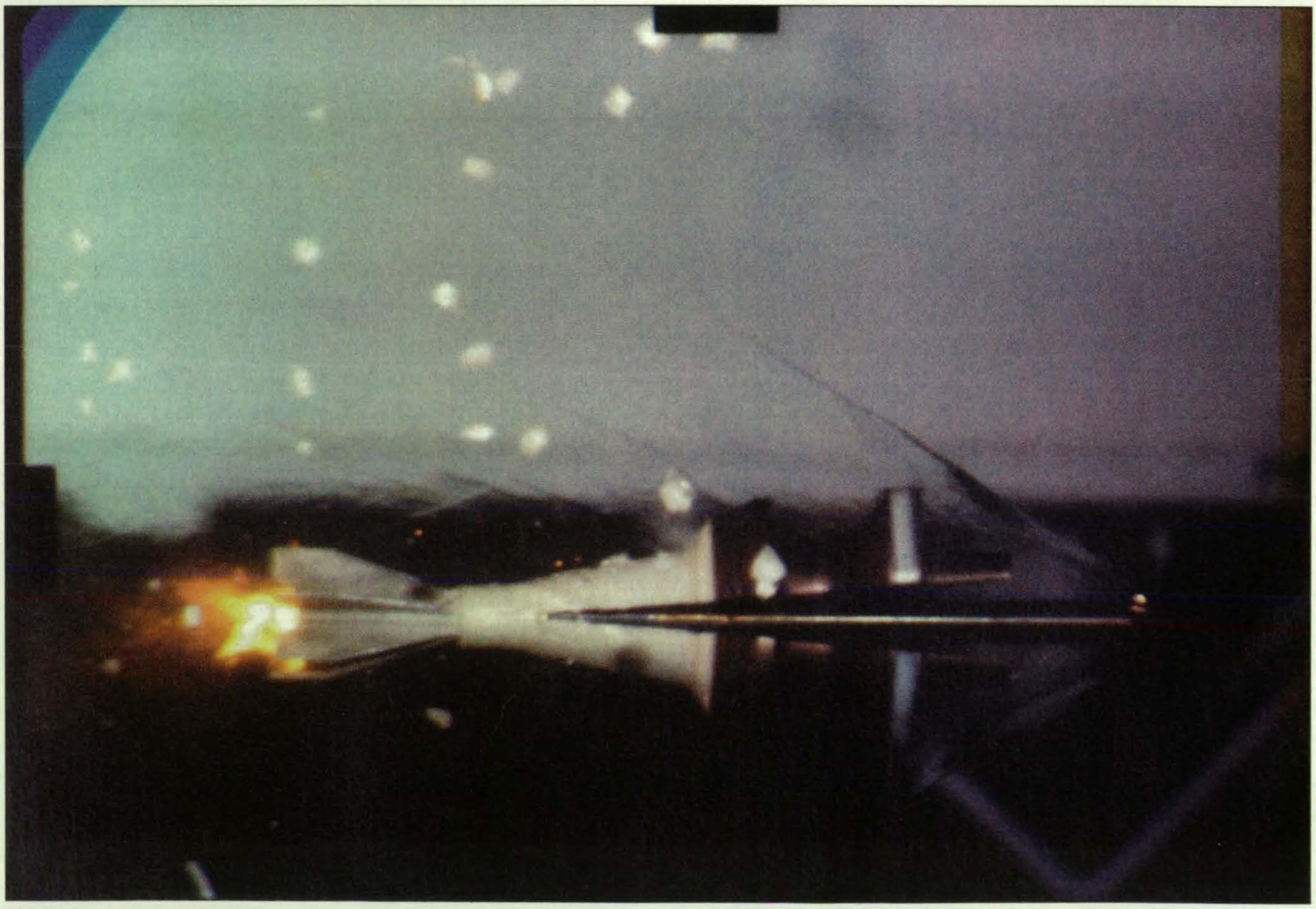


Figure 1. Hadland CSVR capturing a 120-mm projectile in flight.

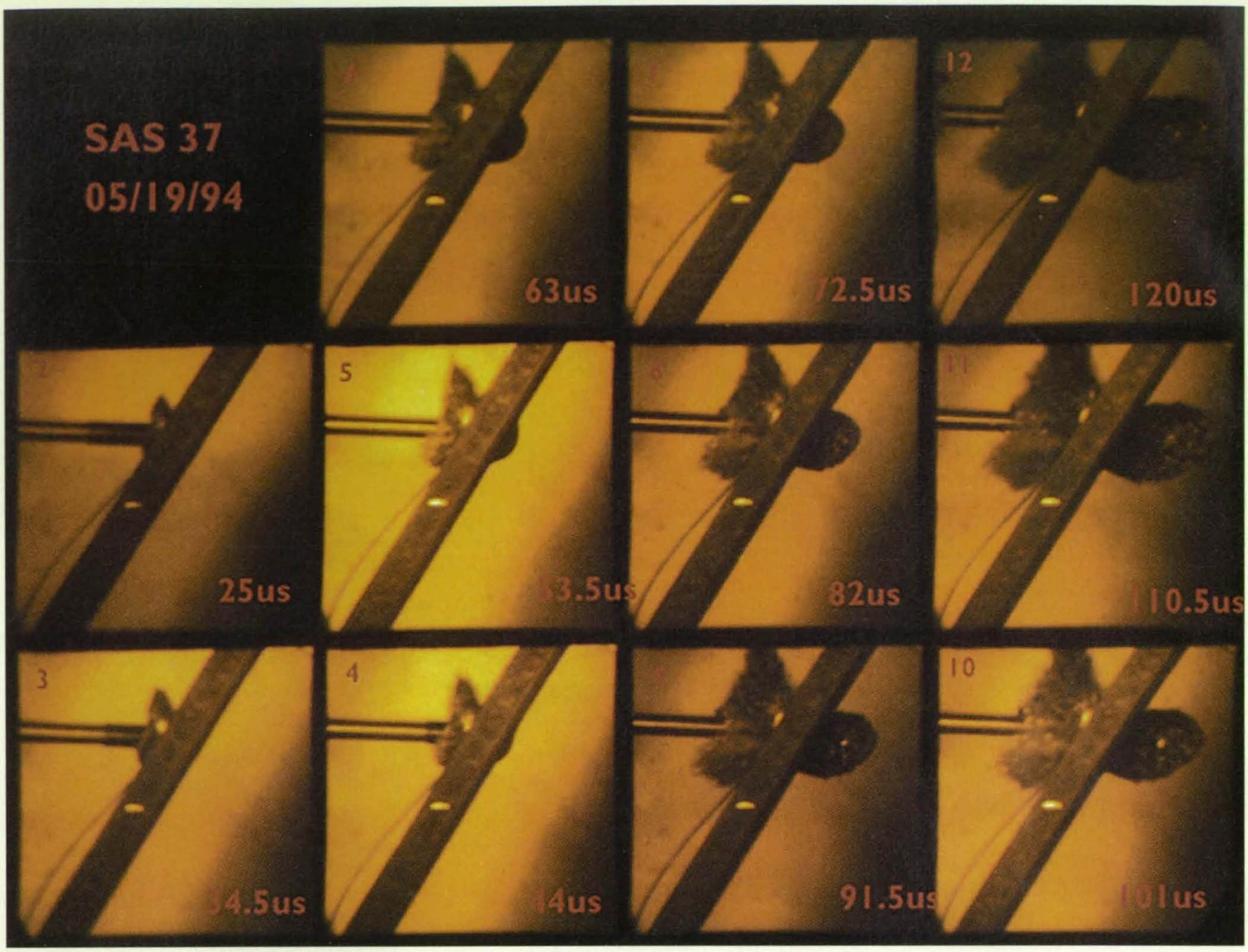


Figure 2. **Digital UltraNAC image** of a projectile penetrating a range target.

a remarkably clear photographic image. The system is designed for ballistic research and proofing. Data extracted from the digital photograph of a projectile frozen in flight can be analyzed for pitch and yaw, sabot separation, velocity, and target scoring.

Another advanced technology used by CSTA is the Hadland color ballistic range camera CSVR. This technology is a unique capability, as there are only three of these cameras in use worldwide, two by CSTA and one by the manufacturer for demonstration purposes. The specifications and capabilities are similar to those of the B&W units with the additional capacity to detect color variation in metal and burning residues. An additional advantage of the CSVR is the ability to take a single-shot color image or three separate b&W images with 5 million frames per second equivalent interframe time. Figure 1 illustrates the Hadland CSVR capturing a 120-mm projectile in flight.

Rounding out CSTA's high-speed arsenal is the NAC electronic computerized digital image converter camera known as the UltraNAC. this camera is capable of recording rates of up to 20 million fps. This capability provides ultrahigh-speed imaging; that is, imaging in excess of 1 million fps. Additionally the UltraNAC is computer-programmable, allowing for exceptional flexibility with each individual exposure, as well as permitting the user to control the timed events between exposures. Both of these capabilities enable the collection of very distinctive data points, since more frames can be programmed for sampling during the most crucial points of the test. Output of this camera is quite flexible, with a choice of film (Polaroid or 4-X-5-inch sheet) or to a high-resolution (1152 X 770 pixels) ultra-light-sensitive CCD camera head. The image is then converted from analog to digital format and transferred via fiber optic link to a computer for storage, image enhancement, and analysis. Through electronic conversion and computer enhancements, the UltraNAC produces high-resolution images that can be used to analyze warhead information, threat and target interaction, and multiple warhead timing. Figure 2 is a digital UltraNAC image of a projectile penetrating a target; Figure 3 shows the film output format of the UltraNAC.

CSTA is exploring new technologies to meet future customer needs. One of these is laser (monochromatic) illumination. This technology will enable the customer to view events currently obscured by infrared light. The processing laboratory for traditional 16-mm and 35-mm film is being transformed into an Electronic Multimedia Imaging Center. Future plans include a professional image workstation to make photo compact discs. These will replace chemical-based processing and printing and will permit electronic transfer of images via computer network directly to the customer.

This work was done by the Technical Photographic Branch at **Combat Systems Test Activity, Aberdeen Proving Ground**. *For further information, contact US Army CSTA, Attn: STECS-EN-B, Building 319, Aberdeen Proving Ground, MD 21005-5059, or the Office of Research and Technology Applications; (410) 278-9477.*

Use of trademarked names does not imply endorsement by the US Army, but is intended only to assist in the identification of a specific product. The opinions or assertions contained *herein are the private views of the author (Mark Stern, Electronic Technician) and not to be construed as reflecting the views of the Department of the Army or the Department of Defense.*

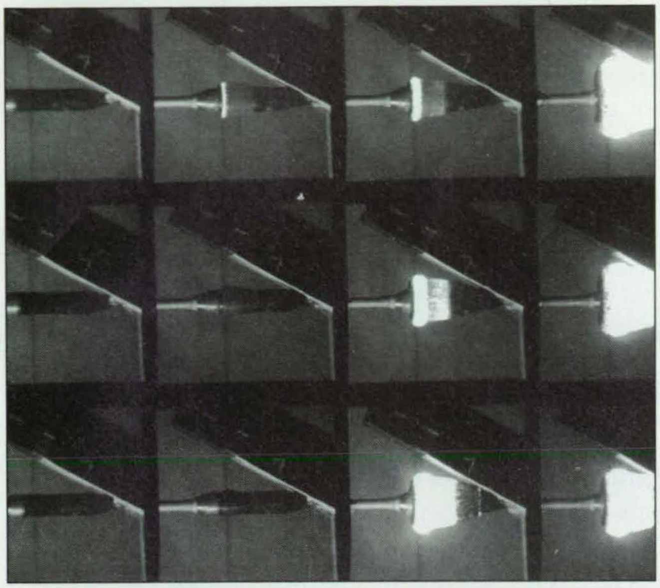


Figure 3. Film output format of the **UltraNAC camera.**

Optical Interconnections Using Semiconductor Optical Amplifiers

A crossbar switch based on optical amplifiers in a distributed-gain configuration is compact and low in cost.

Rome Laboratory, Photonics Center, Griffiss Air Force Base, New York

Optical interconnects are well known to offer a variety of advantages over conventional electronic interconnects and are recognized as a critical technology area for the Air Force. Optical interconnects provided by a crossbar switch have a broad range of important applications in communications and signal processing in both commercial and military sectors, and meet interconnect requirements that include high bandwidth, low dispersion and attenuation, fault tolerance, immunity to interference and crosstalk, small size and weight, security from intrusion, and electrical isolation. Optical switching also provides diverse routing of broadband digital and analog signals without the need for optoelectronic conversion.

A new type of optical crossbar switch under development utilizes semiconductor optical amplifiers (SOAs) in a compact, low-cost module. The package consists of a monolithically integrated SOA crossbar switch chip with multiple low-loss fiber interfaces. The SOAs on the chip are in a distributed-gain configuration and act as active switch elements to reduce insertion losses and reconfiguration times for computer interconnect and network applications. The switch module contains both control and drive electronics for the packaged switch chip.

The multi-fiber packaging approach uses tapered planar optical waveguides to achieve low losses through mode matching and simultaneous alignment of multiple optical interfaces. The

result is development of systems and subsystems for exploiting SOA-based switches and a flexible procedure for the packaging of integrated SOA-based devices with low-loss optical fiber interfaces. The packaging procedure developed applies to any general optoelectronic integrated circuit.

This work was performed under **Rome Laboratory** *contract no. F30602-92-C-0178 by R.F. Kalman, L.R. McAdams, J.W. Goodman, K.K. Chau, and D. Knapp of Optivision, Inc., 4009 Miranda Ave., Palo Alto, CA 94304. For further information contact the research team or Joanne Maurice of Rome Laboratory, RL/OCPB, 25 Electronics Pkwy., Griffiss AFB, NY 13441-4515.*

Inquiries concerning rights to the commercial use of this technology may be addressed to Rome Laboratory, Office of the JA, Griffiss AFB, NY 13441.

A Smart Pixel for Optical Processing and Communication

An optical smart pixel based on the quenching of a vertical cavity surface-emitting laser by an in-plane laser performs both logic and communication functions.

Rome Laboratory, Photonics Center, Griffiss Air Force Base, New York

Vertical cavity surface-emitting lasers (VCSELs) are becoming the laser of choice for applications requiring a symmetrical beam with relatively little divergence that emits normal to the wafer. These lasers can be densely packed into two-dimensional arrays and monolithically integrated with other optoelectronic components. In addition, they can have very low threshold currents. Other optoelectronic components can be added to the basic VCSEL to form high-performance optical logic elements. These lasers are ideal as optical emitters (interconnects) for multiplanar optical signal processing architectures and in communications systems.

Rome Laboratory and Cornell University have developed a new high-speed smart pixel based on a VCSEL that is optically controlled by an in-plane laser. This smart pixel performs both the interconnect and the logic function using the phenomenon of laser quenching. Figure 1 shows an example structure for the smart pixel. Two cleaved

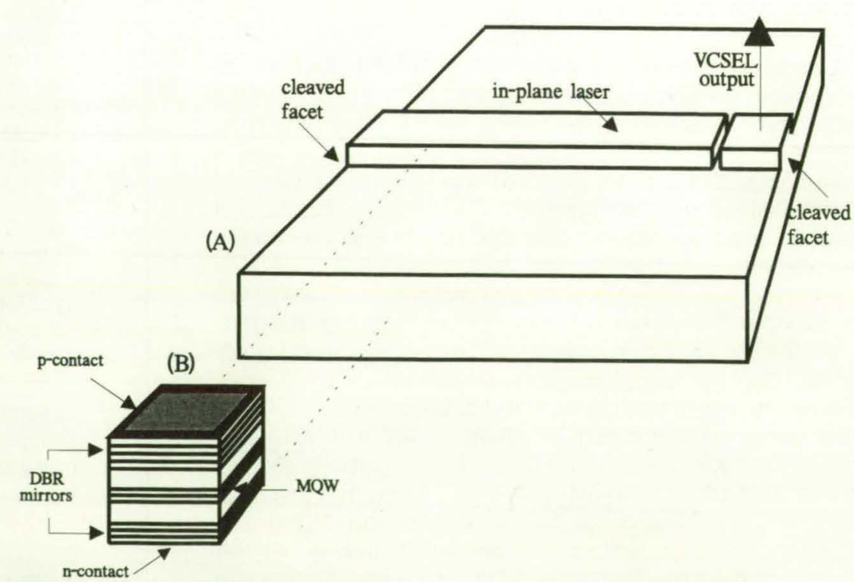


Figure 1: The top diagram shows a schematic representation of the optical smart pixel incorporating a VCSEL that is quenched by an in-plane laser. The lower diagram shows the laser heterostructure.

facets form mirrors for the in-plane laser, and the VCSEL serves as part of the in-plane laser cavity. The top electrodes on the two sections are separated by a shallow etch that is implanted by hydrogen protons for electrical isolation. Normally, the VCSEL is biased above threshold. When the in-plane cavity lases, the VCSEL output is quenched. The in-plane laser can be switched by several methods, including optical quenching. Both of the lasers are monolithically integrated in the same laser heterostructure.

