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April 1994 Vol.18 No.4

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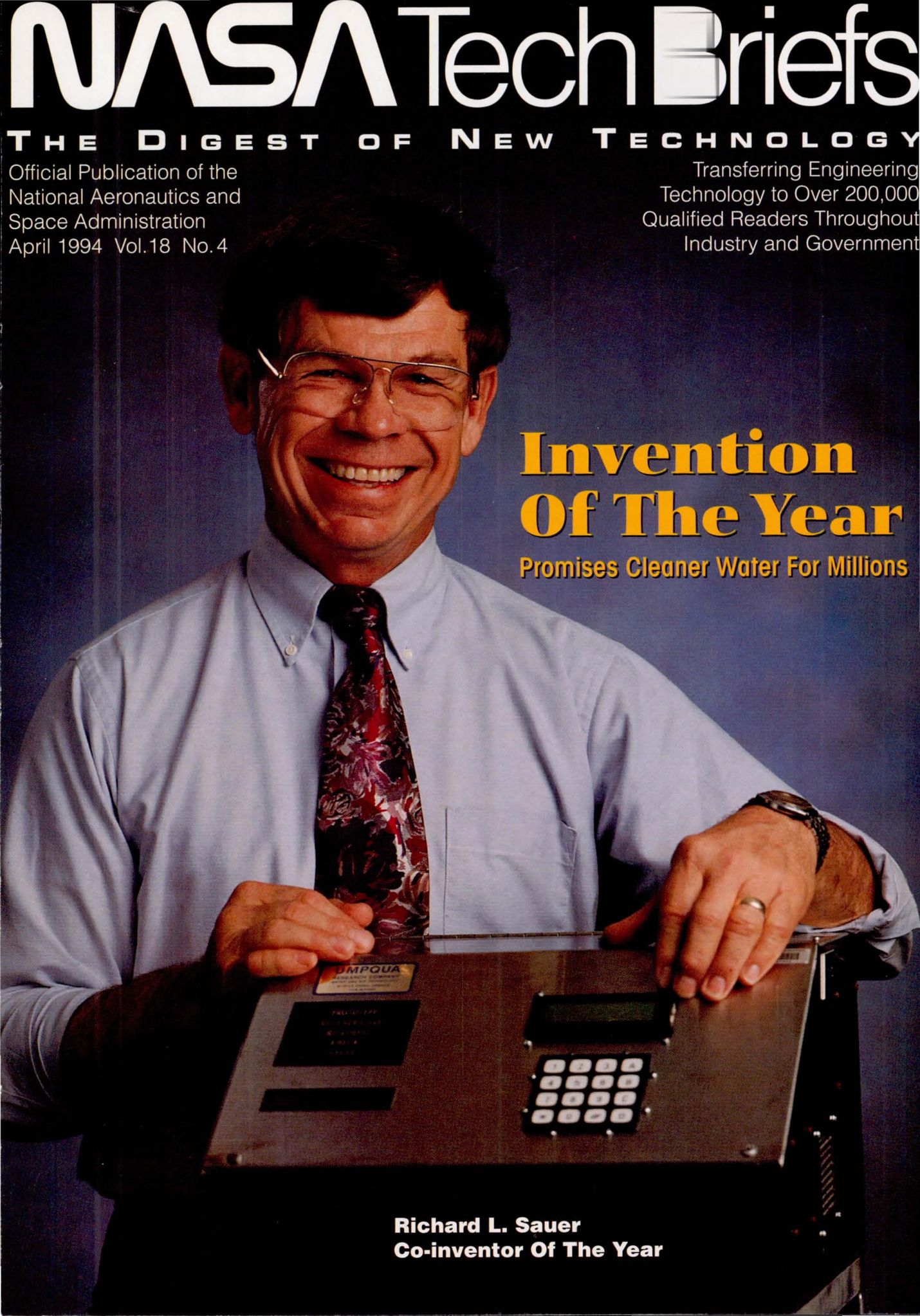

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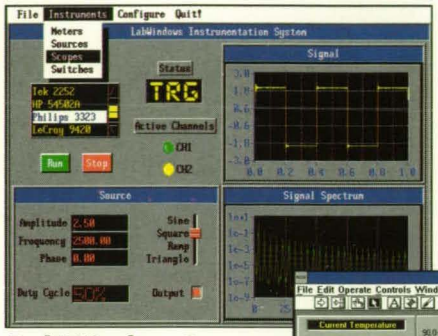

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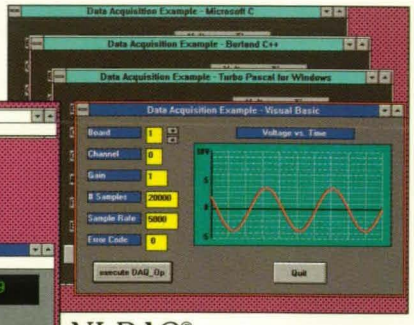

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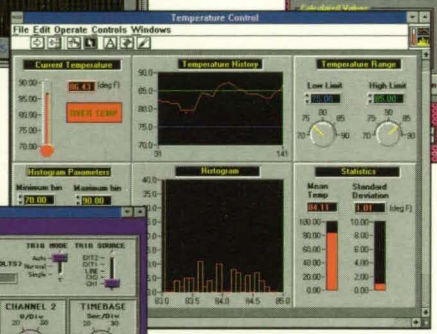

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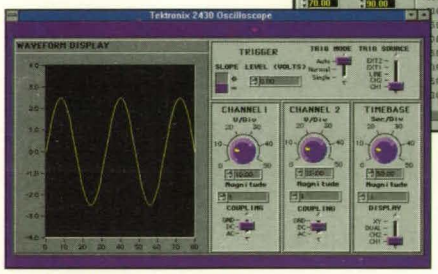
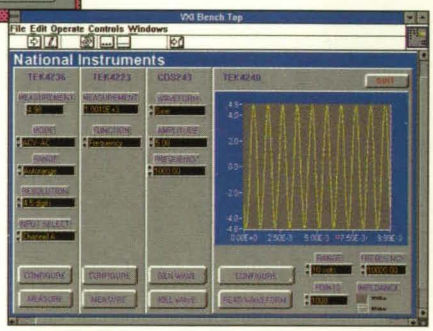


LabWindows/CVI



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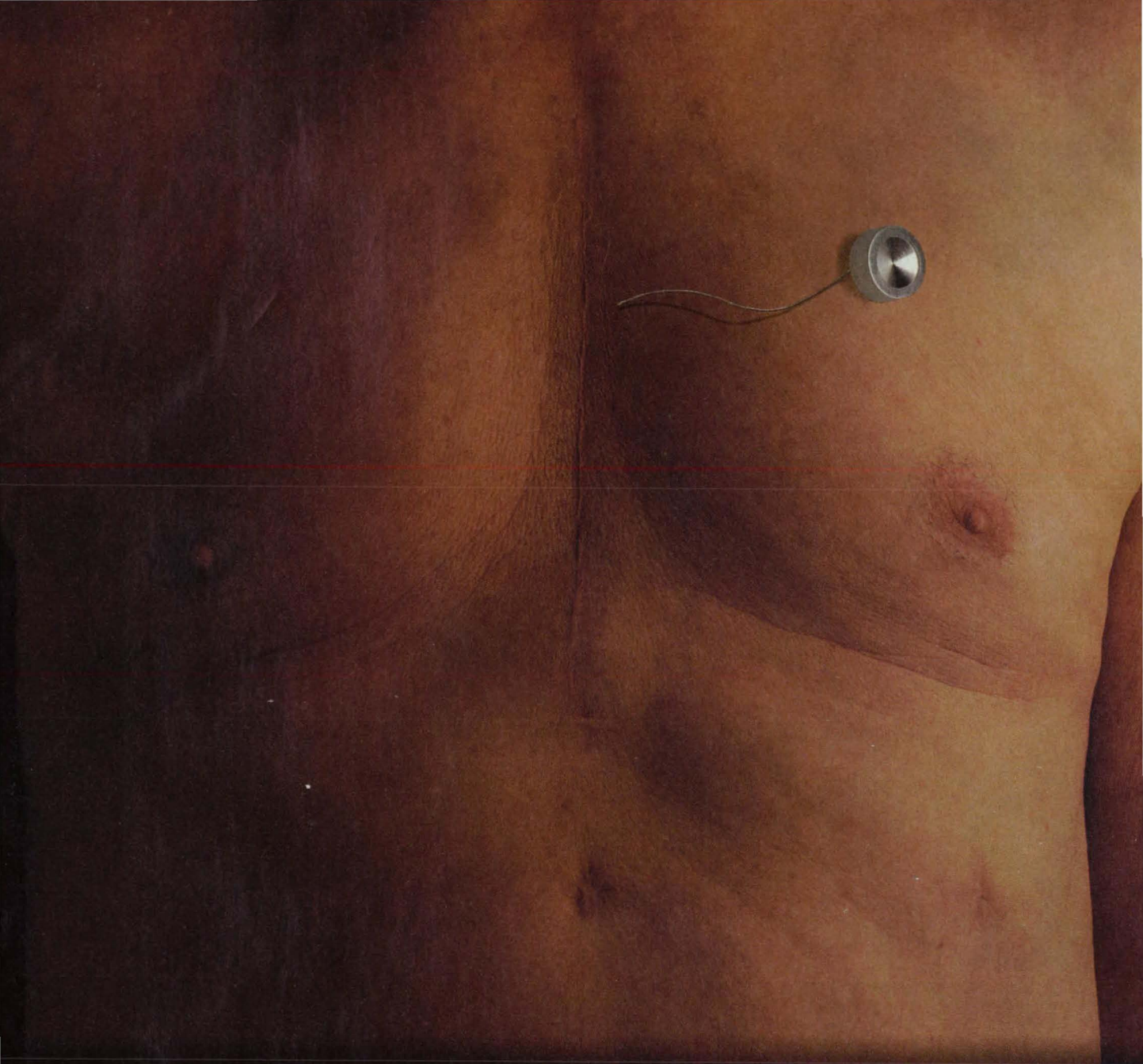