The inset in Figure 1 shows a schematic representation of the wafer grown by Photonics Research Incorporated. Typical for a VCSEL is the multiple-quantum-well (MQW) active region centered between distributed Bragg reflection (DBR) mirror stacks; electrical connections are made to the outside surface of the mirrors. New high-performance material from PRI will be used in future versions of the device.

Plans are currently underway to develop optical NOR gates and optical memory elements. Such devices will be important for packet switching, multiplanar computer architectures, and video processing.

These smart pixels are designed, fabricated, and tested in part by M.A. Parker, J.S. Kimmet, and R.J. Michalak at the Air Force Photonics Center, Surveillance and Photonics Directorate, **Rome Laboratory***, and by D.B. Shire, P.D. Swanson, and C.L. Tang at the School of Engineering,* **Cornell University***. No further information is available.*

Inquiries concerning rights for the commercial use of this invention should be address to the Patent Counsel, RL/JA, Griffiss AFB, NY 13441.

Infrared-Proximity-Sensor Modules for Robot

Proximity alarms are based on data received from multiple sensor modules.

John F. Kennedy Space Center, Florida

A collision-avoidance system for articulated robot manipulators uses infrared proximity sensors grouped together in an array of sensor modules. These sensor modules, called "sensorCells," are distributed processing board-level products for acquiring data from proximity-sensors strategically mounted on robot manipulators. Each sensorCell is self-contained and consists of multiple sensing elements, discrete electronics, a microcontroller and communications components. The modules are connected to a central control computer by a redundant serial digital communication subsystem that includes both a serial and a multi-drop bus. This sensor system is able to detect objects made of various materials at a distance of up to 50 cm (19 in.). For some materials, such as thermal protection system tiles, the detection range is reduced to approximately 20 cm (8 in.).

Each module (see figure) contains light-emitting diodes that illuminate the scene to be monitored with infrared light (wavelength 880 nm), plus up to sixteen positive/intrinsic/negative photodiodes that detect infrared light reflected from objects in the scene. The outputs of the photodiodes are processed into digital signals in a standard format for transmission to the control computer. This arrangement reduces vulnerability to electronic noise, which can degrade the performance of an all-analog sensing system. Since the digital communication is independent of the specific type of sensing media, different types, such as acoustical or capacitive sensors, could be used within the same system.

The central component of the sensorCell is the onboard microcontroller. The microcontroller communicates with the control computer via the buses, controls the operation of the sensing elements, and performs low-level processing of sensory data. This distributed processing architecture greatly reduces the computational overhead of a central control computer and, by pre-processing the sensor data with the microcontroller, the communication requirements are also reduced. Operating according to commands from the control computer in conjunction with embedded firmware instructions, the microcontroller causes a signal generator to drive the light-emitting diodes with a signal at a frequency of 31.25-kHz when commanded to perform a scan. Simultaneously, the microcontroller sends the outputs of the photodiodes in sequence through an analog multiplexer to a high pass filter that removes most ambient noise while preserving the 31.25-kHz signals indicative of infrared reflections detected by the photodiodes.

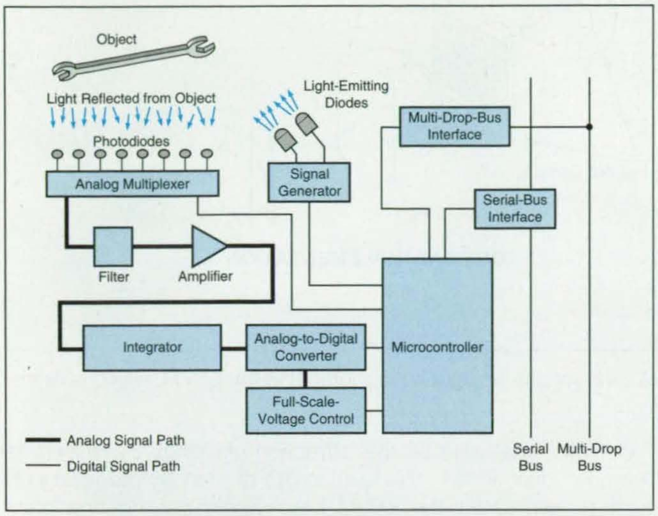
The filtered signals are fed to a high-gain amplifier, then to an analog integrator that converts the signals to voltages proportional to the energies of the detected infrared reflections. An analog to digital converter then converts the dc voltages to digital form for processing by the microcontroller into proximity data and proximity alarms.

The serial bus is a standard RS-485 serial interface that operates at a data rate of up to 9,600 bits per second. This bus enables the control computer to identify an alarming module by its address, and provides communications by module address for coordination of scanning. The serial-bus scanning time is approximately 10 ms per module when no proximity alarms are encountered.

The multidrop bus enables the control computer to simultaneously command all modules and to receive a proximity alarm from any module immediately, identifying that module by its address, which is part of the alarm signal. The multidrop bus can be used, as a backup to the serial bus, to scan by polling the modules; in this case, the scanning time is approximately 12 ms per module in the absence of proximity alarms. Programs at the control computer initialize hardware ports for communication on the buses, generate sensor cell addresses, and initially set default gain and threshold values for each module.

This work was done by William Parton, Daniel Wegerif, and Douglas Rosinski of Merritt Systems, Inc., for **Kennedy**

Space Center. *For further information,* **write in 238** *on the TSP Request Card.*
KSC-11608



A **Proximity-Sensor Module** (one of many) contains two infrared-light-emitting diodes, eight photodetectors that detect reflected infrared light, and control and signal-processing circuits. The microcontroller in the module communicates with a central control computer via serial and multidrop buses.

Optical Interconnection via Computer-Generated Holograms

Connections between many sources and many detectors can be reconfigured in real time.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of free-space optical interconnection is being developed for data-processing applications like parallel optical computing, neural-network computing, and switching in optical communication networks. In this method, multiple optical connections between multiple sources of light in one array and multiple photodetectors in another array are made via computer-generated holograms in electrically addressed spatial light modulators (ESLMs).

In comparison with electronic interconnections, free-space optical interconnections in general offer potential advantages of massive parallelism, high space-bandwidth product, high time-bandwidth product, low power consumption, low cross talk, and low time skew. The present method of optical interconnection offers the additional potential advantage of programmability with flexibility of reconfiguration, including variation of the strengths of optical connections in real time.

This method makes possible a large variety of interconnection schemes, including one-to-many, crossover, and many-to-many (see Figure 1). The computer-generated hologram that implements a given interconnection scheme is formed by applying suitable voltages to the terminals of the affected ESLM to obtain the required complex-amplitude (magnitude and phase) transmittance in each pixel of the ESLM. In practice, an ESLM is typically a liquid-crystal television (LCTV) display unit that has some imperfections, including leakage of light and gaps between its pixels.

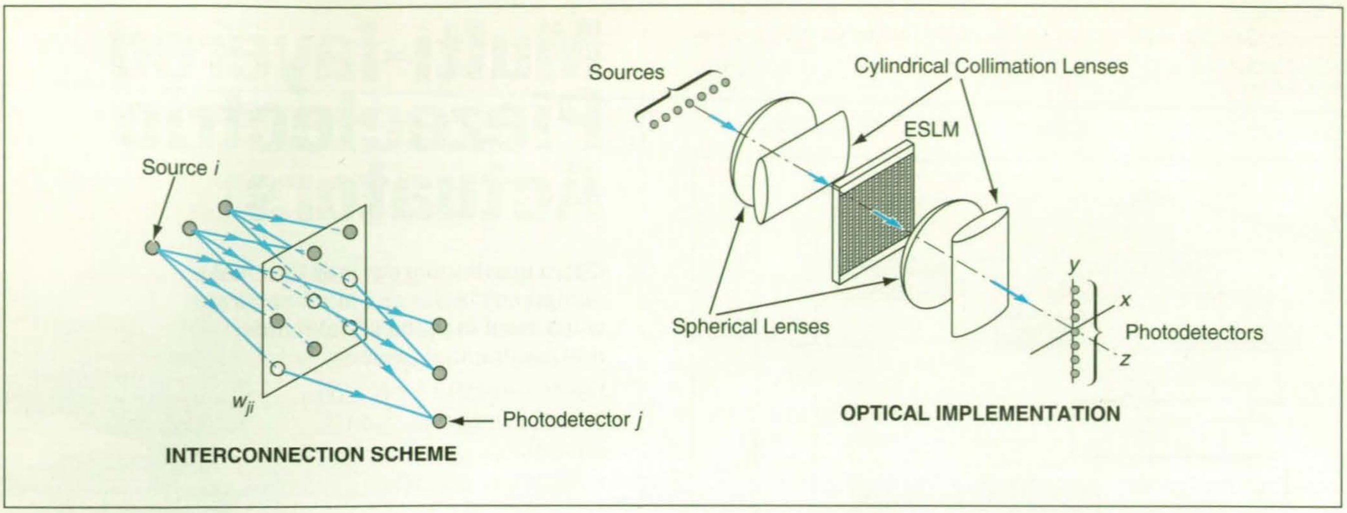


Figure 1. In This **Many-to-Many Interconnection Network**, a number of different sub-holograms are formed in the ESLM, which is illuminated by a number of sources.

The ESLM holographic pattern needed to produce a given interconnection scheme is computed, taking account of these imperfections, by use of a fast-Fourier-transform algorithm in conjunction with a simulated-annealing iteration algorithm. The hologram can comprise a number of sub-holograms that effect multiple interconnections characterized by a matrix w_{ji} (where w_{ji} denotes the strength of the connection between the ith light source and the jth photodetector).

The error measure used to determine whether a given iteration of the computed ESLM holographic pattern would or would not achieve a close enough approximation to the desired interconnection scheme is the sum of (1) the root-mean-square error of the intensities of light at the required focal points on the photodetector array and (2) the diffraction efficiency expressed as the sum of powers in the focal spots divided by the total incident power. Once the ESLM holographic pattern has been computed, the voltages needed to produce it are computed with the help of voltage-vs.-complex-amplitude data from calibration measurements on the ESLM.

In a prototype, an LCTV was operated in phase mode, so that only phase-vs.-voltage calibration data were used. The prototype was tested by computer simulation and by experiment on a number of different interconnection schemes. The tests yielded excellent results (for example, see Figure 2), thereby demonstrating the feasibility of the method.

This work was done by Hua-Kuang Liu and Shaomin Zhou of Caltech for NASA's **Jet Propulsion Laboratory**. *For further information,* **write in 33** *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 2a]. Refer to NPO-19039.

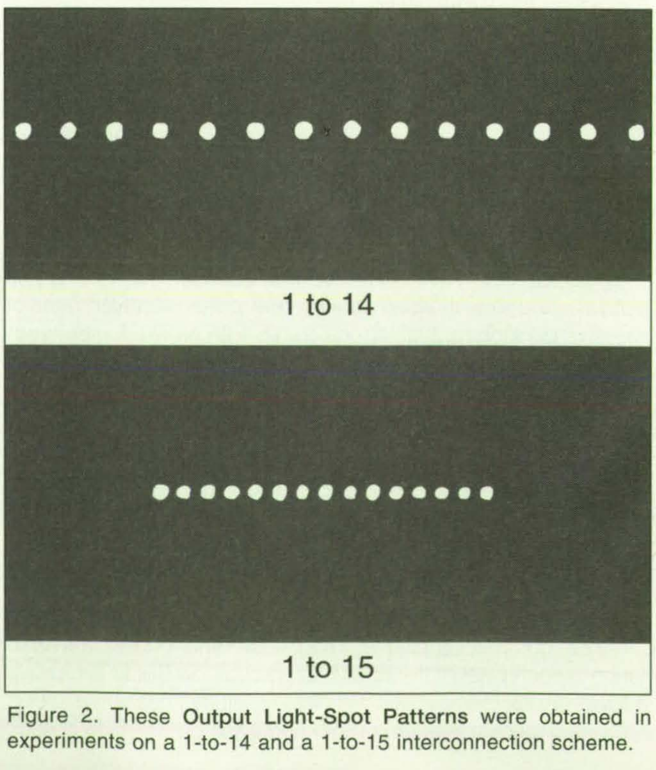


Figure 2. These **Output Light-Spot Patterns** were obtained in experiments on a 1-to-14 and a 1-to-15 interconnection scheme.

Optoelectronic Particle-Fallout Sensor

Measured accumulation of particles could be correlated with activities in the vicinity.

John F. Kennedy Space Center, Florida

A portable optoelectronic system monitors fallout of small particles (dust and fibers) onto a surface at a given location during an extended time. Data on the accumulated fallout can be downloaded from this system to a computer for display and analysis. A typical display is a plot of a signal proportional to the amount of accumulated fallout as a function of time and thus can be read to determine when contamination occurs. In many cases, it may be possible to establish correlations between accumulations of particles and activities in the vicinity (see figure). The system is also capable of signaling an alarm in the event that contamination by fallout exceeds a specified level.

The system includes a sensor module and a data-acquisition module. Both modules are battery-powered and contain microcontrollers and other circuitry. The sensor module can operate either independently or under control by the data-acquisition module.

The sensor module includes a black acetal plastic housing with a top opening through which dust can fall onto a mirror. A portion of the mirror is illuminated by an infrared light-emitting diode through a limiting aperture. Particles that have accumulated on the mirror are detected via the infrared light that they scatter. When particles are not present on the mirror (and provided that the mirror is not scratched), the infrared light is reflected specularly by the mirror and absorbed by the black sides and top of the housing. When particles are present, the infrared light that they scatter is measured by an optoelectronic detector assembly.

The optics are arranged to minimize the detection of both ambient light and light scattered from surfaces other than that of the mirror. The optoelectronic detector assembly includes two lenses, a long-wavelength-pass filter that helps to suppress ambient visible light, and a large-area silicon photodetector. The output of the photodetector is amplified and digitized, and the digital value is shown on a liquid-crystal display unit.

At the press of a momentary contact button, the sensor module displays a number proportional to the amount of scattered light received by the detector.

To conserve battery energy, the sensor module is designed to operate for only a few seconds — just long enough to take a reading when it is commanded to do so. When separated from the data-acquisition module, the sensor module is turned on to take a reading by pressing a momentary-contact button switch. To increase sensitivity and facilitate discrimination against background signals, the infrared light-emitting diode is turned off and on several thousand times during each sampling interval. The difference between the signals measured in the "on" and "off" states is averaged over the sampling interval to produce a signal that contains relatively low noise.

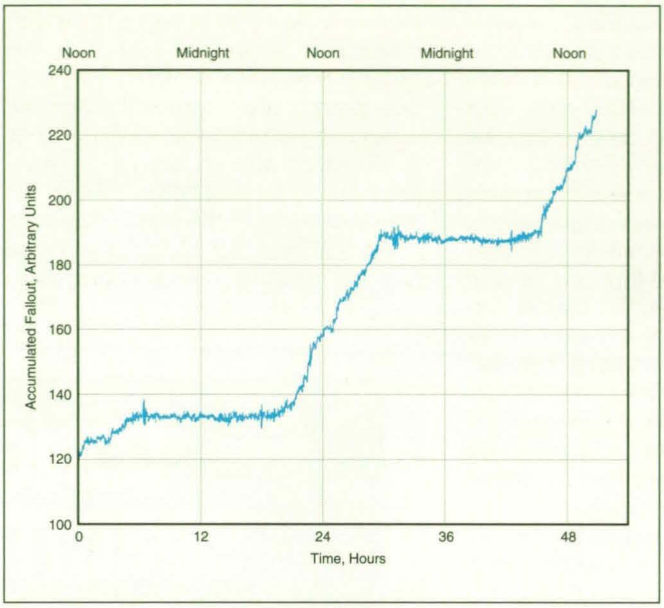
To operate the two modules together, it is necessary to connect them via a ribbon cable. In this configuration, the data-acquisition module takes control of, and supplies power to, the sensor module. At time intervals selected by the operator, the data-acquisition module commands the sensor module to take readings and records each reading and the time when it was taken. The module can later be connected to a computer to transfer the reading and time data to the computer for display and/or analysis and to program the data-acquisition module for subsequent readings.

The system can be made very inexpensively and can be used to monitor the accumulation of dust and fibers associated with motion of air in a variety of environments. Phenomena that could be monitored indirectly by use of this system might include circulation of air in buildings, and human and animal activity. The system could also serve as an auxiliary intrusion monitor (though probably not a real-time alarm) in a sealed room because motion of an intruder inevitably stirs up some dust.

This work was done by Curtis Ihlefeld and Paul A. Mogan of **Kennedy Space Center** *and Robert C. Youngquist, John S. Moerk, William D. Haskell, Robert B. Cox, and Kenneth A. Rose of I-NET. For further information,* **write in 32** *on the TSP Request Card.*

Further development of this instrumentation by NASA is anticipated. Potential dual-use development partners are encouraged to call the Kennedy Space Center at (407) 867-3017.

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, Kennedy Space Center [see page 2a]. Refer to KSC-11687.



This **Plot of Particle Fallout Readings** in an optical-instrumentation laboratory begins at about noon on a work day. During the night, when the air in the laboratory is still, there is little increase in fallout. During the day, there is a significant increase, corresponding to activity in the laboratory.

Compact Microadjusters for Optical Components

These devices fit into spaces too small to accommodate ordinary adjusters.

Lewis Research Center, Cleveland, Ohio

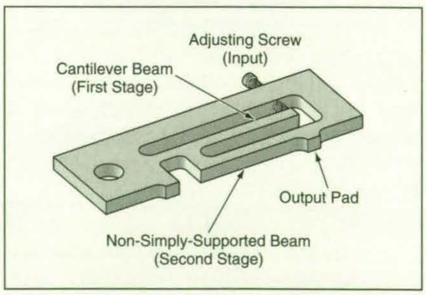
Compact microadjusters for fine positioning of optical components have been designed to fit into small, confined spaces. Typically, these microadjusters would be used to move corner mirrors of optical interferometers by precise amounts with resolutions of about 1 μm. These microadjusters can be used in place of micrometer-style adjusters, most of which are at least an inch (2.54 cm) long and are often too big for compact optical setups. These microadjusters can also be used in place of other screw adjusters, the resolutions of which are often not fine enough.

A microadjuster of this type (see figure) consists largely of cantilever and non-simply-supported beams joined in a single unit. It can be fabricated relatively inexpensively by machining the beams out of a single piece of metal. Each beam constitutes a stage that attenuates a deflection transmitted to it from the preceding stage. A relatively coarse displacement applied via a screw to the input stage is thus converted to a fine movement at the output stage.

In principle, any number of cantilever stages can be connected together to obtain the desired reduction ratio. The pitch of the screw is selected according to the required reduction ratio and output resolution. The prototype microadjuster shown in the figure is actuated by a common 40-pitch (pitch = 0.635 mm) screw. A quarter turn of the screw results in a displacement of 3 μm at the output.

This work was done by Nathan R. Pfeifer and John B. Hammond of Westinghouse Electric Corp. for **Lewis Research Center**. *For further information,* **write in 221** *on the TSP Request Card.*

LEW-15422



Integral Beam Stages in a stiff structure attenuate the displacement applied via the screw. For greater attenuation, a device of this type could be designed with more stages than the two shown here.

NEW PRODUCTS

3D Interactive Optical Modelling

Optical Research Associates, Pasadena, CA, has developed LightTools®, a three-dimensional interactive solid modelling system. "As fabricated" component shapes for lenses, mirrors, beamsplitters, diffractive optics, prisms, and polygon scanners can be generated by fundamental Boolean operations, and so can mechanical entities such as baffles, physical envelopes, and product structures. The accurately displayed and rendered objects are completely ray-traceable to optical accuracies. LightTools is import/export compatible with CODE V®, and provides a variety of output mechanisms, including text, PostScript™, IGES, and DXF.

For More Information Write In No. 740

"Hands-Off" Ion Laser

The Innova Sabre from Coherent Inc., Santa Clara, CA, is an ion laser system that incorporates many automated features aimed at increasing productivity. Sabre automatically aligns its cavity to locate lasing action and then maximize power. The operator can select the wavelength from a remote control or computer and the system will adjust the high-reflectivity mirror for immediate tuning. It also automatically determines and sets the aperture for TEM_{00} operation. Sabre's plasma tube is the Innova Series V™, which the company says has demonstrated lifetimes of more than 5000 hours.

For More Information Write In No. 741

Digitized Laser Data Measurement

The Laser Pulse Train Analyzer™ from Laser Power Research, San Diego, CA, can record more than 100,000 samples at a rate of up to 100,000 pps for any laser wavelength between 400-1100 nm. Designed primarily to monitor Q-switched pulses as narrow as 25 ns, it also accommodates long pulses and CW signals. Pulses are digitized and measured to a precision of 4%. An optical dual sensor configuration enables monitoring a pair of laser sources simultaneously. LPR is the research division of Laser Power Optics.

For More Information Write In No. 742

High Laser-Damage-Threshold Fiber

Polymicro Technologies, Phoenix, AZ, announced new optical fiber for high-power laser transmission in the deep UV and the near-IR. It can withstand up to 5 GW/cm^2 peak powers, or 80 J/cm^2. The company says its durability makes it suitable for laser delivery systems for surgical catheters and laser ignition systems. Core sizes from 40-2000 micrometers are available.

For More Information Write In No. 743

Raman Cells for Wavelength Shifting

Princeton Optics, Princeton, NJ, introduces two series of Raman cells. The RC series of high-pressure (75 atmospheres) cells is specially designed for shifting the Nd:YAG's 1.06 micrometers to 1.54 micrometers, an eyesafe wavelength. Cell length is customizable. The RCL series are low-pressure (30 atmospheres) hydrogen Raman cells.

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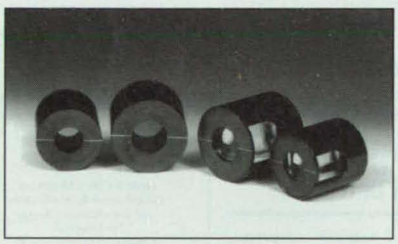

Coated and Uncoated Calcite Polarizers

Meadowlark Optics, Longmont, CO, offers a complete line of calcite polarizers, including Glan-Laser and Glan-Thompson designs. Manufactured from grade-A calcite material, they are precision-assembled to meet stringent performance specifications, the company says. Uncoated calcite polarizers are shipped from stock. Coated versions currently require two weeks for delivery.

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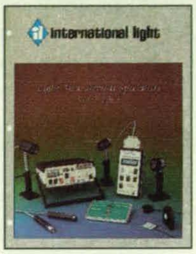

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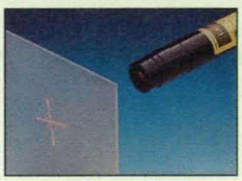
NEW CROSSHAIR PROJECTOR



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

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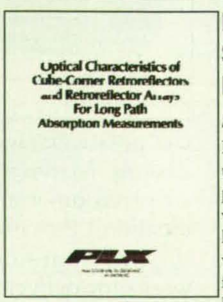

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For More Information Write In No. 469

Aircraft Sensor Platform Has Increased Angular Range

Translation and rotation are combined to enhance adjustability within limited space.

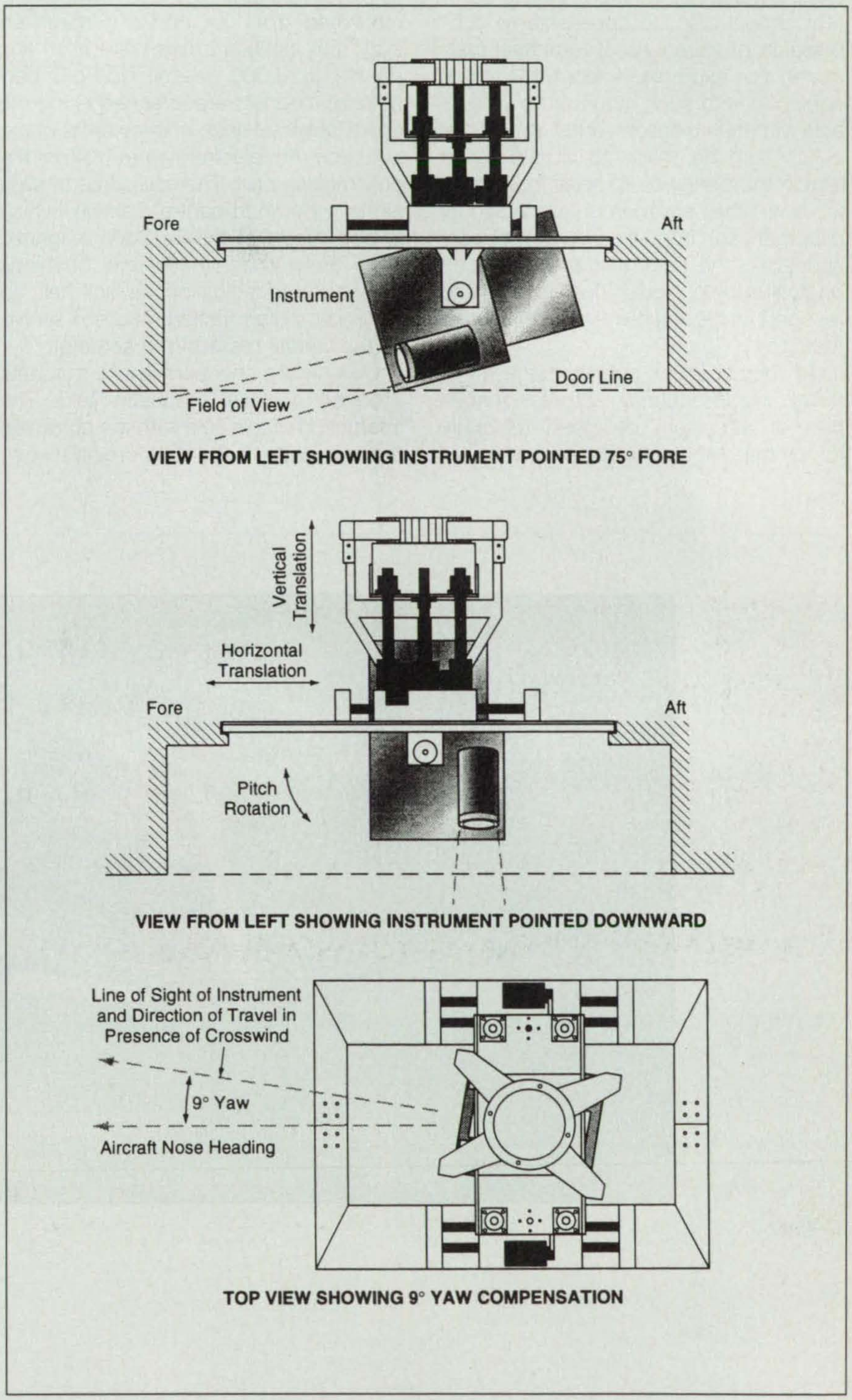
Goddard Space Flight Center, Greenbelt, Maryland

The figure shows selected aspects of a mechanism that rotates and translates an instrument platform within a pressure housing in an aircraft to aim a remote-sensing instrument toward a target on the ground below. In the original application, the mechanism enables an 80-lb (36-kg) imaging spectroradiometer to look 75° fore and 60° aft of the nadir. The mechanism moves the platform and instrument aft and down when pointing the instrument forward, or forward and down when pointing the instrument aft. These movements enable the instrument to look under the aircraft structure at larger fore and aft angles (more than the fore and aft angles of 45° of an older instrument mount) than it otherwise could, without having to deploy the instrument into the air stream outside.

In a typical operation, the instrument is initially positioned down and aft, aimed 75° forward of the nadir as the aircraft approaches the target. As the aircraft passes over the target, the instrument is stepped through a series of pointing angles. When angles of less than 45° forward of the nadir are reached, the instrument platform is moved up and forward to the midpoint between the fore and aft extremes of its translation. When the pointing angle passes 45° aft of the nadir after the aircraft has passed the target, the instrument is moved down and forward. As the aircraft continues to move away from the target, the instrument continues to pivot until it points 60° aft of the nadir.

The mechanism also provides 10° of yaw compensation, thereby reducing further the need for adjustment of the attitude of the aircraft to keep the target in sight. With yaw compensation, the pilot can fly with wings level and nose pointed into the crosswind while on the desired flight path over the target.

This work was done by Philip W. Dabney of **Goddard Space Flight Center** *and Suneel Bhardwaj of Hughes — STX. For further information,* ***write in 5*** *on the TSP Request Card.*
GSC-13624



The **Instrument Can Be Rotated and Translated** to aim it along lines of sight over a wide range of angles.

Inertial Linear Actuators

Unbalanced masses are pushed and pulled magnetically.

Lewis Research Center, Cleveland, Ohio

Inertial linear actuators are being developed to suppress residual accelerations of nominally stationary or steadily moving platforms. In the original intended application, the platforms would hold scientific instruments for materials-processing experiments in outer space. The basic concept of the inertial linear actuator should also be applicable to suppression of vibrations of terrestrial platforms. For example, a laboratory table equipped with such actuators plus suitable vibration sensors and control circuits might be made to vibrate much less in the presence of seismic, vehicular, and other environmental vibrational disturbances; from the vibrational perspective of the instrumentation mounted on it, the table would thus be made to respond as though it were much heavier than it is.

An inertial linear actuator is a long-throw, high-frequency actuator that is part of a system designed to apply forces that cancel the forces that would otherwise cause accelerations. The other major subsystems of the system are one or more motion sensors (e.g., inertial accelerometers) and a control subsystem, which comprises a digital computer and/or analog compensators.

The figure illustrates a prototype inertial linear actuator. The main structure is machined from an Fe/Co/V magnetic alloy that exhibits a high saturation flux density (>23,000 gauss). Nd/Fe/B permanent magnets are attached along the entire length of each of three arms of the actuator. An electromagnet coil is the only moving part. The coil is free to slide along a polished central spindle, which is also made of the Fe/Co/V magnetic alloy. Polytetrafluoroethylene bushings on the inner radius of the coil help to minimize sliding friction. The coil serves as the inertial mass of the actuator.

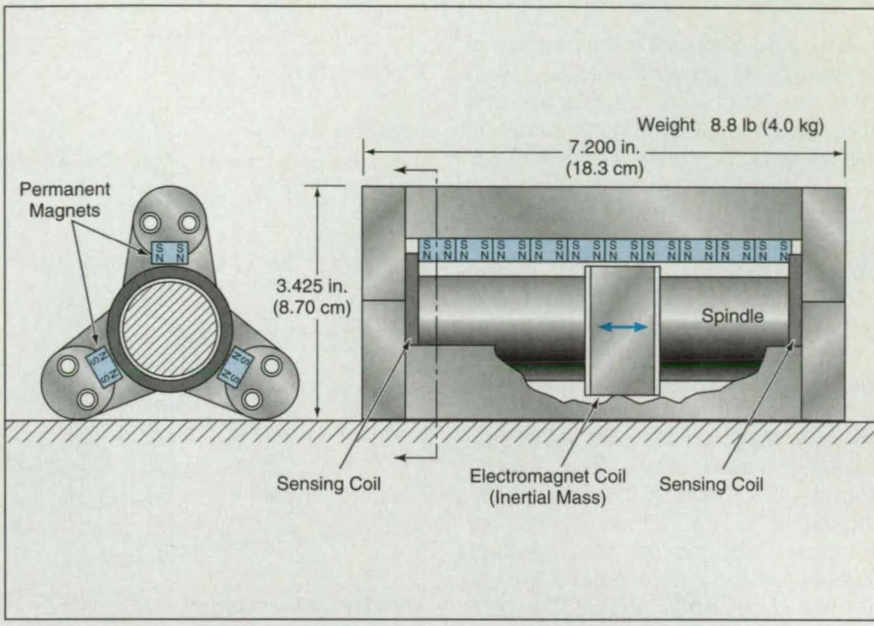
Collectively, the permanent magnets produce a radial magnetic field. The interaction of this field with the current in the coil results in an axial force between the coil and the spindle. This is the force that one seeks to produce, and it accelerates the coil along the spindle. In this aspect of its design, the actuator functions like a long-stroke version of a voice coil in a conventional loudspeaker. The length of the spindle — 6 in. (≈15 cm) — allows for a stroke longer than the strokes of most moving-coil actuators.

The control subsystem processes the sensed acceleration(s) into a command voltage proportional to the compensating force to be applied by the actuator. Because the force is directly proportional to the current in the electromagnet coil, the voltage command is fed to a voltage-to-current converter to generate a current, and thus a force, that is truly proportional to the command voltage over the frequency range of the actuator. The frequency range of the prototype is 0 to 1,000 Hz.

A sensing coil is attached rigidly to the actuator frame at each end of the spindle. The sensing coils are parts of a subsystem that controls the slowly-varying component of the axial position of the electromagnet coil; that is, the component that varies at frequencies much less than the frequencies of the accelerations to be suppressed. This subsystem, called a low-frequency caging loop, keeps the electromagnet coil/inertial mass from drifting over a long time and hitting either end of the spindle.

In addition to the actuating current, a sinusoidal current at a higher frequency (10 kHz) is also applied to the electromagnet coil. With respect to this sinusoidal excitation, the electromagnet coil functions as the primary winding of a variable-inductance transformer. The sensing coils are the secondary windings of this transformer. A simple measurement of the difference between outputs of the two sensing coils indicates the position of the electromagnet coil. In this aspect, the actuator functions as a linear variable-differential transformer. When the electromagnet coil is at the midlength of the spindle, the outputs of the sensing coils are equal in amplitude. When the electromagnet coil is off center, the output of the closer sensing coil exceeds that of the farther sensing coil. The sensing coils are connected in series so that the difference between their outputs can be detected and used to generate a slowly varying control voltage, which is fed back into the drive circuitry to force the electromagnet coil toward the midlength of the spindle.

This work was done by Darren Laughlin of Applied Technology Associates, Inc., for **Lewis Research Center.** *For further information,* ***write in 75*** *on the TSP Request Card.*
LEW-15533



An **Inertial Linear Actuator** functions like a long-stroke version of a voice coil in a conventional loudspeaker, with a superimposed linear variable-differential transformer.