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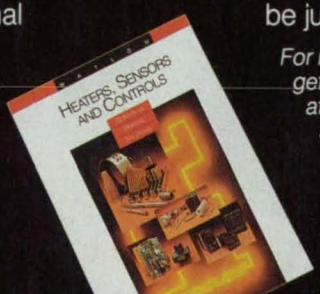

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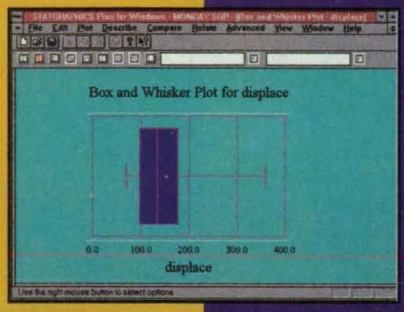

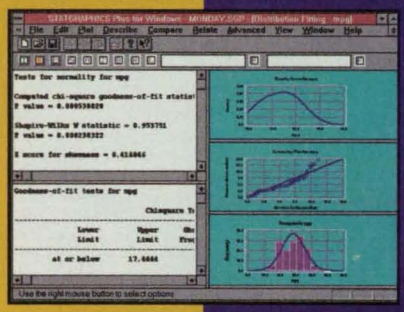

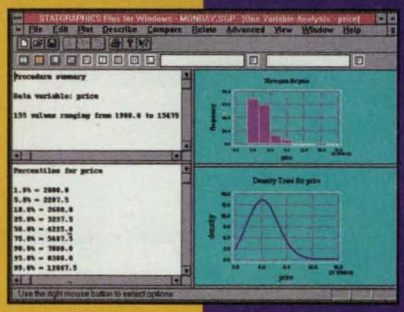

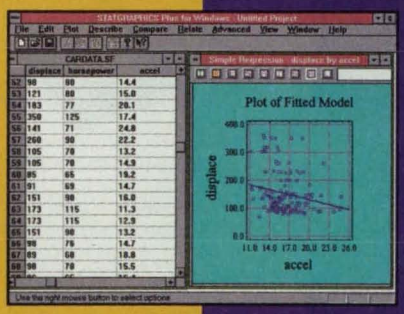

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Mathematica

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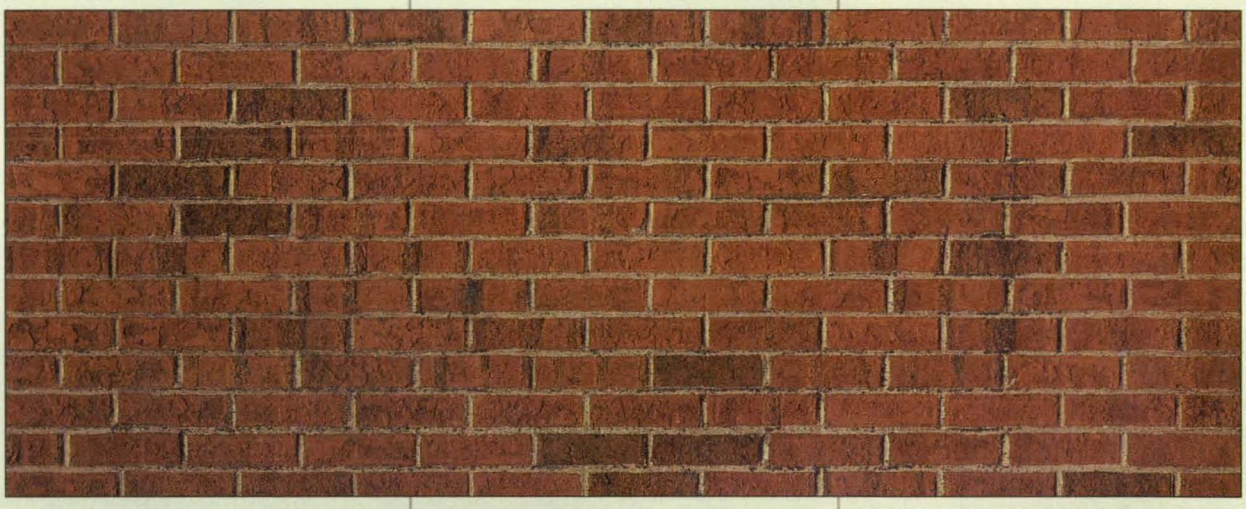
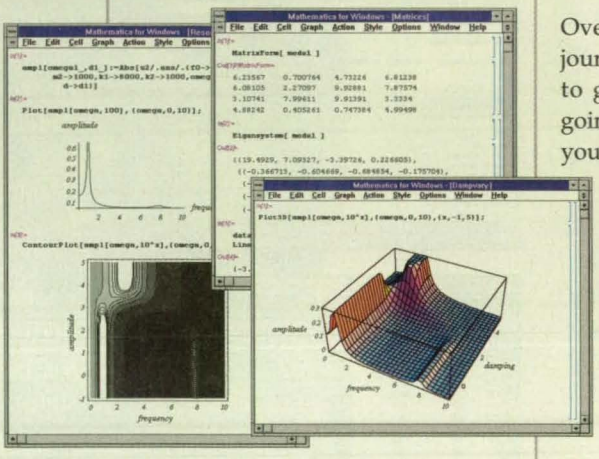
RUNNING INTO A WALL WITH YOUR OTHER SOFTWARE?



Engineers and scientists with other technical software can do fine...within certain boundaries. But try to find something useful, such as the FFT of an array whose size is not a power of two, or compute the value of a Bessel function with complex arguments, and you hit a wall. With *Mathematica*, common obstacles like these don't stop you in your tracks.



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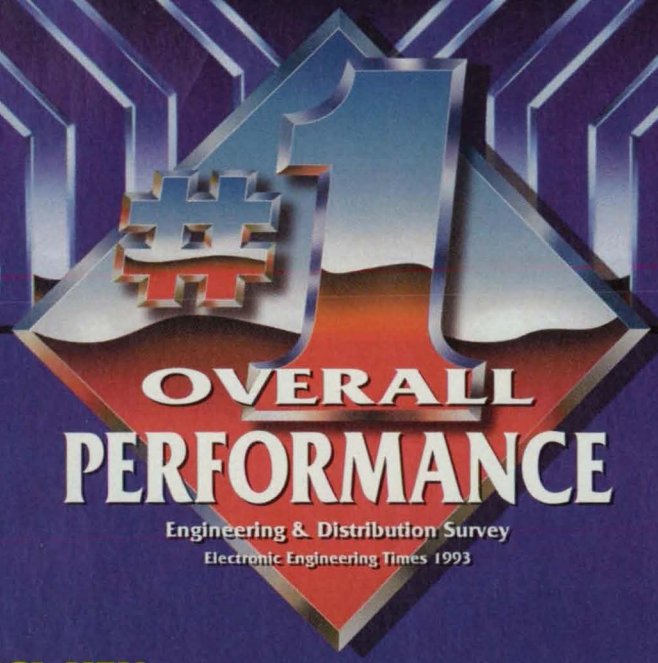

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April 1994
Volume 18 Number 4