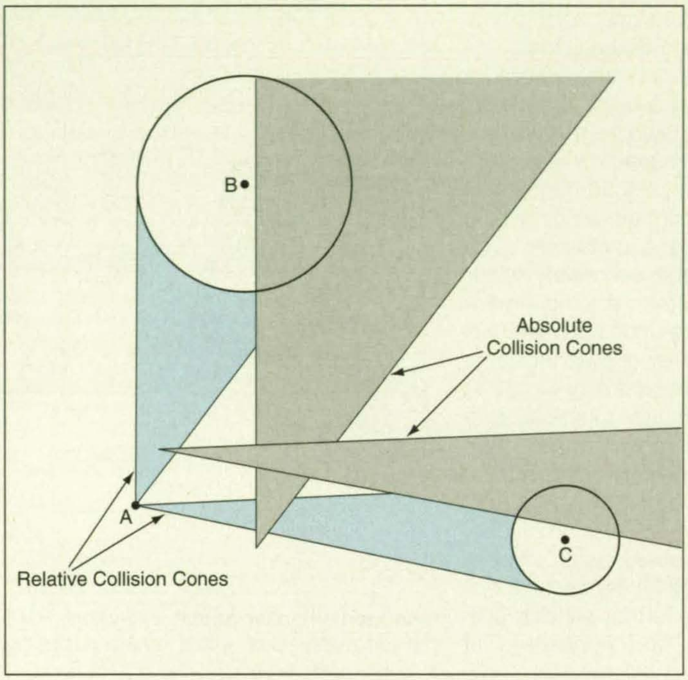
Planning Motions To Avoid Moving Obstacles

Collision cones in velocity space are computed, then maneuvers are chosen to avoid these cones.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of planning the motions of an object to prevent collisions with other moving objects has been derived from the concept of collision cones in relative-velocity space. This method can be considered a prototype of an automated method of planning motions in diverse applications, including complex manufacturing tasks that involve coordination of multiple robots and controlling land, air, and sea traffic.

The basic simplifying assumptions that underlie the mathematical model of this method are that (1) both the object undergoing the planned motion (hereafter called simply "the object") and the other objects (hereafter called "obstacles") are either circles or spheres, depending on whether motions are to be planned in a two- or a three-dimensional space, (2) each obstacle is either stationary or moving on a trajectory that can be approximated by a sequence of straight-line



Collision Cones in Velocity Space contain the range of velocities at which continued motion of object A will eventually result in a collision with obstacle B or C, respectively. To avoid a collision, the object must move at a velocity that does not point into the absolute collision cones.

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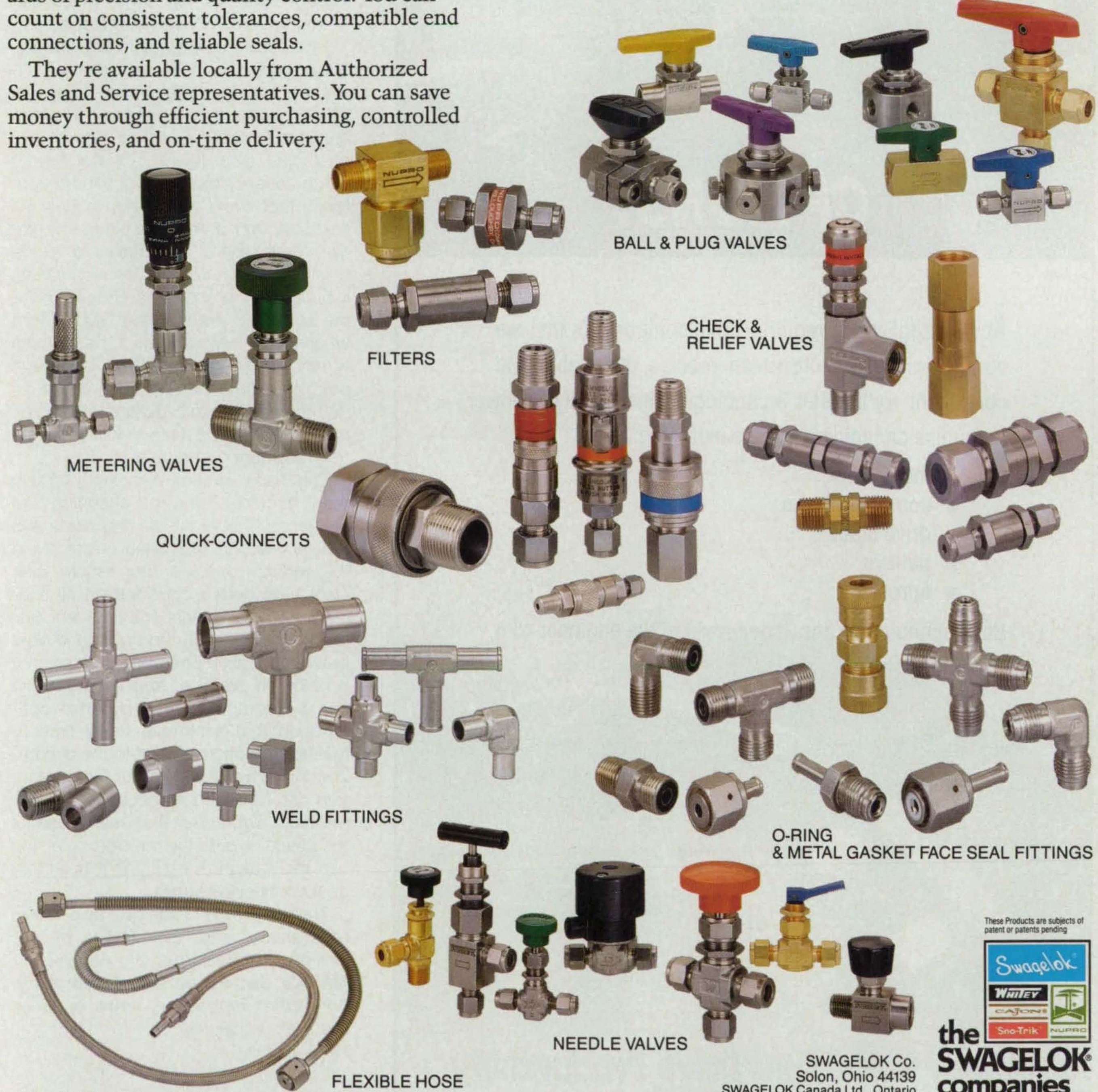

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segments, and (3) the object can travel along a trajectory that is approximated by a sequence of straight-line, constant velocity segments.

With respect to the object and one of the obstacles at their present positions, the collision cone in relative-velocity space is simply the conical range of relative velocities at which continued motion will eventually cause the object and obstacle to collide. The corresponding collision cone for the motion of the object in absolute-velocity space ("absolute collision cone" for short) is found by translating the relative velocities into absolute velocities. Thus, to prevent a collision with a given obstacle, the object must avoid the corresponding absolute collision cone, which can be regarded as a velocity obstacle.

By extension, one way to prevent collisions with multiple obstacles is to choose a simple straight-line trajectory with a velocity that lies outside all of the applicable collision cones or velocity obstacles (see figure). Of course, in some cases, simple straight-line trajectories that avoid all collision cones will not exist; that is, traveling along any single straight line at any attainable velocity will result in a collision. In such cases, it becomes necessary to choose multiple-segment trajectories such that whenever a velocity must be chosen within a collision cone, there is enough margin of time before the collision so that the object can avoid the collision by maneuvering to a safe velocity on the next segment of the trajectory.

The basic motion-planning problem then becomes one of choosing the sequence of straight-line segments and the corresponding maneuvers to avoid the collision cones and/or assure sufficient time before collisions on all segments of the straight-line-segment trajectory. Of course, abrupt maneuvers between straight-line segments are not possible in practice, and the trajectory can be computed with dynamic optimization that minimizes travel time or fuel consumption subject to the dynamic constraints of the object. These factors can be taken into account in optimization algorithms that make use of the space outside the collision cone and use the straight-line-segment trajectory as a nominal trajectory.

This work was done by Paolo Fiorini of Caltech and Zvi Shiller of the University of California, Los Angeles, for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 85*** *on the TSP Request Card.*
NPO-19031

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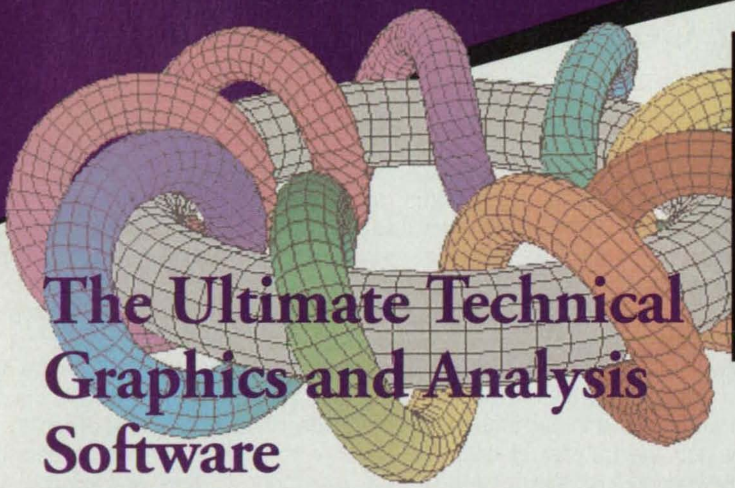

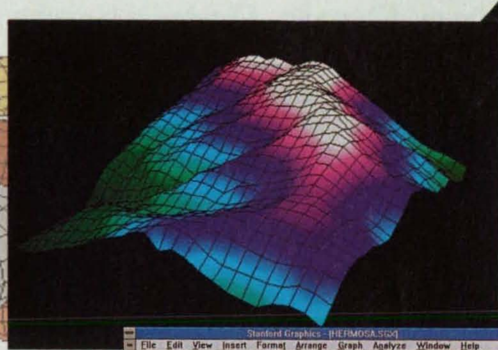

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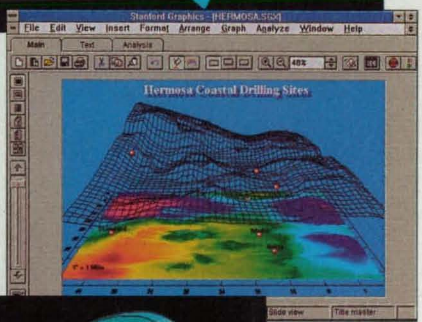

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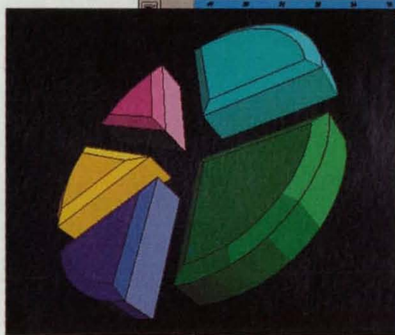

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Stirling-Cycle Refrigerator Containing Piezoelectric Pumps

Advantages would include greater reliability, relative simplicity, and lower cost.

Langley Research Center, Hampton, Virginia

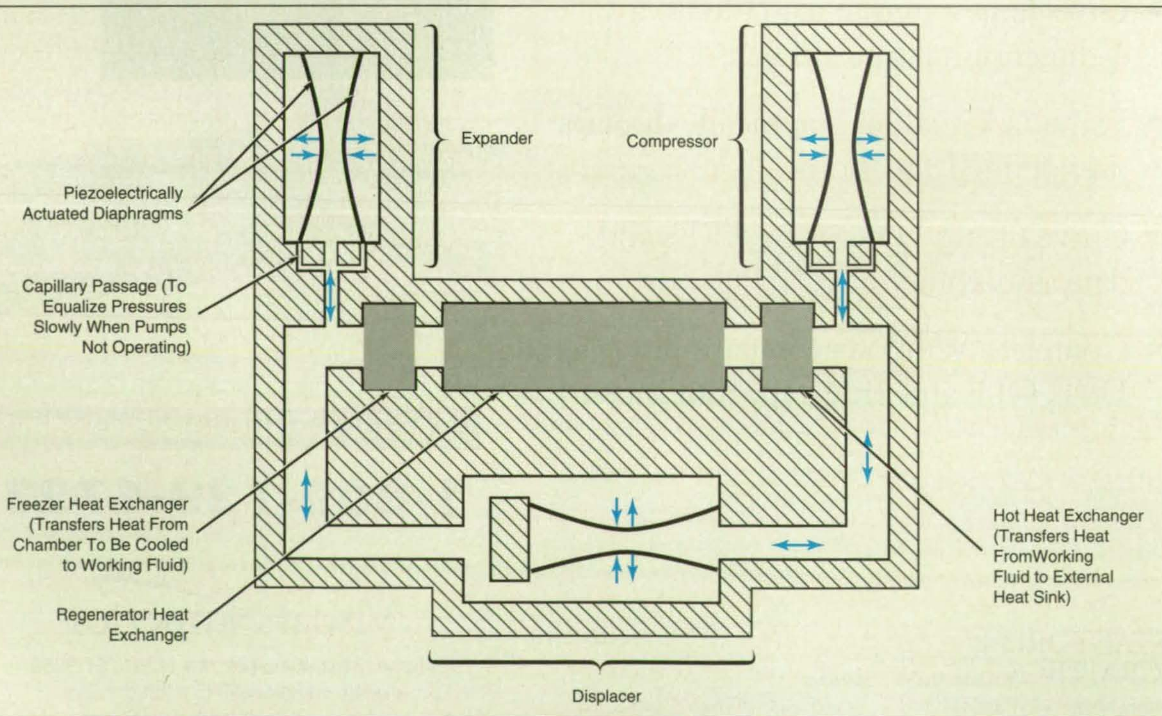
The figure shows an advanced Stirling-cycle cryogenic apparatus that is suitable for cooling sensitive infrared detectors to very low temperatures. The working fluid in this refrigerator is helium. The working fluid is compressed and circulated by three piezoelectrically actuated diaphragm pumps that offer advantages of greater reliability, relative simplicity, and lower cost in comparison with older piston-in-cylinder pumps.

Each diaphragm is a piezoelectric disk that has been chemically reduced on one side to give it a spherical curvature when no voltage is applied. Depending on the polarity of an applied voltage, the diaphragm becomes deformed, via the piezoelectric effect, toward a flatter or more curved shape. Each of the three pumps contains two diaphragms that are simultaneously deformed outward to increase the volume of the pump chamber (to draw fluid in) or simultaneously deformed inward to decrease the volume of the pump chamber (to expel fluid). Because these deformations involve motion of lightweight parts in opposite directions, the pumping action contributes very little (other than through motion of the fluid) to vibration; this is an important advantage where vibration could disturb a delicately aimed infrared instrument.

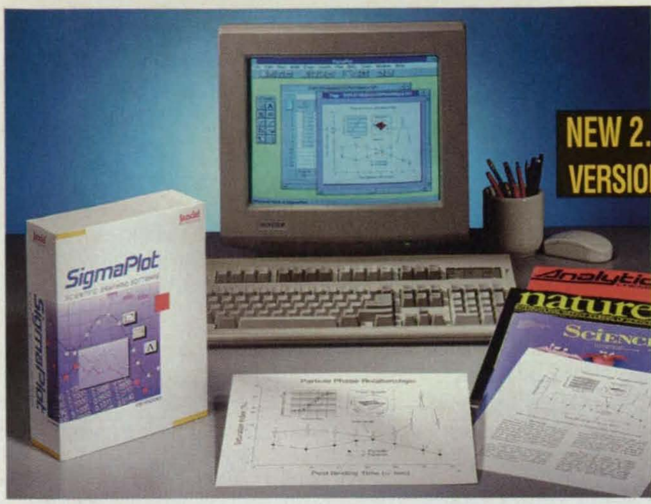
With respect to the compression and expansion of the working fluid, the circulation of the working fluid through the heat exchangers, and the transfer of heat to and from the working fluid, this apparatus operates according to principles that have long been familiar in the technology of refrigeration. One major innovative feature is the use of the piezoelectric pumps. Another major innovative feature is the particular three-pump configuration and pumping sequence, in which one pump serves as a compressor, one pump serves as an expander, and one pump serves as a displacer.

The operation of the pumps is coordinated by synchronizing the piezoelectric-actuator voltages in such a way that the net effect of the displacer is to reduce the deleterious effect of dead space — that is, to circulate a greater fraction of the working fluid through the heat exchangers than would be possible by use of the compressor and expander alone. In addition, the displacer can be controlled separately to make the flow of working fluid in the heat exchangers turbulent (to increase the rate of transfer of heat at the cost of greater resistance to flow) or laminar (to decrease the resistance to flow at the cost of a lower heat-transfer rate). Thus, the innovative design provides for optimization of the heat-exchanger performance.

This work was done by Antony Jalink, Jr., and R. F. Hellbaum of **Langley Research Center**. *For further information,* ***write in 49*** *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 20]. Refer to LAR-15065.*



This **Stirling-Cycle Refrigerator** contains three diaphragm pumps in which the diaphragms are opposed, lightweight, reliable piezoelectric actuators. Electrically, these actuators are essentially capacitors; unlike the electric motors of older motor-driven refrigerators, they do not exhibit large resistive heat losses in copper windings and eddy-current heat losses in magnetic cores.



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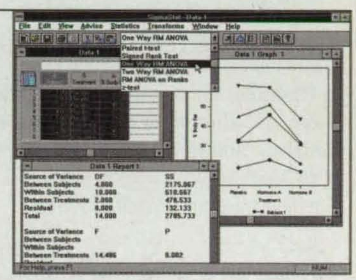

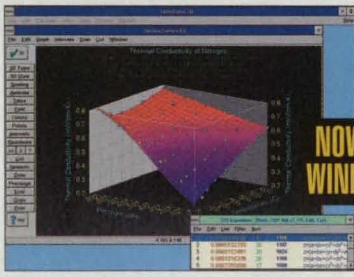

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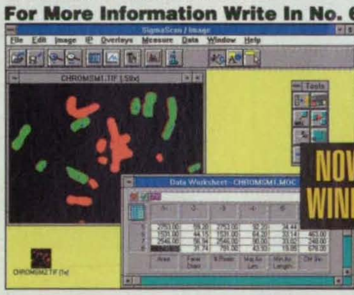

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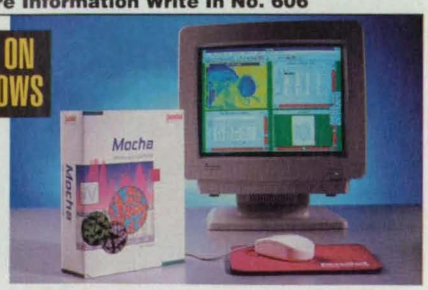

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*Image courtesy of Drs. Marder & Morgan, Radiobiology Laboratory, UC San Francisco. Windows is a trademark of Microsoft Corp.

Linear Proof-Mass Actuator

This unit is designed for active damping of vibrations in a structure.

Langley Research Center, Hampton, Virginia

The linear proof-mass actuator (LPMA) is a friction-driven linear mass actuator capable of applying a controlled force to a structure in outer space to damp out oscillations. The LPMA is capable of high accelerations and provides smooth, bidirectional travel of the mass. The design of the LPMA eliminates gears and belts, which are parts of prior actuators and which contribute to loose fits.

The LPMA consists of close-tolerance machined parts, four dc torque motors, an encoder, an accelerometer, and controlling hardware and software. Mechanically, the LPMA consists of four major parts: the upper and lower housing assemblies, the mass, and the center support (see figure). The upper housing assembly contains two dc torque motors, shafts, and associated hardware. The lower housing assembly is similar, except that it also contains two sets of guide bearings that laterally position the mass.

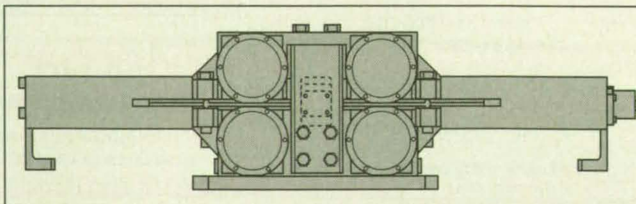
The center support is bolted to the lower housing assembly. The mass is positioned on the shafts of the lower housing assembly. The upper housing assembly is positioned on the center support, with the upper housing shafts resting on top of the mass. The upper and lower housing assemblies are then bolted together, providing the clamping force necessary to produce the required amount of frictional force between the shafts and the mass. The shafts and mass are made of dissimilar metals to prevent galling.

The dc torque motors, which fit on the ends of the shafts, rotate the shafts, which in turn translate the mass linearly. For this assembly to function, the parts are designed to very close tolerances. The shafts and mass must remain in contact at all times. The encoder gives the software, which controls the motors, data on the position of the mass, and the accelerometer provides acceleration feedback to the software controls.

The LPMA can be applied to future structures in outer space to provide oscillating forces to damp out vibrations. It is also strong enough to be used terrestrially where linear actuators are needed to excite or damp out oscillations. High flexibility can be designed into the LPMA by varying the size of the motors, the mass, and the length of the stroke, and by modifying the control software.

This work was done by Sidney E. Holloway, III, Edward A. Crossley, James B. Miller, Irby W. Jones, and C. Calvin Davis of **Langley Research Center** *and Vaughn D. Behun and Lewis R. Goodrich, Sr., of Planning Research Corp. For further information,* ***write in 3*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,150,875). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14352



Direct-Current Torque Motors Rotate the Shafts of the upper and lower housing assemblies to accelerate the mass.

Redesigned Electron-Beam Furnace Boosts Productivity

Modifications increase the number of experiments per loading, among other benefits.

Marshall Space Flight Center, Alabama

An electron-beam furnace has been redesigned to enable it to operate more efficiently and reliably. The furnace melts wires to make drops of molten metals for experiments on processing of materials in a drop tube. Samples of wire on a carousel are moved in sequence into a tungsten-loop filament and an electron-focusing grid, both at a potential of –4,000 Vdc with respect to the wires. Electrons from the filament bombard the tip of the wire in position at a given moment, melting the tip to form drops that fall into the tube.

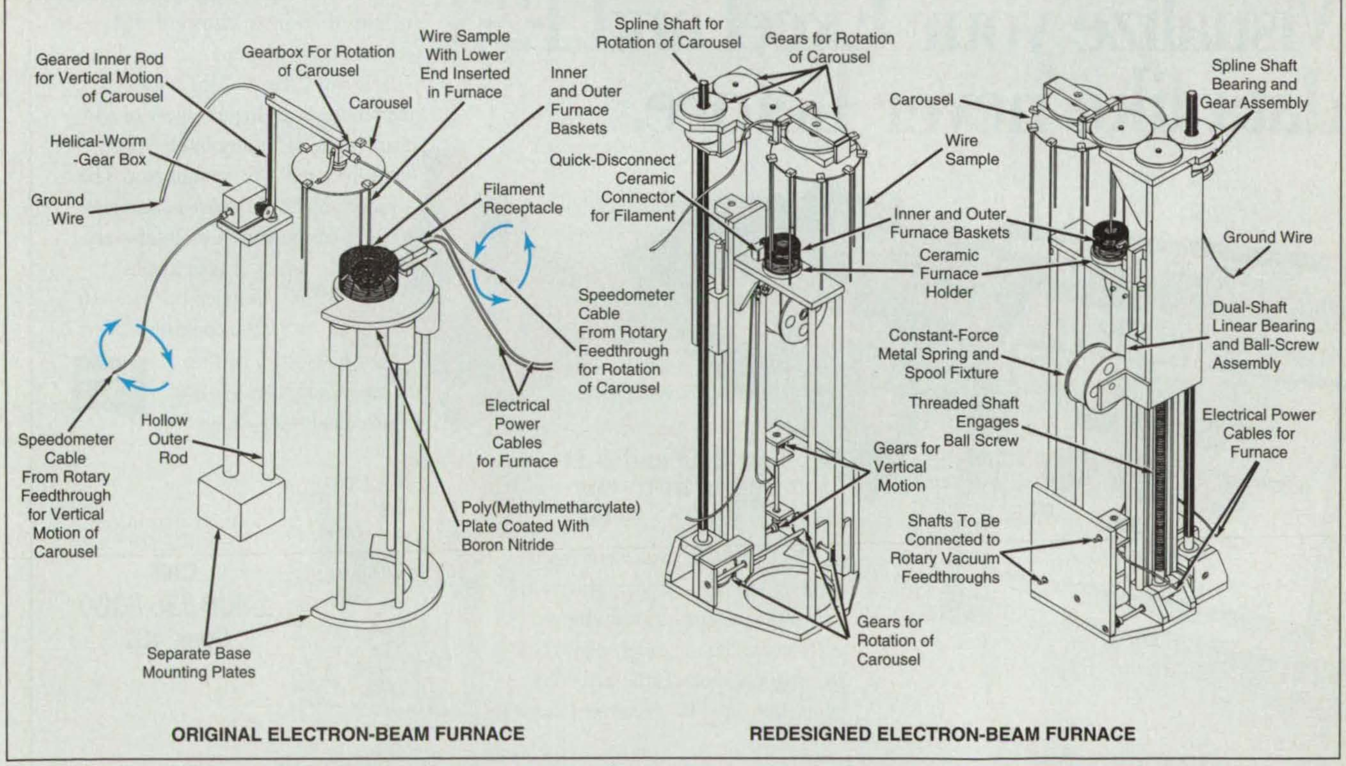
In the redesigned furnace (see figure), both the source of electrons and the carousel mechanism are mounted on the same plate, whereas they were previously mounted on separate plates. As a result, they can now be installed and aligned more easily and quickly, and they vibrate less. The redesigned furnace holder is smaller and made of a high-temperature ceramic instead of polymethylmethacrylate so that it outgases less and the vacuum bell jar in which the furnace operates can be evacuated faster.

The position of the main axis of the carousel has been changed, and the diameter of the carousel has been changed so that the carousel can accommodate nine samples of wire instead of only four. The net result of redesign of the carousel is that one can do about 36 experiments (that is, one can make about 36 drops) in a single loading of the carousel instead of 8 to 12 experiments in the original design. Thus, productivity is increased greatly, and the time spent pumping down the bell jar is reduced.

The diameter of the outer furnace basket has been reduced and the shape of the inner furnace basket has been altered to give a video camera and pyrometer a better view of melting wires. The outer basket now restrains movement of the inner basket, helping to preserve alignment of the baskets and filament and reducing stress on the filament.

A dual-shaft linear bearing system produces smooth, rigid, vibration-free vertical motion of the carousel. Mitre gears on stainless-steel shafts are linked with rotary feedthroughs by universal swivel joint unions; the linkage eliminates flexible cables and their attendant problems of twisting, jumping, and breakage. For rotation of the carousel, bevel gears are mounted in series on stainless-steel shafts with spur gears to provide a rigid drive.

This work was done by Gary A. Williams of the University of Alabama in Huntsville for **Marshall Space Flight Center**. *For further information,* ***write in 73*** *on the TSP Request Card.*
MFS-26255



The **Redesigned Electron-Beam Furnace** features a carousel of greater capacity so that more experiments can be conducted per loading, and time spent on reloading and vacuum pump-down is reduced. A common mounting plate for the electron source and the carousel simplifies installation and reduces vibration.

Multilead, Vaporization-Cooled Soldering Heat Sink

Compliant wicks would be saturated with water.

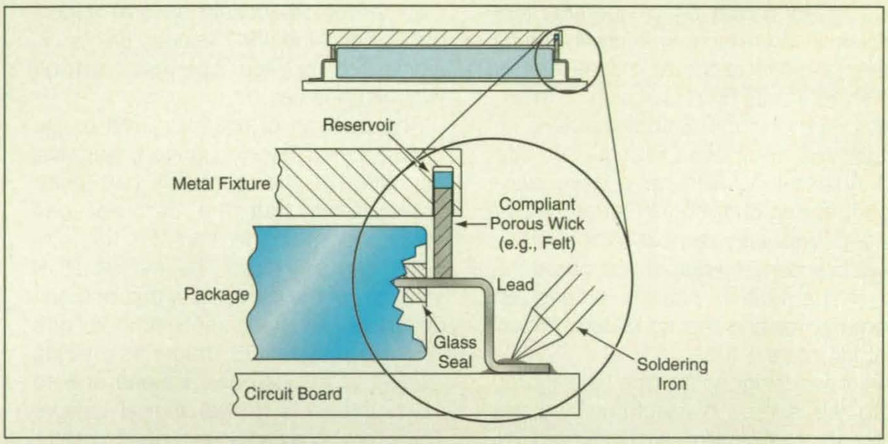
NASA's Jet Propulsion Laboratory, Pasadena, California

A vaporization-cooled heat sink has been proposed for use during the soldering of multiple electrical leads of packaged electronic devices to circuit boards. Heat sinking during soldering is necessary to prevent excessive increases in temperature at the seals where the leads penetrate the walls of the packages; typically, these are glass-to-metal seals, which are easily damaged by thermal shock.

The heat sink (see figure) would include compliant wicks held in grooves on the edges of a metal fixture. The wicks would be saturated with water. The heat sink would be sized to fit the electronic package so that wicks would rest in the desired positions on the leads when the heat sink was placed over the package. The weight of the overlying metal fixture would press the wicks into contact with the leads. Reservoirs in the upper parts of the grooves would help keep the wicks saturated.

As in all cases of soldering heat-sunk leads of delicate electronic devices, soldering should be performed quickly. Vaporization of the water in the wicks would limit the temperatures of the leads at and near the entrances to the package: provided that the heat sink was positioned correctly and the correct soldering technique was used, the temperatures should not rise above the boiling temperature of water (100 °C at normal atmospheric pressure). In principle, a liquid other than water could be used to limit the temperature to a different value, but of course liquids other than water could pose problems of toxicity and/or contamination.

This work was done by John Rice of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 88*** *on the TSP Request Card.* *NPO-19182*



The **Multilead, Vaporization-Cooled Heat Sink** would prevent excessive increases in temperature at the entrances of the leads into the package.

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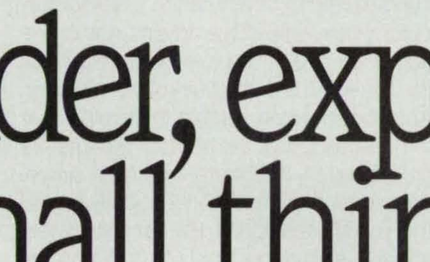

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Mathematics and Information Sciences

Learning Identification From One Set of Input/Output Data

Recursive and nonrecursive techniques are used to estimate Markov parameters in state-space format.

Langley Research Center, Hampton, Virginia

A method of learning identification from a single set of input/output data has been formulated. To make it possible to explain the significance of this development meaningfully, it is first necessary to define some specialized terms from the discipline of mathematical modeling of multivariable linear systems like vibrating structures. "Learning" and "identification" as used in this discipline have meanings different from their colloquial meanings. "Identification" is short for "system identification," which means identification of the parameters of a mathematical model that represents the system. "Learning identification" is short for "learning system identification," which is a method of system identification in which new information from successive experiments on a system (e.g., excitation/response tests of a vibrating structure) is used to obtain increasingly refined estimates of the parameters.

In the usual approach to system identification, one determines the time-domain parameters of a system from input/output data (e.g., vibrational-excitation/vibrational response data). It is customary to average together input/output data from multiple experiments in the hope that averaging will reduce the effects of irregularities such as slight nonlinearities, instrumentation errors, background noise, and repetitive disturbances.

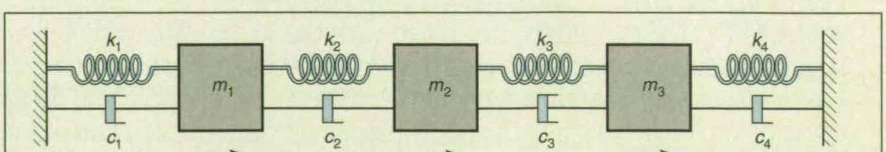
In learning system identification, the parameters to be identified are the Markov parameters. Once the Markov parameters have been found, standard procedures can be used to compute the time-domain parameters. One of the advantages of this approach is that there is no ambiguity in the dimensions of the Markov parameters. Another advantage is that in learning system identification, the Markov parameters are related to input/output data via simple linear equations and consequently any of the many techniques for handling linear equations can be applied. Yet another advantage is that for a given linear system, the Markov parameters are unique and invariant with respect to any coordinate transformation of vectors that are used to represent the state of the system ("state vectors" for short).

The Markov parameters of a system in state-space format are related to the impulse-response functions of the system, which can be used in identification of modal (as in vibrational modes) parameters. From the identified Markov parameters, such modal parameters as natural frequencies, modal damping ratios, and modal shapes can be deduced by use of standard procedures like the Eigensystem Realization Algorithm. The Eigensystem Realization Algorithm is a computational procedure which computes modal parameters from impulse-response functions.

The present method of learning system identification is derived from the previous method by extension of the concept of a repetition domain to include shifting time intervals. In a sense, for the purpose of successive approximation, the input/output data from each successive time interval can be regarded as data from a new experiment. The present algorithm allows for application of both recursive and nonrecursive techniques to estimate the Markov parameters of a system in state-space format.

The model structure includes the conceptual equivalent of an embedded observer structure that, among other things, places the locations of the poles of the response of the observer system in the complex-frequency plane. The primary role of the observer structure is not to estimate the states of the system for identification, but rather to provide a set of asymptotically stable autoregressive-moving-average (ARMA) equations, the parameters of which can be identified. These parameters contain the desired information about the system. An initial assumption about the order of the system can be removed later by an iterative process (see figure) or by knowledge of an upper bound on the effective order of the system.