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TECHNICAL SECTION

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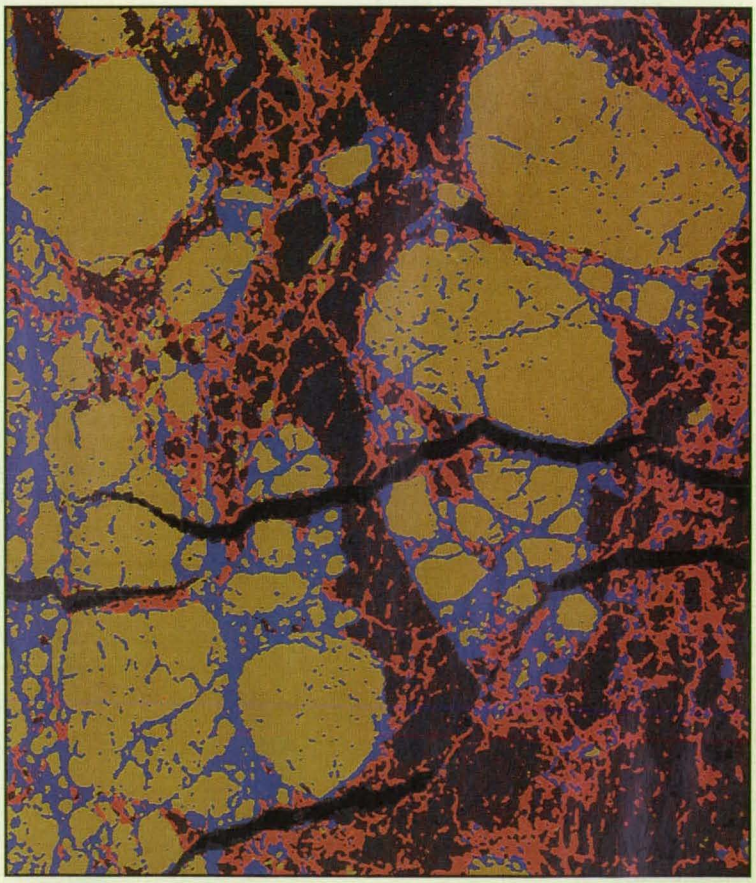

Scientists at the Jet Propulsion Laboratory have devised a set of mathematical models and algorithms to segment multifrequency complex-amplitude synthetic-aperture-radar (SAR) images. Each type of terrain captured in the image—such as forest, farmland, or water—is assigned a different color. The above SAR image of sea-ice has been classified by ice type—first-year ridges are colored red, deformed first-year ice is light blue, and aged ice flows are yellow. See the tech brief on page 52.

Photo courtesy the Jet Propulsion Laboratory

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Contents *(continued)*

DEPARTMENTS

On the cover:

NASA's Invention of the Year is a regenerable biocide delivery unit developed at Johnson Space Center for long-term space missions. Pictured with Richard Sauer, Johnson deputy branch chief and co-inventor with contractor personnel Gerald Colombo and Clifford Jolly, the unit employs a regenerable iodinated resin bed that greatly extends its life. Ideal for use in emergency situations and remote locations, the invention holds promise for developing countries as an inexpensive and portable source of potable water. *See the story on page 14.*

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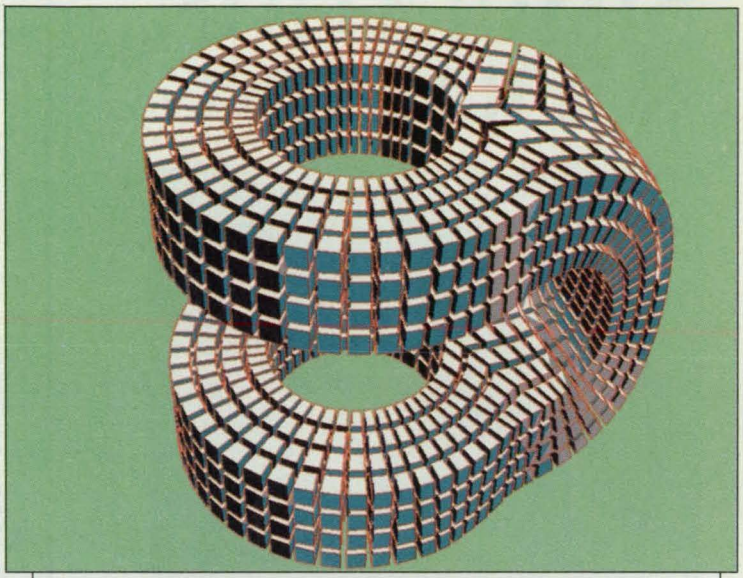

A simple mouse click created this solid, 8-node "brick" element model from a pre-defined surface mesh (paving) using Algor's proprietary surface to volume method.

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The Apple Report On PowerPC

Number 3 – Power Macintosh for Technical Users

If you use applications that do floating-point mathematical calculations, your performance levels could be up to ten times faster than those of the same program running on a 68040 machine—and several times faster than the fastest Pentium system–based computers.

The PowerPC chip is the first workstation-level microprocessor ever introduced in a mainstream personal computer. In fact, many workstation developers are now writing applications for Power Macintosh computers.

A Power Macintosh offers unprecedented compatibility between Macintosh, MS-DOS and Windows environments, thanks to an emulation program called SoftWindows, which licenses actual Windows code from Microsoft.

If you buy a 68040-based Macintosh today, can you upgrade it tomorrow? In a word, yes. Just look for the "Ready for PowerPC upgrade" sticker on the box.

For more information about Power Macintosh computers for technical users, give us a call at 1-800-732-3131, ext. 350. In Canada, call 1-800-665-2775, ext. 910.

Power Macintosh™ computers are here. Apple's new generation of Macintosh® computers are powered by the PowerPC™ microprocessor, a chip developed jointly by Apple, IBM and Motorola.

Accelerated for Macintosh with PowerPC™

With these Macintosh computers, you can expect to see speed and functionality increase dramatically, while prices remain the same – or even drop. And if you're an engineer, architect or other power user working with large, complex files, you can also expect to see significant increases in productivity.

For the first time, a personal computer can offer you the kind of power that was previously available only in high-performance, high-cost workstations.

More compatible personal computers.

Of course, a Power Macintosh is still a Mac,® so it's compatible with your present Macintosh computers, peripherals, software and files. You can also run most current DOS and Windows programs, thanks to a program called SoftWindows, which licenses Windows code from Microsoft.*

The real benefit of Power Macintosh computers, however, will be seen with new applications optimized to take advantage of the chip's advanced capabilities.

Developers move to Power Macintosh.

Applications optimized for the new Power Macintosh computers, often called native applications, will offer two to four times the performance – and in the case of some programs that perform floating-point mathematical calculations, ten times the performance – of programs available for the fastest Macintosh computers today.

Right now, the world's leading developers are updating their most popular programs to take full advantage of Power Macintosh computers *(see box)*. In fact, Apple has been working closely with more than 200 major third-party developers since 1992 to create new versions of their applications. And hundreds of additional developers have begun the move to PowerPC.

What about software?

A Power Macintosh will run virtually all of your existing Macintosh system–based programs. The real benefit of a Macintosh with PowerPC technology, however, will be with applications optimized to take advantage of the new chip's advanced capabilities. Here are some of the native applications that are available now or will be out in the next few months.

Abacus StatView	*Knowledge Revolution Working Model*
Alias Sketch!	*MacroMedia MacroModel*
Asblar Vellum	*Microsoft Excel*
auto·des·sys form·Z	*Microsoft Word*
Electric Image ElectricImage Animation System	*National Instruments LabView & HiQ*
GraphiSoft ArchiCAD	*Specular Infini-D*
Graphsoft MiniCad	*Strata StudioPro*
Gryphon Morph	*VIDI Presenter Professional*
Imagine That! Extend	*Virtus WalkThrough*
Insignia Solutions SoftWindows	*Wolfram Research Mathematica*
ITEDO IsoDraw	

Get more done, faster.

There are immediate benefits to running native applications on a Power Macintosh computer: You spend less time waiting for the computer to complete complex tasks. So you can do more work in less time.

This is especially significant for applications that require a lot of processing power – CAD programs and programs that perform floating-point mathematical calculations, for instance – as well as for larger or more complex files.

Developers will also be exploring new features in areas such as intelligent help, 3-D design, video and animation, speech recognition and text-to-speech conversion. These are functions that simply wouldn't be practical without the superior processing capabilities of the PowerPC chip's RISC-based architecture and innovative Macintosh technology.

Why RISC?

The new generation of Macintosh computers are the first personal computers with RISC (Reduced Instruction Set Computing) chips. RISC chips are smaller and more efficient than comparably powered CISC (Complex Instruction Set Computing) chips, so they cost less to produce.

Which means not only will Power Macintosh computers offer you substantial performance increases, they will do so far more affordably than a CISC-based system can. In other words, they'll provide you with unprecedented power.

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NASA PATENTS

NASA has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Neural Network for Processing Both Spatial and Temporal Data With Time-Based Back Propagation

(US Patent No. 5,253,329)

Inventors: **James Villarreal** and **Robert Shelton**, Johnson Space Center

A novel technique adds the dimension of time to the back-propagation neural network algorithm, hitherto applied successfully to model spatial information. The synaptic weights between two processing elements are replaced with an adaptable-adjustable digital filter. Instead of a single synaptic weight (representing spatial association in the standard back-propagation network), the invention uses a plurality of weights representing both spatial and temporal data.

For More Information Write In No. 700

Method of Forming Silicon Structures With Selectable Optical Characteristics

(US Patent No. 5,273,617)

Inventors: **Robert W. Fathauer** and **Leo Schowalter**, Jet Propulsion Laboratory

JPL researchers have developed a silicon-based technique to make optical components with selected linear and nonlinear characteristics. Molecular beam epitaxy is used to control silicide particle shape and orientation, which allows tailoring of particle matrices to interact better with specific light wavelengths. Devices that could employ wavelength-specific optical layers include optical computing elements, holographic devices, optical correlators and phase conjugators, and bistable memory devices.

For More Information Write In No. 701

Composite Flexible Blanket Insulation

(US Patent No. 5,277,959)

Inventors: **Demetrius Kourtides** and **David Lowe**, Ames Research Center

An improved blanket insulation protects against environments containing conductive, convective, and radiative heating components. The insulation comprises a honeycomb-patterned polyamide radiation shield or spacer, a single-sided aluminized foil radiation shield, and a new interlocked silicon carbide fabric top and bottom. It is well-suited for use in spacecraft, furnace curtains, fire tools and equipment, and wherever temperature capability, insulation efficiency, and light weight are important.

For More Information Write In No. 702

Magnetic Power Piston Fluid Compressor

(US Patent No. 5,275,537)

Inventor: **Max G. Gasser**, Goddard Space Flight Center

Reciprocating, rotary, jet, centrifugal, or axial-flow compressors share one drawback: they contain moving parts such as pistons, valves, or rotating vanes. Mr. Gasser's compressor has no moving parts in the conventional sense. Within its housing are one or more compression stages to increase fluid pressure, each containing magnetic powder supported by a screen that allows passage of the fluid and a coil for selectively activating a magnetic field across the powder. When the field is not present, the powder particles are separated and allow the fluid to flow; when the field is present, the particles pack together, causing the powder to expand, prevent flow, and compress the fluid.

For More Information Write In No. 704

Non-Volatile, Solid-State Bistable Electrical Switch

(US Patent No. 5,278,636)

Inventor: **Roger M. Williams**, Jet Propulsion Laboratory

Mr. Williams has devised a two-terminal solid-state memory switch that may be written on, read, and erased by applying voltages of varying magnitudes and opposite polarities. The switch's novel structure employs a thermal phase transition to control ion conduction to or from an electrically intercalatable material. The switch can be applied to both ordinary computers and neural network computers with characteristics similar to existing RAMs.

For More Information Write In No. 703

Automatic Locking Orthotic Knee Device

(US Patent No. 5,267,950)

Inventor: **Bruce C. Weddendorf**, Marshall Space Flight Center

Conventional automatically-locking strap-on orthotic devices worn by persons recuperating from knee surgery or injuries have two drawbacks: locking can occur only when the knee is fully extended, and disengaging or unlocking the joint is manual. Mr. Weddendorf's device incorporates a tang in clevis joint that automatically locks when weight is applied to it, even when the knee is slightly bent, allowing the joint to rotate freely when unloaded and permitting more freedom of movement to the user. Removing the load automatically unlocks the joint.

For More Information Write In No. 705

Method for Anisotropic Etching in the Manufacture of Semiconductor Devices

(US Patent No. 5,271,800)

Inventors: **Steven L. Koontz** and **Jon B. Cross**, Johnson Space Center

The primary cause of damage to the underlying substrate in semiconductor fabrication with atomic oxygen (AO) plasmas is the incidence of energetic particles such as ions and UV photons from the plasma to the substrate surface. A new method uses a hyperthermal AO beam to obtain highly anisotropic etching with sharp boundaries between etched and mask-protected areas, particularly in photoresist stripping and multilayer lithography applications.

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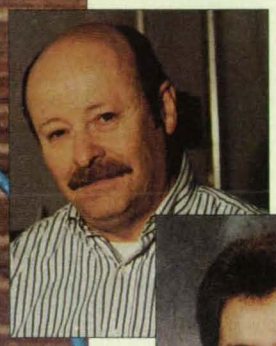
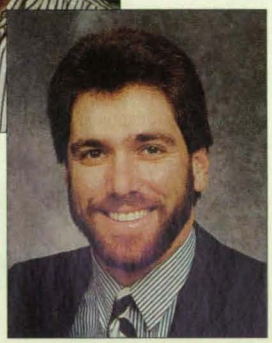
NASA Invention of the Year:

The Regenerable Biocide Delivery Unit





The iodinated resin bed in this portable water treatment device can be regenerated more than a hundred times. Insets: Gerald Colombo (top) and Clifford Jolly (bottom), co-inventors with Richard Sauer (see cover) of the regenerable biocide delivery unit.

Inventors:
Richard L. Sauer,
Gerald V. Colombo,
and Clifford D. Jolly
Johnson Space Center

The need for safe, potable water extends from the remotest village to the deepest submarine and even out into space—to every place a human may live, work, or venture. Securing microbe-free water is now easier and cheaper thanks to a water treatment device originally developed for long-term space missions.

Winner of both the NASA Government Invention of the Year and the NASA Commercial Invention of the Year awards, the regenerable biocide delivery unit developed jointly by Richard Sauer of Johnson Space Center, Gerald Colombo of Umpqua Research Company, and Clifford Jolly of Environmental & Life Support Technology is an extension of technology developed by Umpqua for the space shuttle program in the late 1970s and currently used on the shuttle to purify drinking water.

In this system, water is passed through an anion exchange bed that has been treated with iodine—long recognized as an efficient disinfectant of water. While effective, the method requires periodic replacement of the resin bed once it is depleted of iodine.

The new unit improves on prior methods by regenerating the resin bed *in situ* using small amounts of elemental iodine, and thereby significantly extending its life. The water is disinfected by passing it through an iodinated resin bed, from which it absorbs a minute amount of elemental iodine. Water is periodically diverted to flow past through a bed of iodine crystals to produce a concentrated iodine solution that is used to recharge the resin bed with bound iodine. Recharging is activated by a timer or as the resin bed is depleted, monitoring of which can be accomplished using a UV spectrophotometer.

"It's particularly useful out in the field where you can't have somebody there to monitor microbial control technology and you need something simple and rugged enough for a variety of environments," said co-inventor Clifford Jolly, who directed the fundamental development of the regenerable resins at Umpqua.

Using a regenerable iodine resin bed also eliminates the need for electricity and the dangers associated with using chlorine for water treatment, including overtreatment of the water supply and storage and use of hazardous chlorine gas. The new unit's extended shelf life makes it the ideal emergency back-up system, ready for use during power shortages, droughts, floods, and other natural disasters that can result in a contaminated water supply.

Vector Environmental Technologies has incorporated the regenerable resin beds into water purification units for use in developing countries.

"Tests have shown that you can regenerate a single resin a hundred or more times," said Richard Sauer, deputy branch chief of Johnson's Biomedical Operations and Research Branch.

Umpqua has obtained an exclusive license to commercialize the patented technology. "I expect this is going to be the best way to get clean water to developing countries in a hurry," said Umpqua engineer Gerald Colombo.

Vector Environmental Technologies Inc., Umpqua's first sublicensee has developed water purification units from 2 to 15 gallons-per-minute for community applications.

"Our first major project is with Vietnam," said chief financial officer Douglas Washburn. "We've signed an agreement to provide water purification equipment to support 50-70 million people—an estimated 20,000 units to be rolled out over the next three to five years." The company also is negotiating with Ghana, Indonesia, Uganda, Bangladesh, several southern African nations, the Philippines, and China. Bangladesh is experiencing a severe cholera outbreak that the system could help to alleviate.

"The ability to regenerate the resin bed enables us to reduce the cost to make it practical for developing countries," Washburn said. "Over time, the system can produce water at around one cent per gallon compared to 40 to 50 cents a liter for bottled water."

This is the first year NASA has given a separate award for an invention demonstrating commercial potential. The new award is intended to complement the existing government invention award and the winner will serve as NASA's nominee for the Intellectual Property Owners' Inventor of the Year Award.

1994 AWARD FINALISTS

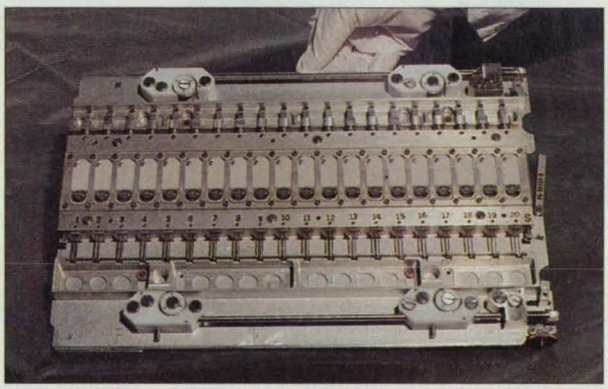
Macromolecular Crystal Growing System

Robert S. Snyder, Blair J. Herren, Daniel C. Carter, Vaughn H. Yost, Charles E. Bugg, Lawrence J. DeLucas, and Fred L. Suddath (dec.)
Marshall Space Flight Center

Recent advances in protein crystallography have significantly reduced the time and labor required to determine the three-dimensional structure of macromolecules once good crystals are obtained. Unfortunately, proteins and other biological macromolecules are notoriously difficult to crystallize.