This work was done by Jer-Nan Juang of **Langley Research Center**, *Richard W. Longman of Columbia University, and Minh Phan of Princeton University. For further information,* ***write in 33*** *on the TSP Request Card.*
LAR-14665



This **Mass/Spring/Dashpot System**, which has six degrees of freedom, was simulated numerically in a test of the algorithm. Even when the order of the system was initially overestimated at 8 or underestimated at 2, 3, 4, or 5, the true order of 6 and all the Markov parameters were recovered at the final step. The algorithm failed only when the order of the system was grossly underestimated at 1.

Universal Formulation for Symmetries in Computed Flows

Special procedures for coding symmetries of high order are no longer needed.

Langley Research Center, Hampton, Virginia

A universal formulation for high-order symmetries in boundary conditions on flows has been devised. Symmetries that are commonly encountered include symmetries across any or all of the three principal coordinate planes, polar symmetry, and symmetry across wedge sectors. Furthermore complex geometries can exhibit symmetries that are not aligned with any of the principal coordinate axes. The present universal formulation eliminates the need for special procedures to incorporate such symmetries and the corresponding boundary conditions into computer codes that solve the Navier-Stokes and Euler equations of flow.

In the general case, a flow is computed in a general three-dimensional curvilinear coordinate system $\mathbf{x} = (x_1, x_2, x_3)^T$, where the superscript T denotes the matrix or vector transpose. For the purpose of the universal formulation of symmetry, a local Cartesian coordinate system $\mathbf{X} = (X_1, X_2, X_3)^T$ is established at each face of each cell of the computational grid defined by the curvilinear coordinate system (see figure). The three coordinate axes of **X** are the inward normal to the face, plus two linearly independent axes in the plane of the face.

A velocity vector (**u** in the general curvilinear coordinate system, **U** in the local Cartesian coordinate system) in the neighborhood of the face is decomposed into vector components (U_1, U_2, U_3) in the local Cartesian coordinate system. Regarding the face as a mirror boundary, a ghost point (b) is assumed to be located at the mirror image of an original point (p) within the computational domain. The velocity vector $\mathbf{U}^b$ associated with the ghost point is the mirror image of the original velocity vector $\mathbf{U}^p$; these two velocity vectors are related by

$$\begin{pmatrix} U_1 \\ U_2 \\ U_3 \end{pmatrix}^b = \begin{pmatrix} -U_1 \\ U_2 \\ U_3 \end{pmatrix}^p$$

The relationships between the velocities in the two coordinate systems are given by $\mathbf{U}^b = A\mathbf{u}^b$ and $\mathbf{U}^p = A\mathbf{u}^p$, where A is the matrix of direction cosines between the **X** and **x** coordinates, given by

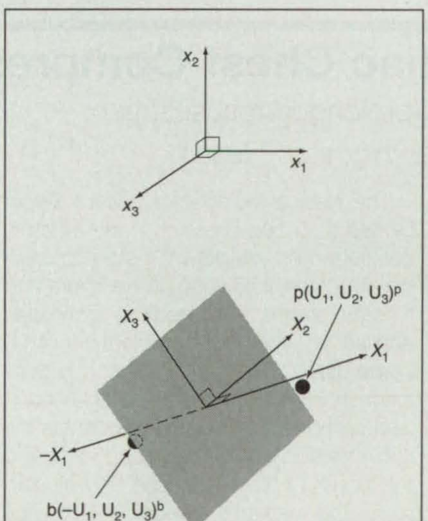
$$A = \begin{pmatrix} n_1 & n_2 & n_3 \\ m_1 & m_2 & m_3 \\ l_1 & l_2 & l_3 \end{pmatrix} \text{ and } A^{-1} = A^T$$

The foregoing equations can be combined and manipulated to obtain $\mathbf{u}^b = \mathbf{u}^p - 2U_1(n_1, n_2, n_3)^T$. All of the special cases of flow symmetry can be recovered from this general formula.

This formulation has been implemented in the PAB3D Navier-Stokes computer code. In this and other advanced Navier-Stokes and Euler codes it simplifies the bookkeeping involved in the specification of boundary conditions and provides the flexibility to incorporate symmetrical boundary conditions into computational grids without need for planes of symmetry to be aligned with principal coordinate axes. It provides flexibility for choosing boundary conditions and computational domains in such a way as to save computer memory and computing time; in many cases, the use of these computational resources can be reduced by half or more.

This work was done by S. Paul Pao of **Langley Research Center** *and Khaled S. Abdol-Hamid of Analytical Services and Materials. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-15148.



A Local Cartesian Coordinate System is used, along with a global curvilinear coordinate system, to formulate boundary conditions that involve symmetries of various kinds.

Using Spider-Web Patterns To Determine Toxicity

Webs are visibly altered when spun by spiders exposed to chemicals.

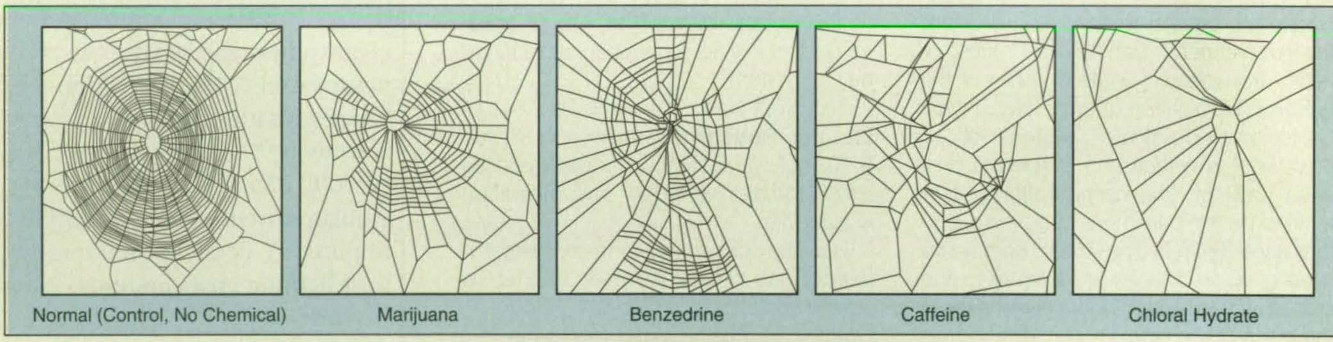
Marshall Space Flight Center, Alabama

A method of determining the toxicities of chemicals involves recording and analysis of spider-web patterns. The method is based on the observation that spiders exposed to various chemicals spin webs that differ, in various ways, from their normal webs (see figure). Spider-web toxicity testing has potential as an alternative to toxicity testing on higher animals, which is expensive, time-consuming and becoming increasingly restricted by law.

The changes in webs reflect the degree of toxicity of a substance. The more toxic the chemical, the more deformed a web looks in comparison with a normal web. Inasmuch as the shape of a spider web resembles that of a crystal lattice in some respects, techniques of statistical crystallography are applied to obtain several quantitative measures of toxicity as manifested in the differences between photographs of webs spun under toxic and normal conditions.

The images of the cells are digitized and processed by an image-data-analysis program that computes various measures of the cellular structures of the webs, including numbers of cells and average areas, perimeters, and radii of cells. It appears that one of the most telling measures of toxicity is a decrease, in comparison with a normal web, of the numbers of completed sides in the cells: the greater the toxicity, the more sides the spider fails to complete.

This work was done by David A. Noever, Raymond J. Cronise, and Rachna A. Relwani of **Marshall Space Flight Center**. *For further information,* ***write in 48*** *on the TSP Request Card.*
MFS-28921



The **Web Spun by an Araneus diadematus (House Spider)** is altered when the spider is exposed to chemicals. The alterations can be quantified and used as measures of toxicity.

Device Assists Cardiac Chest Compression

This device enables effective and prolonged resuscitation.

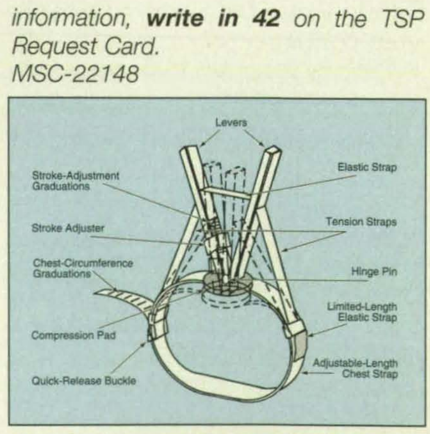
Lyndon B. Johnson Space Center, Houston, Texas

A portable device facilitates effective and prolonged cardiac resuscitation by chest compression. Developed originally for use in the absence of gravitation, the device may also be useful in terrestrial environments and situations (confined spaces, water rescue, medical transport) that are not conducive to standard manual cardiopulmonary resuscitation (CPR) techniques.

The figure shows one version of the device, which is attached to the patient by an adjustable chest strap. Unlike some other devices designed for the same purpose, this one does not require any structural attachments or supplemental restraints; both the patient and the medical technician can be floating.

The device includes a pair of levers hinged to a compression pad, which is positioned on the patient's sternum during attachment. By use of the levers and tension straps, the medical technician applies an effective combination of (1) compression of the entire chest by constriction via the chest strap and (2) localized compression of the sternum via the compression pad. The applied force and the length of the stroke can be adjusted to fit the patient's needs. The device applies compression during more than half of the compression cycle, as is desirable for efficient CPR.

This work was done by Frank T. Eichstadt of McDonnell Douglas Corp. for **Johnson Space Center**. *For further information,* ***write in 42*** *on the TSP Request Card.*
MSC-22148



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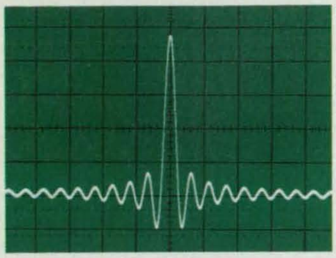

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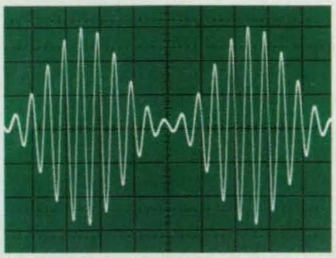

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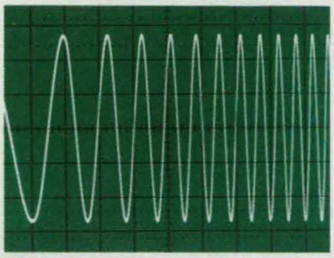

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Manufacturing/Fabrication

Rocket Combustion Chambers Resist Thermal Fatigue

Lewis Research Center developed an improved design concept for combustion chambers for rocket engines, described in three reports. The improved design concept provides compliance that allows unrestrained thermal expansion in the circumferential direction. This compliance lengthens the life of the rocket engine by reducing the amount of thermal deformation caused by repeated firings. Preliminary results of experiments on subscale models suggest that a suitable compliant design could double or perhaps even quadruple the life of the space shuttle main engine.

A conventional rocket engine combus

This work was done by John M. Kazaroff and Robert S. Jankovsky of **Lewis Research Center** *and Albert J. Pavli of Sverdrup Technology, Inc. To obtain copies of the reports "Hot Fire Fatigue Testing Results for the Compliant Combustion Chamber" and "Hot Fire Test Results of Subscale Tubular Combustion Chambers,"* ***write in 235*** *on the TSP Request Card.*

Further information is also contained in AIAA paper 92A44509, "Advanced Tube-Bundle Rocket Thrust Chambers." Copies may be purchased [prepayment required] from AEROPLUS, Burlingame, California 94010, Telephone No. (800) 662-2376, Fax No. (415) 259-5047.
LEW-15766

More About Plasma-Spraying Ceramics Onto Smooth Metals

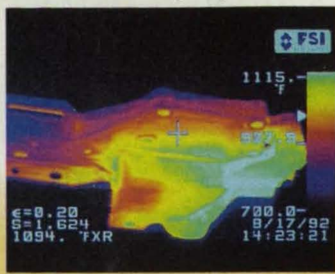
A short paper presents additional information on the fabrication process described in "Plasma-Spraying Ceramics Onto Smooth Metallic Substrates" (LEW-15164), *NASA Tech Briefs*, Vol. 17, No. 4 (April 1993), page 56. To recapitulate, the process involves optional preoxidation of the substrate surface followed by low-pressure plasma spraying of a thin layer of a thermal-barrier ceramic (zirconia/yttria) onto the substrate, followed by atmospheric-pressure plasma spraying of a second layer of the ceramic onto the first layer. The new paper provides additional information on specific substrate materials that could be advantageously coated in the two-stage plasma-spraying process. The paper describes an application of the process to coating specimen substrates of NiAl + 0.1 atomic percent Zr. Specimen substrates coated in this process survived as many as 294 thermal cycles between ambient temperature and 1,200 °C in a burner rig.

This work was done by Robert A. Miller and Joseph Doychak of **Lewis Research Center**. *To obtain a copy of the report, "Plasma Sprayed Ceramic Thermal Barrier Coating for NiAl-based Substrates,"* ***write in 64*** *on the TSP Request Card.*

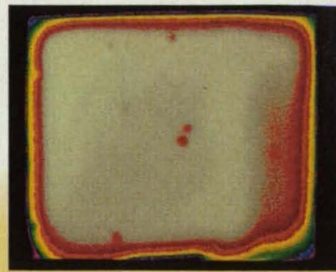
This invention has been patented by NASA (U.S. Patent No. 5,302,465). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 20]. Refer to LEW-15535.

Engine development

Measure casting temperatures

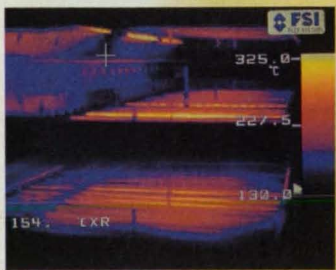


Defects in composite materials



Moisture content in paper

Monitor soldering processes



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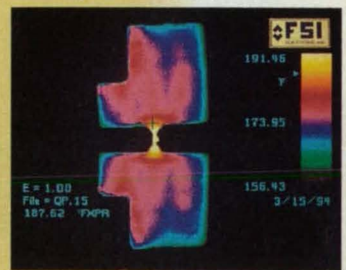
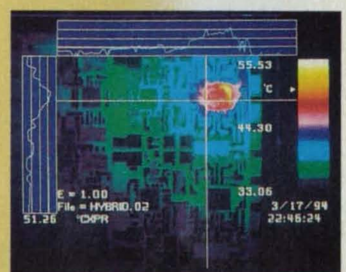
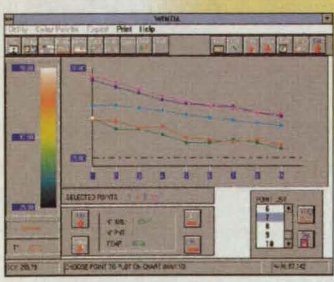
Injection mold performance



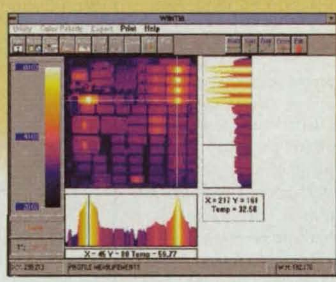
Evaluate wax injection presses



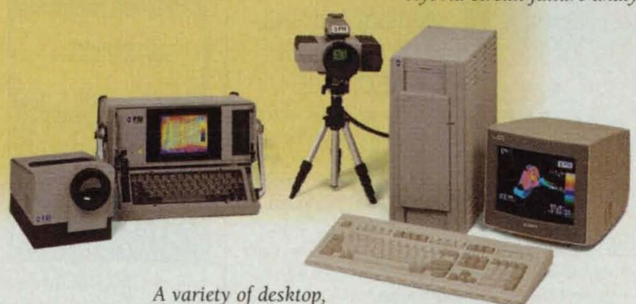
Hybrid circuit failure analysis



Analyze trend data



Post-processing thermal analysis



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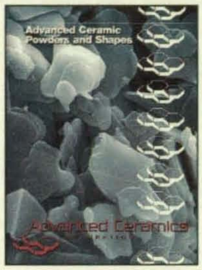

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National Instruments

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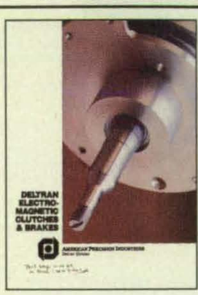

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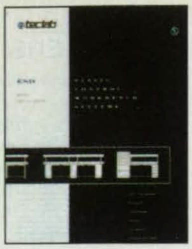

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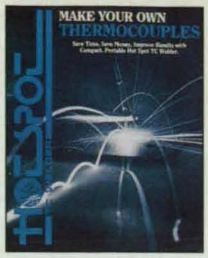

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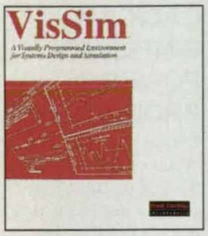

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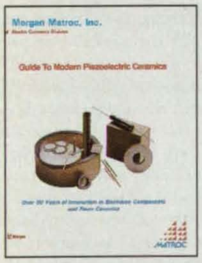

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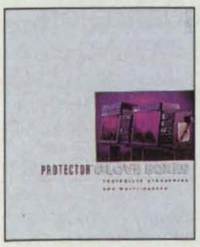

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Daedal Div., Parker Hannifin Corp.
Tel: 800-245-6903; Fax: 412-744-7626.