The microgravity of space, however, has proven fertile "ground" for growing crystals that are both larger and more uniform than those produced on Earth. Away from the planet's gravitational field, there is no density-driven convective flow or sedimentation during crystal growth. The result: better crystals that yield higher resolution x-ray diffraction data for improved structural analysis.

"Not only do many crystals grow significantly better in microgravity but, in some cases, we've seen different structures than ever seen on the ground," said Marshall engineer Vaughn Yost, co-inventor of a crystal-growing system developed by scientists from Marshall, the University of Alabama at Birmingham, and Georgia Tech that has enabled hundreds of crystal growth experiments on space shuttle flights in the last five years.



An automated system grows protein crystals in space for structural analysis.

The apparatus employs a vapor diffusion technique, growing crystals in droplets that are extruded from syringes and combined with precipitating agent solutions within tiny sealed chambers. Three trays of 20 chambers are contained in a refrigeration incubator module that regulates the temperature. A cranking tool manipulates all of the syringes and chamber plugs in a tray simultaneously to control initiation and termination of crystal growth.

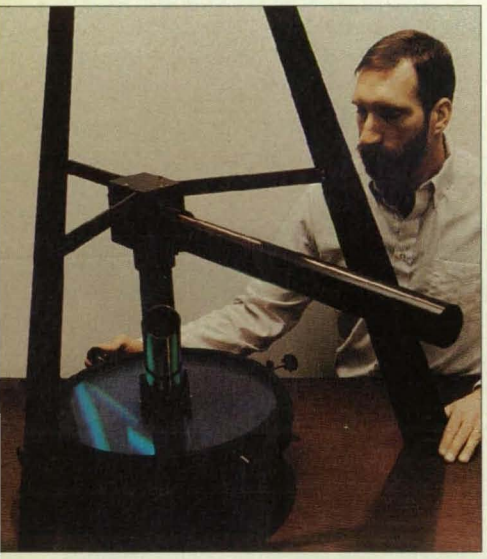
The present system evolved from a handheld protein crystal growth device developed in 1984 that required the astronaut to work each syringe individually. According to Robert Snyder, mission scientist for the International Microgravity Laboratory, automating the device reduced the time required of the astronauts by 95%.

Learning the structure of a protein can provide keys to its biological function and may lead to methods of altering or controlling its function to create new or better drugs. Several pharmaceutical makers, including the Upjohn Company, have performed crystal growth experiments in the apparatus, which is scheduled to fly on five future shuttle missions.

Conically-Scanned Holographic Lidar Telescope

Geary Schwemmer
Goddard Space Flight Center

Proposed spaceborne lidars employing conventional telescope technology in a conical scan pattern would be heavy and costly because their design requires scanning the entire assembly of mirrors, baffles, and detector package, or rotating a separate scanning mirror larger than the primary collection optic. By placing a holographic optical element (HOE) at the heart of the scanning assembly, Schwemmer's invention greatly reduces the rotating mass, an obvious advantage in satellite and airborne applications. Another advantage is that the only moving parts in the scheme are the HOE and its motor.



A holographic optical element replaces the primary mirror in a telescope to greatly reduce its weight for spaceborne lidar applications.

An HOE acts like a lens or curved mirror, diffracting light via a surface relief pattern or a series of refractive index modulations to form images. The HOE is spectrally dispersive, so that in a lidar system it can be wavelength-selective, eliminating or reducing the requirement for a narrow-pass filter.

In the holographic lidar telescope, a flat HOE, rotating like a compact disk on a turntable, replaces the primary mirror in a conventional telescope. It is placed at the center of a series of conical baffles, where its field of view is at a fixed angle with its optical axis. This axis is its rotational axis as well, so that it not only directs the desired laser wavelengths outward from its center but also focuses them as they are reflected by the atmospheric phenomenon of interest. Because the HOE focuses the returning signals onto the fixed rotational axis, the detector and its optics can remain stationary.

Since demonstration of the first prototype last year at Goddard's Photonics Commercialization Workshop, Schwemmer has been managing a research project to extend the instrument to other wavelengths and to multiplex the wavelengths for use in a multi-wavelength system. The Houston Advanced Research Center has built a second model for use in a commercial lidar topographic mapper.

"The telescope could be used in systems to measure wind, water vapor, clouds, temperature, pressure, ozone—all the things we measure with lasers now," said Schwemmer, who is preparing now to use it for ground-based atmospheric aerosol measurements.

Method of Fabricating a Rocket Engine Combustion Chamber

Richard R. Holmes, Timothy N. McKechnie, Christopher A. Power, Ronald L. Daniel, Jr., and Robert M. Saxelby
Marshall Space Flight Center

A new technique that dramatically reduces the labor, cost, and risks associated with the fabrication of the space shuttle combustion chambers may help pave the way for future generations of high-performance aircraft engines. The technique employs the latest advances in vacuum plasma spray and casting technologies to address several problems with the conventional method.

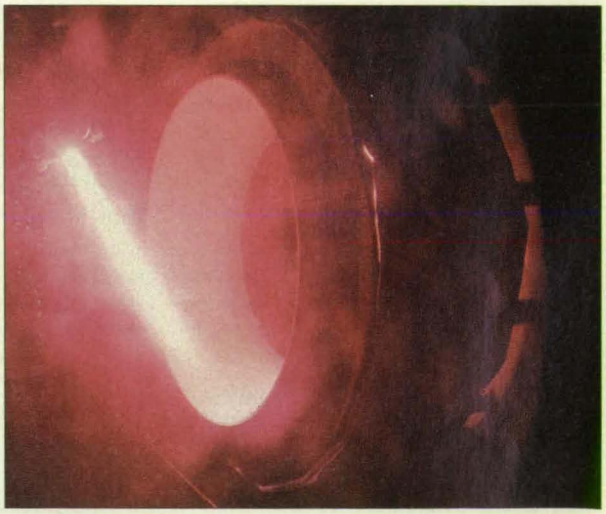
Currently, the combustion chambers are made by casting a liner and then forging it into the desired hourglass shape. Cooling channels are cut into the outer surface of the liner and filled with wax. Next, a thin layer of copper and then a thicker layer of nickel are electrodeposited over the liner's surface. Finally, the wax is removed, an alloy support jacket is fitted around the liner, and the entire assembly is welded together.

The procedure is fraught with difficulty: electrodeposition of copper and nickel is extremely time-consuming, copper tends to debond, extensive welding is required, and, most importantly, the welds on the backside cannot be inspected. These blind welds are classified as Criticality 1 welds because the failure of one could result in a catastrophic failure of the shuttle during liftoff.

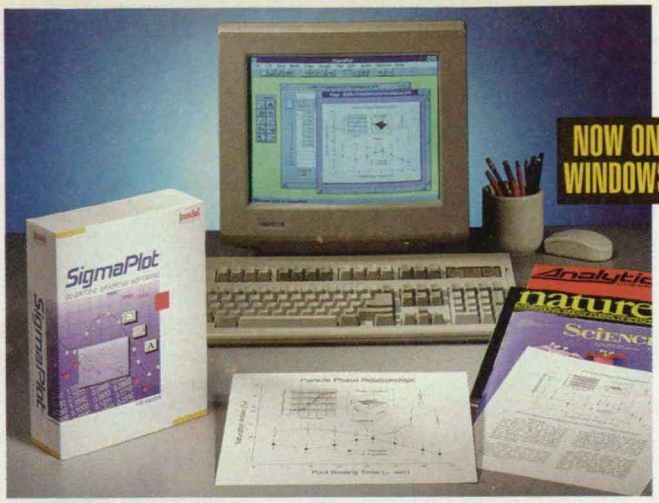
The new procedure starts not with a spun cast liner but with a one-piece structural JBK-75 jacket casting. This casting already has the necessary manifolds and attachment ears built into it, eliminating many welds from the start. A structural alloy liner is applied to the inside of the casting using a vacuum plasma spray technique; a powder of the copper alloy NARloy-Z is injected into a plasma stream, where it is heated to a semimolten state and accelerated toward the casting's inside to bond with the inner wall. After a layer of alloy is formed, slots for cooling fluid are cut into the layer and filled temporarily with a mild stainless steel. Then another layer of particles is deposited and, finally, the temporary filler is removed.

Compared with the conventional method of manufacturing combustion chambers, the process saves 15,000 man-hours and reduces manufacturing time from three years to six months. This results in a costs savings of $3 million per chamber, of which each space shuttle has three.

Marshall's vacuum plasma spray facility already is equipped to spray space shuttle-sized combustion chambers. "We expect it to be used in any advanced engines built to replace the



Vacuum plasma spray technology cuts the cost of manufacturing rockets engine combustion chambers by $3 million.



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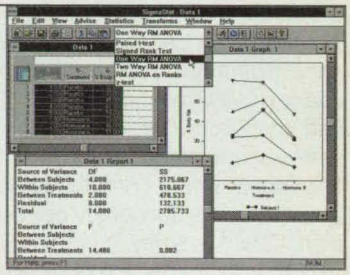

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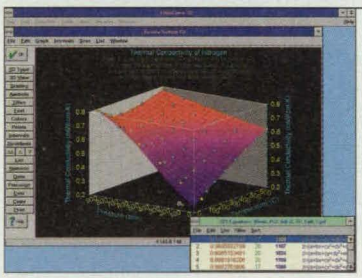

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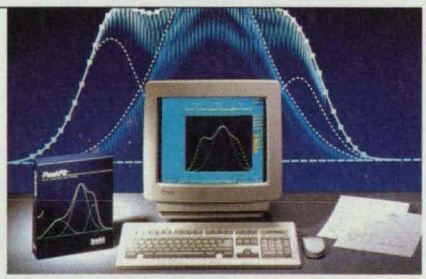

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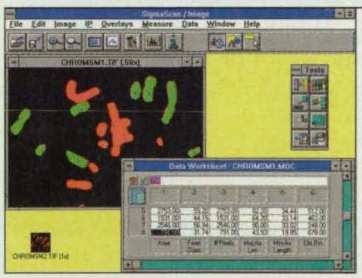

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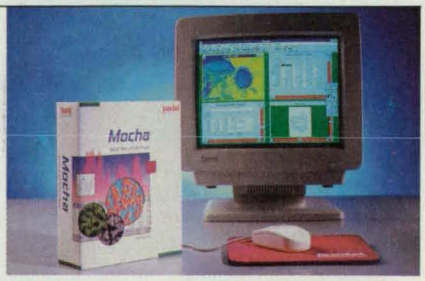

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*Image courtesy of Drs. Marder & Morgan, Radiobiology Laboratory, UC San Francisco. Windows is a trademark of Microsoft Corp.

existing fleet," said Richard Holmes, a materials engineer in the Space Systems Chief Engineers Office. "Variations eventually will be used for lightweight engines for jet aircraft."

Driven Shielding Capacitive Proximity Sensor

John M. Vranish and Robert L. McConnell
Goddard Space Flight Center

Robotic manufacturing and security applications on Earth can get a boost in precision and sensitivity from the "Capaciflector," a capacitive proximity sensor originally developed to prevent space robots from colliding with humans and spaceborne structures. Simple, versatile, and inexpensive to manufacture, the sensor offers unmatched accuracy and the ability to detect objects more than 12 inches away.

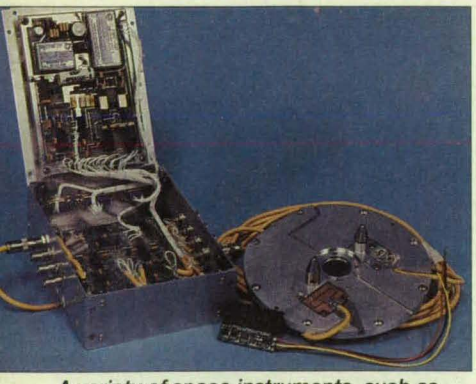
The invention is a robotic arm proximity sensing skin made of a capacitive sensing element and backed by a reflector driven at the same voltage as, and in phase with, the sensing element. Its exceptional range and sensitivity stem from an ability to reflect electric field lines of the sensor capacitor away from the grounded robot arm toward an oncoming object. "We can pack several sensors in immediate proximity to each other without crosstalk, which takes them to new dimensions in capabilities," said co-inventor and Goddard electronics engineer John Vranish.

In addition to the devices' utility for collision avoidance, circuitry modifications now allow them to be used for precision assembly. Sensors have been embedded in robot grippers and power tools as well as screw tips that can be driven into holes at clearances of three thousandths of an inch without contact. Such an ultra-soft touch is immensely valuable in space assembly, where the slightest contact by the robot may send an object careening away.

By virtue of this new precision, Johnson Space Center engineers have begun building Capaciflectors for future use in space station assembly and maintenance. The sensors also have been installed in Goddard's Robot-Operated Materials Processing System (ROMPS) robot, designed to anneal materials in space. ROMPS is scheduled for launch later this year.

Computer Application Systems, Signal Mountain, TN, markets the units for several commercial uses, including automotive safety, heavy machinery safety and closed-loop control, and robotic obstacle detection.

Vranish envisions a wide range of other spinoffs for the Capaciflector, such as automated maintenance and welding, mechatronic control of magnetically-powered devices, and semiconductor inspection. They could be attached to paintings in art galleries to detect tampering or theft; incorporated into safes and cash boxes or doors and windows of private homes for burglary prevention; embedded into machinery to issue warnings or shut down if people get dangerously close; or used to open and close elevator doors.



A variety of space instruments, such as this spaceborne materials processing system, employ an innovative capacitive proximity sensor for collision avoidance and high-precision assembly.

Method and Apparatus for Characterizing Reflected Ultrasonic Pulses

William T. Yost and John H. Cantrell, Jr.
Langley Research Center

Physicians now have a noninvasive means to accurately diagnose the more than two million burns suffered by Americans each year. Created at Langley Research Center, the burn analyzer employs ultrasonic technology originally developed to detect microscopic flaws in aerospace materials. The unit also has potential for use in skin pathology, locating precancerous and cancerous lesions, and diagnosing breast cancer.

The technology got its start in 1982 when William Yost and John Cantrell, senior research physicists at Langley, performed ultrasound testing on skin collagen. The denaturization of collagen caused by burns—whether from flames, scalding, or chemicals—alters the tissue's acoustical properties. As a result, the boundary between necrotic and viable tissue can be detected by ultrasonic pulse reflection. This interface has been proven to correspond to actual burn depth.

Serious burn wounds result in over 10,000 deaths each year in the US alone. Determining the depth of the burn is vital to prescribing treatment. Second-degree burns will generally heal on their own, while third-degree burns must be excised and replaced with skin grafts. Until now, physicians have relied on subjective visual inspection to assess burn depth. However, inaccurate diagnosis of a burn's degree can result in bacterial infection, the primary cause of burn victim deaths.

Co-inventors William Yost and John Cantrell, with Evelyna Cantwell, president of Supra Medical Corp., and the company's burn analyzer.

The technology has been licensed exclusively to Supra Medical Corp., Chadds Ford, PA, which has developed a commercial version of the burn analyzer called the Supra Scanner®. It measures skin thickness to a depth of 37 mm with an average resolution of 65 microns, yielding a two-dimensional view of epidermis, dermis, and subcutaneous tissue through enlarged ultrasound scans on a color monitor.

The Supra Scanner was placed in several clinical and research settings in 1993. Supra Medical has created a portable unit of the scanner and currently is adapting the ultrasound technology to a scanner for early detection of breast cancer. ❑

For more information about the technology described above, contact the technology transfer officer at the NASA Field Center that sponsored the research (see page 22).

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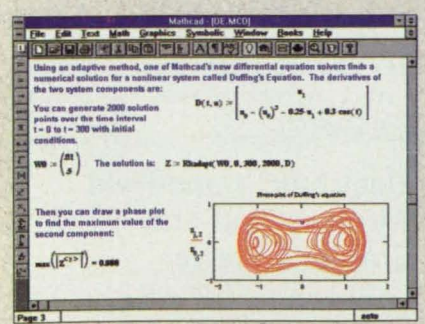

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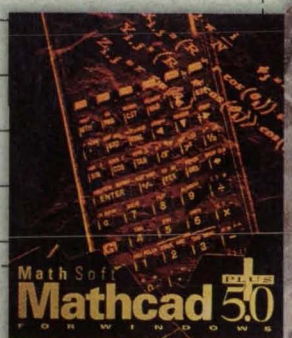

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New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 22). NASA's patent-licensing program to encourage commercial development is described on page 22.

Metal-Ion Additives Reduce Thermal Expansion of Polyimides

Incorporation of metal ions into polyimides has reduced the coefficients of thermal expansion of the polyimides. Reductions range from 11 to over 100 percent. Such polyimides may prove useful as film and coating materials for both industrial and aerospace applications in which dimensional stability, mechanical strength, and thermal stability are required.
(See page 57.)

Synthesis of Benzoxazole Monomers and Polymers

Di(hydroxyphenyl) benzoxazole monomers have been synthesized by the condensation reaction of phenyl-4- hydroxybenzoate with aromatic bis(o-aminophenol)s. The new poly benzoxazoles may prove useful as adhesives, coatings, films, membranes, molding compounds, and composite matrices.
(See page 56.)