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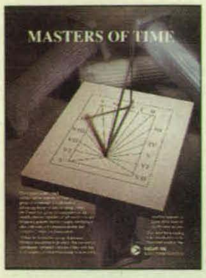

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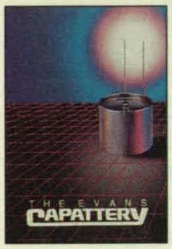
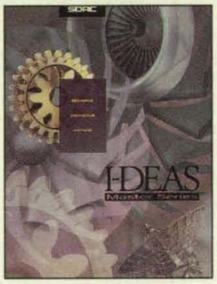


The Capattery is a high-reliability double layer capacitor used as a standby power source in memory back-up and bridge-power applications. It has virtually unlimited cycle life and over 20x the capacitance density of conventional capacitors. With a Permselective valve, patented by Evans, 33 Eastern Ave., East Providence, RI 02914-2107, Tel: 401-434-5600; Fax: 401-434-6908.

Evans

For More Information Write In No. 325

CAE/CAD/CAM SOFTWARE



You can create, simulate, document, build, and test your products all within a single electronic environment: I-IDEAS Master Series, the industry's most comprehensive mechanical design automation system. For a free video and brochure, call 800-848-7372 today.

Structural Dynamics Research Corporation

For More Information Write In No. 326

CAD/CAM SIMPLICITY, POWER & PRODUCTIVITY

TekSoft's 3D/Surf/Mill for Windows delivers productivity with ease of use to generate tool paths faster and more efficiently. The power of true bi-cubic, parametric surface creation and NURBS surface support are packed into TekSoft's advanced sculptured surfacing system. For FREE brochure and more information call TekSoft CAD/CAM Systems at 800-BUY-CADD.

TekSoft

For More Information Write In No. 327

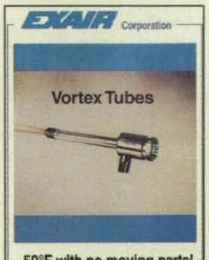
AIR FILTERS

Universal Air Filter Company manufactures custom-designed filter products for original equipment manufacturers. Universal filters are used extensively in the electronics, HVAC, digital switch, medical, defense, and data processing industries. The brochure describes applications and engineering and production capabilities. Universal Air Filter Company, 3400 Missouri Avenue, East St. Louis, Illinois 62203. Tel: 800-541-3478; Fax: 618-271-8808.

Universal Air Filter Company

For More Information Write In No. 328

VORTEX TUBES



Data sheet describes how EXAIR Vortex Tubes produce up to 10,000 Btu/hr with no moving parts. Tubes convert an ordinary supply of compressed air into two streams; one hot and one cold. Temperatures are adjustable from -50 to +250 °F. Bulletin highlights advantages for a variety of industrial cooling applications. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH 45246; Tel: 513-671-3322; Fax: 513-671-3363.

EXAIR Corporation

For More Information Write In No. 329

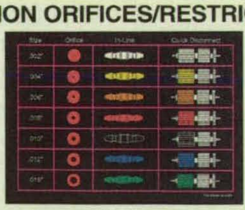
Hardigg Cases offers over 225 standard rotationally molded transit cases, including a full line of 19" EIA rack mount cases, deck cases, and flangemount cases. Hardigg's expert engineering, manufacturing, and test facilities provide start to finish custom design capability. A complete list of standard cases allows for rapid delivery...as few as three working days! Take advantage of over forty years of experience...design a Hardigg case into your next project!

HARDIGG CASES

Tel: 1-800-JHARDIGG; Fax: 413-665-8061

For More Information Write In No. 330

PRECISION ORIFICES/RESTRICTORS



Data sheet introduces quick-disconnect and in-line precision orifice connectors within which synthetic sapphire or ruby—with zero porosity, high temperature tolerance and wear resistance—form the critical internal diameter of the orifice in ranges starting at .0008". These precision orifices are available with filters and in a variety of custom or stock fittings. Data sheet depicts and explains connector construction and dimensions. Also explained is a trail kit program for designers.

Bird Precision

For More Information Write In No. 331

AIR KNIFE FOR BLOWOFF

The EXAIR-Knife reduces air consumption and noise levels in blowoff applications. Using a small amount of compressed air as a power source, the air knife pulls in large volumes of surrounding air to produce a high flow, high velocity curtain of air for blowoff. Compressed air flow is amplified 30:1. Six sizes up to 36" are available. Applications: blowing liquid, chips, and containment from parts and conveyors, cooling hot parts, and air screening. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH 45246; Tel: 513-671-3322; Fax: 513-671-3363.

EXAIR Corporation

For More Information Write In No. 332

CORROSION TRAINING

"Fundamentals of Corrosion and Its Control" training course provides instruction in the process of corrosion and its causes, different forms of corrosion, corrosion control methods and monitoring techniques. Three-day program presented four times in 1995. LaQUE CORROSION SERVICES, PO Box 656, Wrightsville Beach, NC 28480; Tel: 910-256-2271; Fax: 910-256-9816.

LaQue Corrosion Services

For More Information Write In No. 333

REMOTE VIEWING INSTRUMENTS (RVI)

If you have requirements to observe or visually inspect items located in inaccessible areas or hostile environments, select from over 1500 RVI's outlined in this new product catalog from ITI. Borescopes, Fiberscopes and Videoscopes to provide sharp, clear images never before available. INSIGHT from the "Leader in Remote Viewing." Instrument Technology, Inc. Tel: 413-562-3606; Fax: 413-568-9809.

Instrument Technology, Inc.

For More Information Write In No. 334

RUGGED MINIATURE SWITCH

The new Series 70 is an environmentally rugged line of lighted and unlighted switches. Ready for wet, dusty or oily duty, the Series 70 is ideal for a variety of control and instrumentation requirements. Available with DPDT Momentary or Alternate switch actions. Mounts on 0.700" centers with 0.880" behind the panel space. Lighted pushbuttons use T-1 LED or Incandescent MFB lamps for a wide variety of display types, colors, and lighting styles. StacoSwitch, Inc., Costa Mesa, CA 92626. Tel: 714-549-3041; Fax: 714-549-0930.

StacoSwitch, Inc.

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PARTS EXPRESS

Our FREE catalog features 212 pages packed with electronic parts for the do-it-yourselfer. Over 12,000 items including speakers, semiconductors, tools, wire, capacitors, hardware, test equipment, kits, connectors, adhesives, educational books and videos, TV parts, and much more. Call toll free 800-338-0531. Parts Express, 340 E. First St., Dayton, OH 45402.

Parts Express

For More Information Write In No. 336

1995 PCMCIA PRODUCTS CATALOG

The new PCMCIA-PC CARD standard has brought many new devices such as Video Capture, 16-bit Stereo, CD-ROM, Pager, and mini PC Card Camera Cards. ENVOY DATA has released its new catalog with these products plus many others like: Memory, I/O (serial, parallel, SCSI, A/D, etc.) with Industrial Card and Drives, Multimedia, Industrial, and Engineering tools for PCMCIA applications. Tel: 602-892-0954; Fax: 602-892-0029. 953 E. Juanita Ave., #A, Mesa, AZ 85204.

Envoy Data Corporation

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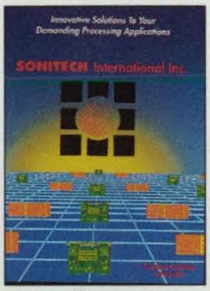

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Sonitech offers hardware and software for ISA, SBus and VME (and soon PCI) platforms based on TI C3x and C40 DSPs. We provide expert solutions for your projects including: Image processing, Data acquisition and analysis, Digital Audio Record/Playback, Speech processing and analysis, MPEG/JPEG, Radar, Sonar, and Parallel Processing. Call 617-235-6824 (or e-mail info@sonitech.com) for your **free** copy of the most comprehensive catalog of the DSP industry.

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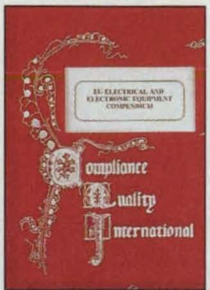


SELLING ELECTRONIC EQUIPMENT IN EUROPE

If you manufacture electrical or electronic equipment, appliances, or machinery, a complete EU Compendium provides everything you need to know to comply with the latest regulations and directives issued by the European Commission. Updated 1995 edition explains the original directives plus all amendments. User-friendly readable format throughout, including tables, references, glossary.

International Quality Press

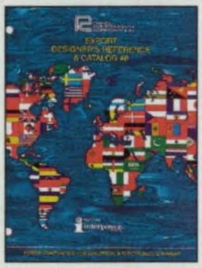
For More Information Write In No. 339

SCANNING SYSTEMS WORK BOOK

LINCOLN LASER COMPANY has released its new Scanning Systems Work Book. The literature is broken out into three separate sections defining design approaches for polygonal mirrors, motors and controls. The work book is formatted to assist the user in selecting or designing the precise solution for their specific scanning requirements. Lincoln Laser Co., 234 East Mohave, Phoenix, AZ. Tel: (602) 257-0407; Fax: (602) 257-0728

Lincoln Laser Company

For More Information Write In No. 340



INTERPOWER™ EXPORT DESIGNER'S REFERENCE CATALOG

New 224 page Reference Catalog #8 helps in designing primary power circuits of international products. Designer's Reference section shows world plug/-socket patterns, voltages and frequencies, international safety agencies and important standards published by IEC, UL and CSA. Tel: 515-673-5000; Fax: 515-673-5100.

PANEL COMPONENTS CORPORATION

For More Information Write In No. 341

SELLING MEDICAL DEVICES IN EUROPE

If you are a manufacturer, OEM, or distributor of medical devices, a complete EC Compendium provides everything you need to know to comply with the latest regulations and directives issued by the European Commission. Updated 1995 edition explains the original directives plus all amendments. User-friendly readable format throughout, including tables, references, glossary. Details Medical Devices, Active Implantables, In-Vitro Diagnostics, Good Manufacturing Practices, Electro-Medical Equipment, and more.

International Quality Press

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The Grieve Corporation

For More Information Write In No. 343

P/M DESIGN KIT

Powder metallurgy design kit includes information on the process, available alloys, standard bearings and custom components. The process is presented in an easy-to-follow flow chart with major descriptions. The alloys sheet identifies 21 different alloys with complete engineering specs. The bearings page lists standard bearing sizes which can be produced without tooling charges. The design guide highlights the capabilities and limitations of P/M tooling for effective component design. The Wakefield Corporation, 22 Foundry Street, Wakefield, Massachusetts 01880; Tel: 617-248-1828; outside MA, 800-548-9253; Fax: 617-245-3598.

The Wakefield Corporation

For More Information Write In No. 344

"HANDS-ON" ADVANCED COMPOSITE WORKSHOPS—SINCE 1983

The brochure describes 13 different "hands-on" workshops in advanced composite materials technology. These workshops cover fabrication, repair, manufacturing, tooling, blueprint reading, adhesive bonding, ultrasonic inspection of composites, and 4 engineering workshops. Emphasis is placed on prepreg carbon and aramid fiber materials and processes, utilizing vacuum bagging and high-temperature curing methods in the oven and autoclave. Three workshops are Canadian DOT approved. REFRESHER WORKSHOPS OFFERED. For a free brochure, call 1-800-638-8441; Fax: 702-827-6599.

Abaris Training Resources

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SELLING MEDICINAL PRODUCTS IN EUROPE

If you are a manufacturer, raw-material supplier, or distributor of pharmaceuticals, a complete EC Compendium provides everything you need to know to comply with the latest regulations and directives issued by the European Commission. Updated 1995 edition explains the original directives plus all amendments. User-friendly readable format throughout, including tables, references, glossary. Details Human Medicinals, Veterinary Medicinals, Good Laboratory Practices, and more.

International Quality Press

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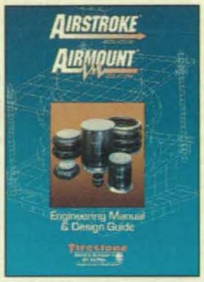
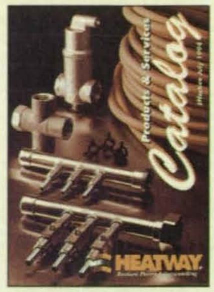


FIRESTONE ENGINEERING MANUAL & DESIGN GUIDE AVAILABLE

The Firestone Engineering Manual & Design Guide for Airmount® isolators and Airstroke® actuators is a 101-page guide containing selection information and application tips. To receive a copy, write to: Firestone Industrial Products Company, 701 Congressional Blvd., Carmel, IN 46032, or call 800-888-0650.

Firestone Industrial Products Company

For More Information Write In No. 347



GAS BARRIER HOSE

Entran 3 features chemical resistant Hypalon cover, aramid or rayon reinforced epdm tube, EVOH barrier. Now available in six sizes, 6.35mm (.25") to 25.4mm (1.00") ID. Tel: 800-255-1996. Free evaluation samples. Widely used in hydronic radiant heating.

Heatway

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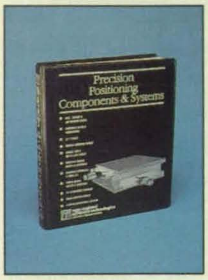

POSITIONING/ MOTION CONTROL CATALOG

NEW, detailed 160 page catalog covers NEAT's expanding line of precision positioning and motion control components and systems. Featured are single axis, X-Y, multi-axis, rotary, high vacuum, air bearing, and microscope stages. NEAT also provides a complementary line of stepping and servometer drives and controls. NEAT specializes in providing modified, custom, and turnkey SOLUTIONS to a wide range of positioning and motion control applications. Please contact our Sales Engineers at 800-227-1066, or send E-mail to neat@tiac.net for more information.

New England Affiliated Technologies

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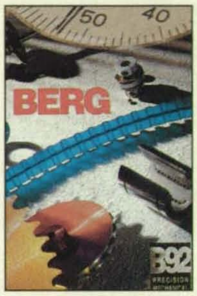

B92 CATALOG RELEASE

The latest catalog from W.M. Berg, Inc., coincides with Berg's silver anniversary. Founded in 1967, Berg has grown to become a recognized industrial leader of miniature precision mechanical components. A significant number of new items are added as well as expanding previous product lines. Featuring 50,000 standard components, 80% of which we are able to ship from stock within 24 hours. Available in metric version too: M92. Tel: 516-596-1700; Fax: 516-599-3274.

W.M. Berg

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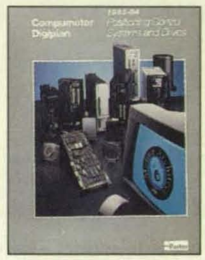

NEW COMPUMOTOR CATALOG! POSITIONING CONTROL SYSTEMS & DRIVES

Compumotor's complete 360 page engineer's guide with specifications, dimensions and performance data presents brushless servos, microstepping motor systems, indexers, linear motors and absolute encoders. Tel: 800-358-9070; Fax: 707-584-8015.

Parker Hannifin Corporation,
Compumotor Division

For More Information Write In No. 351

STATICIDE SOLVES STATIC CONTROL PROBLEMS

STATICIDE, a highly effective topical method for controlling static electricity, is designed for commercial and industrial uses. Available in concentrate, general purpose and heavy duty formulas for long-term static control applications. STATICIDE is non-toxic, non-flammable, non-staining, completely biodegradable and safe for all surfaces. Tel: 312-441-9500.

ACL Incorporated

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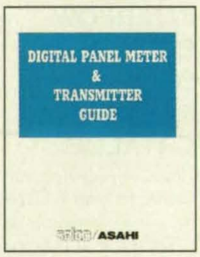

DIGITAL PANEL METER & TRANSMITTER GUIDE

New 8-page product guide summarizes Selco-Asahi's digital instrument line: DC and AC voltmeters and ammeters, process monitors, setpoint comparators, counters, tachometers, frequency meters, strain gauge meters, thermometers, remote monitors, transmitters, modular DPM and DC power supplies. Over 80 models with information on size, number of digits, and measurement setups. Tel: 714-521-8673, 800-229-2332; Fax: 714-739-1507.

Selco/Asahi

For More Information Write In No. 353

ELECTROMAGNETIC DESIGN SOFTWARE

The legendary Vector Fields suite of software, including the TOSCA, ELEKTRA and OPERA packages, combines classical finite element techniques with user friendly interactive graphics for high accuracy 2D and 3D simulation and design of all types of electromagnetic equipment.

Vector Fields Inc.
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For More Information Write In No. 354

SIMPLIFIED REAL-TIME NETWORK APPROACH

The SCRAMNet™ Network, a real-time communications system based on a replicated shared-memory concept, is optimized for the high-speed transfer of data among computers. Call for this FREE brochure. SYSTRAN Corp.; Sales Phone: 800-252-5601; Phone: 800-252-5601; Fax: 513-258-2729; E-mail: info@systran.com.

SYSTRAN Corp.