Low-Dielectric-Constant Polyimide/Glass Composites

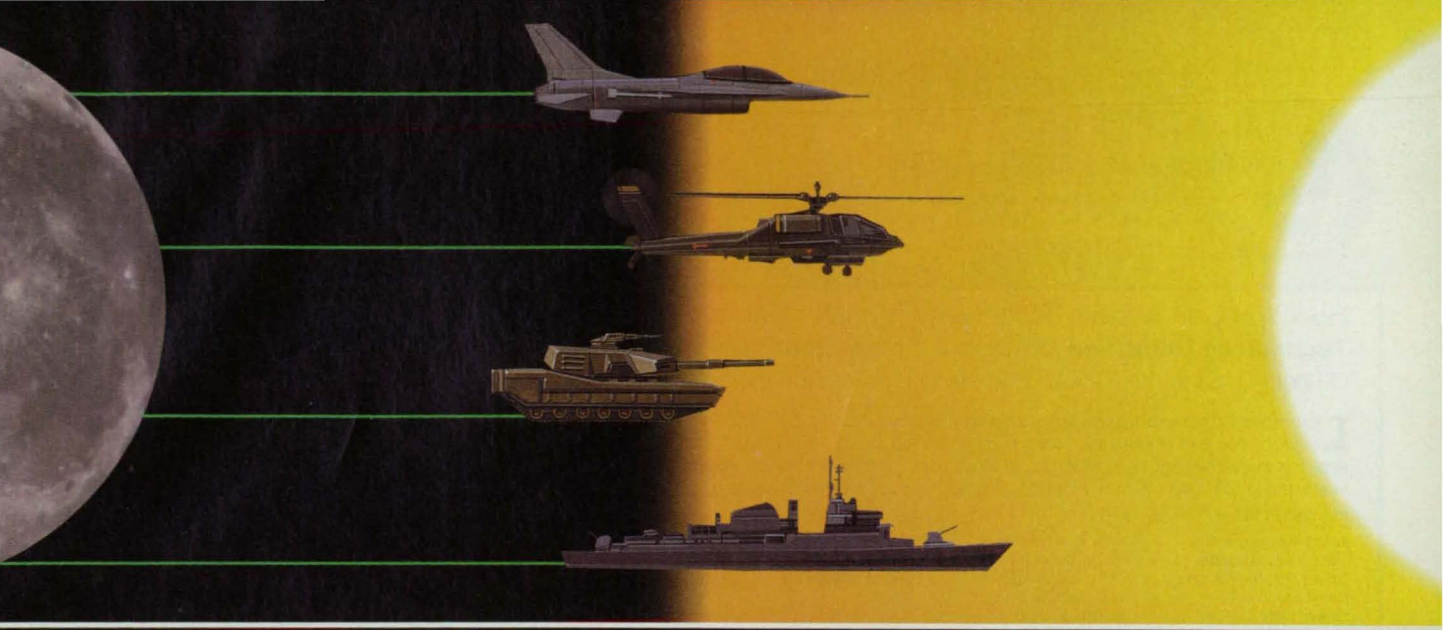
Composites with relatively low dielectric constants have been obtained by reducing the interaction between linear polyimide chains and by the incorporation of fluorine into the polymer backbones. Further reductions in dielectric constants were obtained by physically incorporating selected diamic acid additives into polyimides. Such composites have strong potential for use in the microelectronics industry for the fabrication of printed circuit boards and in the fabrication of components for aircraft.
(See page 24.)

Windowless Airplane With a View

A proposed windowless passenger airplane would give passengers views of the outside world but would be stronger, weigh less, and cost less than the conventional airplane. The ordinary see-through windows would be replaced by flat-panel color television screens connected to outward-looking video cameras in the fuselage.
(See page 48.)

Electronic, Hand-Held Wireless Text-and-Graphics Viewer

A proposed electronic, hand-held, wireless viewer would present written material to the reader in a way that closely resembles that of paper reading material. Because of its hand-held and wireless features, the viewer could be used in positions and areas where books and magazines are normally used, thus contributing to the general acceptance of this device by the public at large.
(See page 50.)



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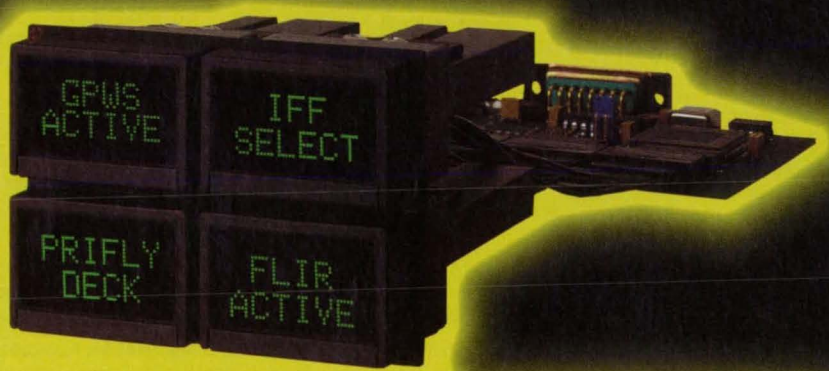

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We've outlined below NASA's Technology Transfer Network—named the participants, described their services, and listed the individuals you can contact for more information relating to your specific needs. We encourage you to make use of the information,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

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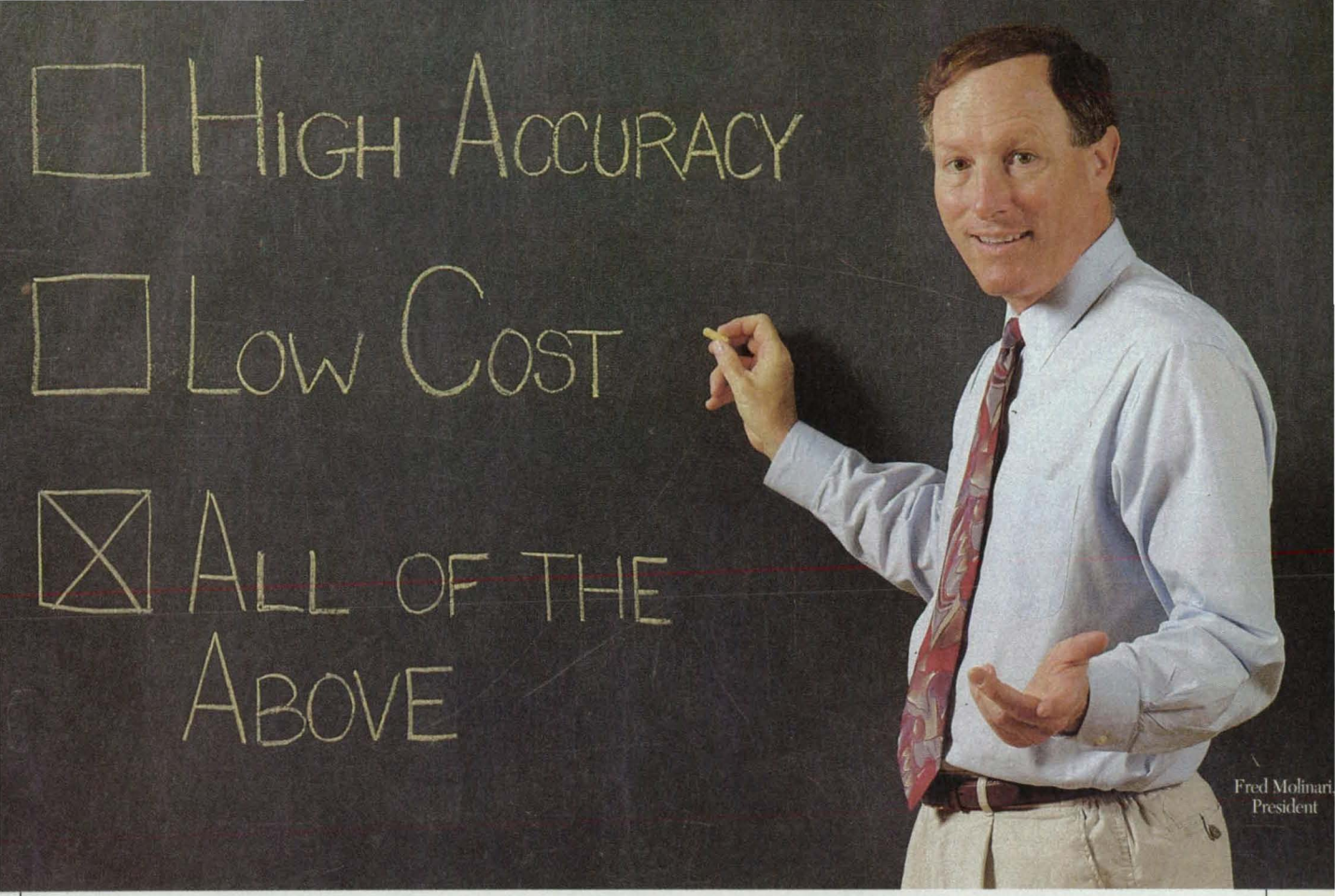

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12/2/93

Low-Dielectric-Constant Polyimide/Glass Composites

An advance in polymer technology yields composites that have relatively low dielectric constants.

Langley Research Center, Hampton, Virginia

High-performance matrix resins that have low dielectric constants are increasingly in demand in the electronics industry for use in printed-circuit boards. The dielectric constants of state-of-the-art commercially available polyimides generally range from 3.2 to 4.0. A significant reduction in dielectric constant has been achieved at NASA Langley Research Center by reducing the interactions between linear polyimide chains and by the incorporation of fluorine into the polymer backbones.