For More Information Write In No. 355

NOISE CONTROL PRODUCTS

New full-line color brochure describes world-leading SONEX and SONEX 1 acoustical treatments. Anechoic shapes provide 400% greater surface area, absorbing sound and eliminating excess noise better than other materials. The brochure highlights new products added to the SONEX line, basic applications, forms, and specifications of SONEX products for effective noise control and acoustic improvements. Tel: 800-662-0032 or 612-520-3620.

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Call For Papers

TECHNOLOGY 2005

October 24-26, 1995

McCormick Place, Chicago

Technology 2005, the world's largest technology transfer conference and exposition, offers a unique forum to present new inventions and innovations to America's top technology managers. Over 5000 corporate executives, project leaders, engineers, and entrepreneurs are expected to attend this NASA-sponsored event, to discover advances they can use in developing products, solving engineering problems, and improving their manufacturing/production processes.

Paper abstracts are invited in two areas:

1. Leading-Edge Inventions

Papers should focus on the novelty and commercial potential of technologies available for private sector use in the following categories:

Advanced Manufacturing
Computers & Communications
Environmental Technology
Materials Science
Medical Technology
Microelectronics
Power & Energy
Sensors/Instrumentation
Transportation
Virtual Reality

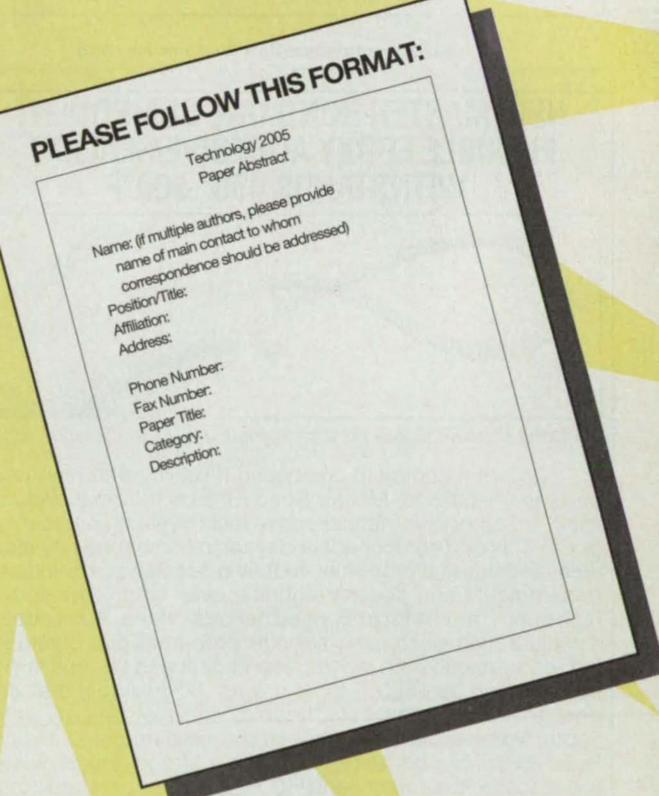
2. Success Stories

Papers should describe successful government-industry partnerships and technology transfers resulting from CRADAs, licensing agreements, SBIR, and other mechanisms, highlighting any marketing or program innovations and lessons learned.

Deadline For Submissions

Paper abstracts (1-1/2 pages long) must be submitted to the Program Chairman no later than May 5, 1995. An independent panel will judge the abstracts based on technical merit and the potential commercial or industrial impact. All submitters will be notified by June 30. Mail or fax abstracts to:

Technology Utilization Foundation
317 Madison Avenue, Suite 921
New York, NY 10017
Fax: (212) 986-7864



PLEASE FOLLOW THIS FORMAT:

Technology 2005
Paper Abstract

Name: (if multiple authors, please provide name of main contact to whom correspondence should be addressed)
Position/Title:
Affiliation:
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Phone Number:
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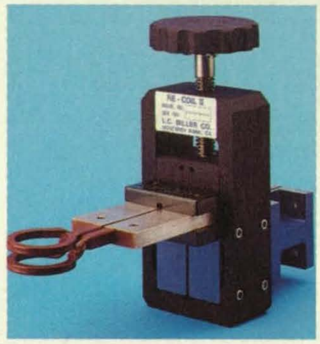
Paper Title:
Category:
Description:

Questions?

Call Wendy Janiel at (212) 490-3999.

New on the Market

Performance Motion Devices Inc., Chelmsford, MA, has announced the MC1401 **motion chipset** incorporating electronic gearing for two axes of servo control. The electronic gear employs a master input axis that drives the servo slave axis at a synchronized velocity rate using a programmable 32-bit gear ratio. The master axis itself can be servo controlled, allowing the user to create tightly coupled multi-axis systems.
For More Information Write In No. 718



Recoil II, a **quick-change coil device** available from L.C. Miller Co., Monterey Park, CA, connects directly to the front of an induction heater and enables rapid change from one work coil to another. The innovative design comprises a robust, single-piece insulating housing, a miniature water-pressure indicator, and self-contained on-off water valves. The valves operate automatically when changing from one work coil to another.
For More Information Write In No. 717

A new family of **brushless servo motors and amplifiers** from Aerotech Inc., Pittsburgh, PA, comprises seven rare-earth models with continuous torque to 90 lb-in in industry-standard NEMA 23, 34, and 42 frame sizes. Conservatively rated to 4000 RPM, the POWERFLEX™ series provide high acceleration capability and power-to-size ratio while the units' skewed laminations eliminate torque ripple to produce smooth low-speed operation.
For More Information Write In No. 707

A high-resolution **scan converter** introduced by PC Video Conversion Corp., San Jose, CA, converts screen resolutions up to 1280x1024, 90 Hz, non-interlaced, 24-bit color to broadcast quality composite, Y/C, and component video signals. The new HyperConverter1280 is available as an ISA-compatible board for PCs or an external desktop with cross-platform capability.
For More Information Write In No. 719

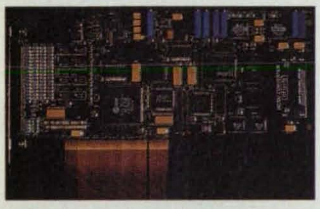
The IMPULSE ENGINE line of **force feedback computer peripherals** from Immersion Corp., Santa Clara, CA, realistically simulates the virtual sensations of solids, liquids, surfaces, and textures. The line includes one, two, and three degree-of-freedom units for tracking motion and manipulating objects in virtual worlds, as well as a five degree-of-freedom device for laparoscopy and endoscopy.
For More Information Write In No. 712

The G-Series of **Coriolis mass flowmeters** introduced by Krohne America, Peabody, MA, feature simple straight-through measuring tubes to eliminate the bellows, brazing, and bends that cause flow obstructions. The meters feature high corrosion resistance, low pressure drop, built-in secondary containment, and 0.15% of rate accuracy. They are suitable for high-viscosity liquids, liquids entrained with solids or air, fibers, and slurries.
For More Information Write In No. 711

Aptech System Inc., Maple Valley, WA, has released *Constrained Maximum Likelihood*, **software for statistical inference in constrained and unconstrained models**. The program solves general maximum likelihood problems by incorporating linear and nonlinear as well as equality and inequality constraints on parameters, and is the first to permit the correct confidence limits to be computed for constrained models.
For More Information Write In No. 700

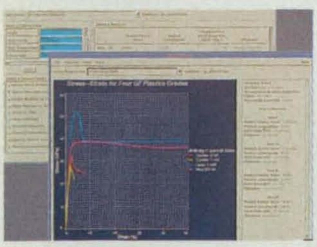
New on the Market

The industry's first **data acquisition boards for the Peripheral Component Interconnect (PCI) bus** have been unveiled by Data Translation, Marlboro, MA. The three PCI-EZ™ series multifunction boards offer a choice of analog inputs to 64 channels, single channel performance to 330,000 samples/sec., or 100,000 samples/sec. scan. All are true Microsoft Windows'95 Plug 'N Play and run any DT-Open Layers software, such as DT VEE.
For More Information Write In No. 713



InvisiLink™ **telecommunication software** from DSP Software Engineering Inc., Bedford, MA, creates a transparent, low bit rate, digital connection between two analog interfaces. Available as an integrated card solution or a portable software package, InvisiLink cards simultaneously accept PCM samples and a digital bit stream, and automatically compress, decompress, and pass signaling, voice, model, and fax.
For More Information Write In No. 702

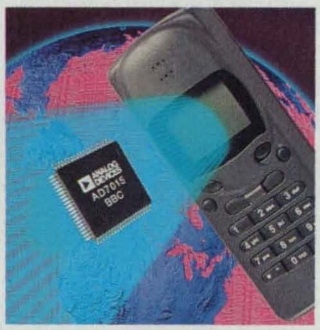
General Electric Plastics and The MacNeal-Schwendler Corp., Los Angeles, CA, have released a **databank of plastics technical information** detailing more than 140 grades of plastic available in the US and Europe. The MSC/MVISION GE Plastics Databank will be updated quarterly with an emphasis on enhancements facilitating structural and thermal analysis of plastic components.
For More Information Write In No. 720



Cray Research Inc., Eagan, MN, has launched the industry's first wireless **supercomputers**, the T90 series. Available with one to 32 CPUs, the T90 provides up to 60 billion calculations per second of peak computer power. Offering a three- to five-fold price/performance improvement over Cray's C90 line, the new series features innovative connectors that eliminate all internal wires.
For More Information Write In No. 705

NeuralWare Inc., Pittsburgh, PA, has released NeuralWorks Predict 1.0, software that enables end-users to develop sophisticated **neural network solutions** in minutes. Predict integrates and automates all of the steps necessary to build effective nonlinear models. Once a model has been developed, Predict provides facilities for testing it, running it within Microsoft Excel, and deploying it as a C, Visual Basic, or FORTRAN program.
For More Information Write In No. 709

Analog Devices Inc., Norwood, MA, has introduced the first 3-V **integrated circuit for GSM (Global Standard for Mobile communications) handsets** that integrates all the mixed-signal components required for complex signal conversion and processing. The AD7015 includes eleven converters, with digital filters, a modulator, amplifiers, multiplexers, references, and logic.
For More Information Write In No. 710



The DLD-55 **pulsed laser diode driver** from Directed Energy Inc., Fort Collins, CO, provides fast high-current pulses in rangefinder, lidar, pulsed Doppler, and other applications. It delivers current pulses in amplitudes ranging from <1 A to 100 A, with rise times ≤20 nanoseconds. The driver's patented high-power MOSFET technology allows an output pulse repetition frequency from single shot to 500 kHz, and a pulse width from <25 nanoseconds to 15 microseconds.
For More Information Write In No. 701

New on the Market

The 1000 series of two- and three-way solenoid **valves for fluid control devices** from Mead Fluid Dynamics, Chicago, IL, features the patented Isonic®"half-shell" design, which facilitates the use of drop-in inserts and integral quick-connect tube fittings. In the new design, the valve body is split down its centerline to produce two mirror-image halves, providing total access to all internal galleries and allowing flow channels to be aerodynamically shaped for maximum air flow and minimum internal friction.

For More Information Write In No. 704

Phar Lap® Software Inc., Cambridge, MA, has released the TNT Embedded ToolSuite™ for **32-bit embedded systems development** on the Intel 386/486 family of microprocessors. Supported DOS and Windows compilers include 32-bit C/C++ compilers from Borland, Microsoft, and MetaWare. The tool suite's components include the Visual System Builder, the LinkLoc 32-bit linker/locator, CVEMB and TDEMB shells for embedded cross-debugging, full support for C/C++ run-time libraries, and a floating point emulation library.

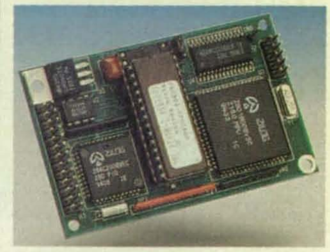
For More Information Write In No. 706

Expert Graphics Inc., Atlanta, GA, has announced three **imaging software** packages designed for mapping professionals and the Geographical Information Systems market: RxAutoImage for Windows™, RxSpotlight for Windows™, and RxVectory for Windows™. Developed by Rasterex, the programs address a range of imaging applications, including scanned map editing, image rectification, and automatic conversion to vector.

For More Information Write In No. 708

Smaller than a credit card, the Micro Genius™ from Z-World Engineering, Davis, CA, is a compact and powerful **C-programmable controller**. The device features 14 lines of individually-configurable I/O, an RS232 serial port, 32K of SRAM, up to 512K EPROM or 256K flash EPROM, power supply, and one analog input channel. It can accommodate a 20,000 line C program including multitasking.

For More Information Write In No. 715



Deister Electronics USA Inc., Manassas, VA, has introduced the Minireader, a hardware package that enables electronic engineers to incorporate **radio frequency proximity technology** into applied automatic identification designs. Featuring the only commercially-available ASIC reader chip, the Minireader identifies objects at distances up to several inches and is available as a chipset or as a fully integrated proximity reader.

For More Information Write In No. 716

The MEPTS-9000 **transducer measurement system** from Techkor Instrumentation, State College, PA, combines measurements for pressure, vibration, force, and temperature in a single 19" rack unit. Users can configure the unit to take combinations of up to 20 simultaneous measurements. It operates most commercially available transducers with low noise, low temperature drift, and accuracies to 0.1%.

For More Information Write In No. 714

The O-Scope I from Allison Technology Corp., Houston, TX, is a low-cost **digital storage oscilloscope** that connects to IBM PC/AT-compatible computers via the printer port. Priced at $190, it features input ranges from 50 mV to 10 V per division and sweep rates from 500 µS to 100 S. A spectrum analyzer display mode provides graphic frequency content of the input signal.

For More Information Write In No. 703

New Literature

An **electronics test accessories** catalog from E-Z-Hook, Arcadia, CA, offers more than 12,000 solutions to common testing, hook-up, and assembly applications. Highlighted products include DIP testing accessories, continuity and voltage testers, multilead assemblies, test leads, wire/cable, jumpers, probes, patch cords, components, adapters, and type N, TNC, BNC, and SMA/UHF coaxial test accessories.
For More Information Write In No. 725

An **instrumentation design** guide from CALEX Mfg. Co., Concord, CA, spotlights modular load cell and strain gage signal conditioners, DC isolated transmitters, constant current sources, alarms, and DC differential amplifiers. It also describes DC/DC converters and linear power supplies for powering instrumentation modules. Application notes include information on popular grounding and shielding techniques and transmitter EMI reduction.
For More Information Write In No. 724

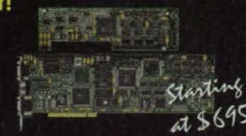
The benefits of **electric resistance preheating** for minimizing fabrication-related cracking and distortion are explained in a brochure from Cooperheat, Piscataway, NJ. It reports that controlled preheating reduces the cooling rate of welds so that thermal stresses are redistributed, hydrogen diffusion increases, and moisture is driven off to remove the vapor that causes porosity.
For More Information Write In No. 722

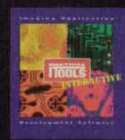
An eight-page brochure from LNP Engineering Plastics, Exton, PA, describes how to prevent dimensional inaccuracies in **injection molded plastic gears**—which can result in gears that are noisy, wear rapidly, and fail prematurely. According to LNP, the proper combination of filler/reinforcement system, mold design, process variations, and base resin can produce highly accurate gears that cost less to manufacture.
For More Information Write In No. 723

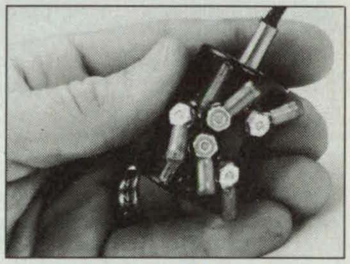
Tech-Etch Inc., Plymouth, MA, has released a 20-page catalog of **EMI shielding products** for doors, panels, covers, connectors, computers, electronic enclosures, and cabinets. A variety of shielding includes knitted mesh, thin sheet and strip gaskets, filters, and honeycomb vents. Featured products are wire mesh with or without an elastomer core, and Silvershield, composed of silver-plated nylon thread with a strand of monel wire knitted over a polyurethane core.
For More Information Write In No. 727

DoAll Co., Des Plaines, IL, has released a catalog describing its **cutting fluids**, tool lubricants, cleaners and other metalworking compounds. The publication details the fluids' properties as well as providing guidelines to their use in various machining applications. Available formulations include heavy and light duty synthetic cutting fluids, soluble oils, and mist lubricants.
For More Information Write In No. 721

The Wilson Composites Group Inc., Folson, CA, has published its updated **composites and plastics industry resources** directory. Available in printed form and on computer disk, the directory features new sections on international companies and government agencies.
For More Information Write In No. 726







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Tech Transfer Events

Army Research Laboratory (ARL) Materials Directorate has developed several ferroelectric composite ceramics for application in phased array antennas and other devices. These materials have electronic properties which can potentially revolutionize the communications industry. Patent licensing and Cooperative Research and Development Agreements (CRADAs) are available for these materials in bulk, thick and thin film forms.

Contact: Mr. Thomas Gilroy
ARL-MD
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