In an extension of the foregoing development, further reductions in dielectric constants are obtained by physically incorporating selected diamic acid additives into polyimides. Polyimides that have a dielectric constant of 2.4 have been developed as candidate matrix resins for use in printed-circuit boards. By use of such resins, one can produce glass-reinforced laminates that have very low dielectric constants.

One low-dielectric-constant polymer known from the previous development efforts is 6FDA/4-BDAF, which is prepared from 2,2-bis(3,4-dicaboxyphenyl)hexafluoropropane dianhydride (6FDA) and 2,2-bis[4(4-aminophenoxy)-phenyl]hexafluoropropane (4-BDAF). This polymer contains fluorine, in the form of $C(CF_3)_2$ groups, in both the dianhydride and the diamine and was chosen as the matrix resin for the glass-reinforced laminates. Prepregs were prepared by use of 6FDA/4-BDAF, with and without diamic acid additive, on two commercially available glass fibers, and laminates were prepared in stainless-steel molds. Multiple-ply unidirectional laminates were prepared for measurements of dielectric constants (see table) and other physical properties.

The results of the measurements show that one can fabricate polyimide/glass composites that have dielectric constants as low as those currently obtained with commercially available polyimide resins alone. This technology has strong potential for use in the microelectronics industry for the fabrication of printed-circuit boards and in the fabrication of components for military aircraft.

This work was done by Diane M. Stoakley, Anne K. St. Clair, Robert M. Baucom, K. Mason Proctor, Ricky E. Smith, and Janice Y. Smith of **Langley Research Center**. *For further information,* ***write in 96*** *on the TSP Request Card.*

LAR-14544d

Polyimide Resin	Dielectric Constant of Film	Dielectric Constant of Fiber	Percentage of Resin in Laminate	Dielectric Constant of Laminate
6FDA/4-BDAF	2.4	5.0	33.3	3.8
			31.9	4.0
6FDA/4-BDAF With 5 Percent Additive	—	5.0	21.8	4.2
6FDA/4-BDAF With 2.5 Percent Additive	—	3.8	25.9	3.3

Dielectric Constants of various polyimide/glass laminates were measured.

More About V-CAP Polyimides

These processible matrix resins extend the continuous-use temperature of composite materials.

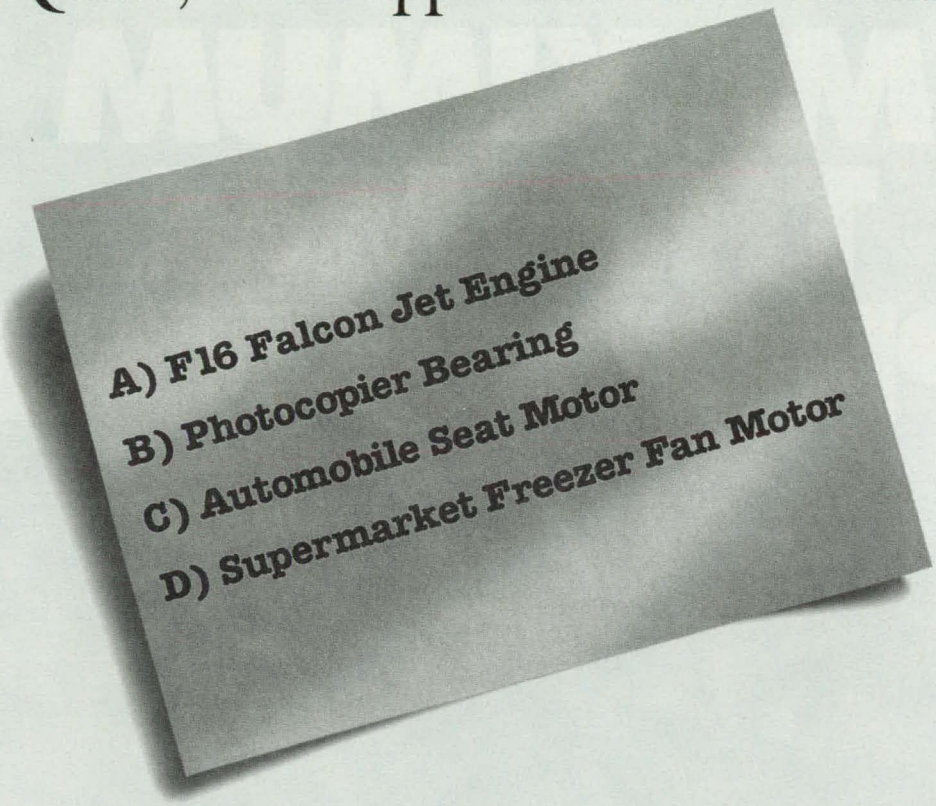
Lewis Research Center, Cleveland, Ohio

V-CAP polyimides, which have been described previously in *NASA Tech Briefs*, have been shown to be processible, high-molecular-weight addition-curing matrix resins that extend the continuous-use temperature of advanced matrix/fiber composite materials. Under contract to NASA, General Electric used VCAP to fabricate and successfully test the hot section of a forward exhaust fairing on their F110 engine (see figure).

V-CAP polyimides can also be used in other components of jet engines and airframes, including vanes, fan frames, cowls, and wing panels. Nonaerospace applications include brake linings, bearings, grinding wheels and slip seals, commutators in electric motors, and parts of motors in refrigerator compressors. Future applications might include printed-circuit boards and components of nacelles in jet engines.

Such competitive previously known addition-curing polyimides as Kerimid (or equivalent) and F178 (or equivalent) have continuous-use temperatures no higher than 500°F (260°C), and PMR-15 polyimide has a continuous-use temperature no higher than 550°F (288°C). In contrast, V-CAP polyimides and structural components made with them can be used continuously at temperatures up to 650°F (about 343°C) and can be

Quick, which application uses VESPEL®?



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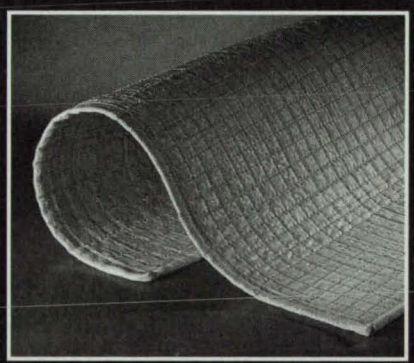

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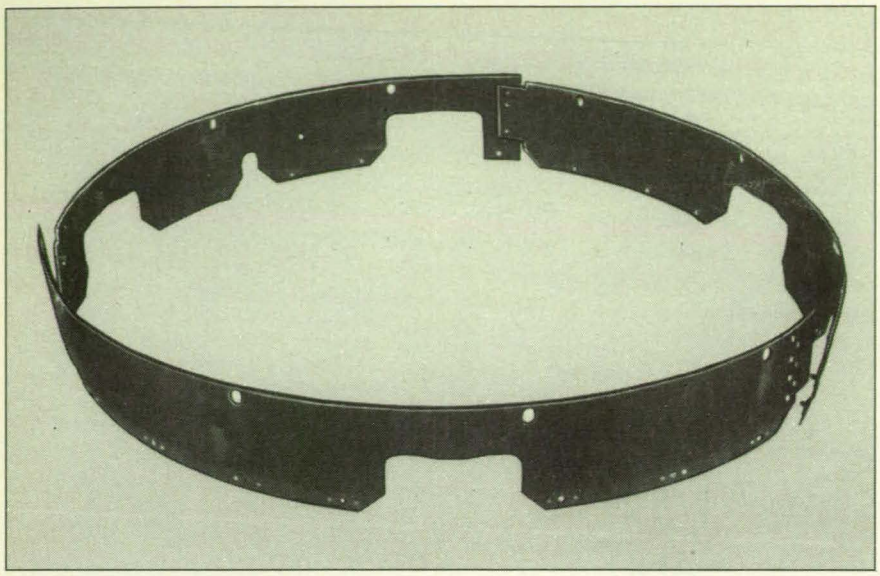
used intermittently up to 700°F (about 371°C); V-CAP polyimides have more than twice the useful life of PMR-15 at 600°F (about 315°C).



This **Forward Exhaust Fairing** of an F110 jet engine was made with a V-CAP polyimide.

Similar to PMR-15, alcohols that boil at low temperatures are used as solvents that facilitate the processing of V-CAP polyimides, and these alcohols are easily removed during processing. Low-void VCAP composite structural components can be autoclave fabricated at pressures as low as 100 psi (0.7 MPa), as well as by compression and transfer molding.

This work was done by Raymond D. Vannucci and Diane C. Malarik of **Lewis Research Center**. *For further information,* ***write in 50*** *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, Lewis Research Center [see page 22].
Refer to LEW-15528.

Predicting Fatigue Lives of Metal-Matrix/Fiber Composites

Tensile properties are used in a simple formula.

Lewis Research Center, Cleveland, Ohio

A method of prediction of the fatigue lives of intermetallic-matrix/fiber composite parts at high temperatures is styled after the method of universal slopes. For more than 20 years, the method of universal slopes has been used to predict approximate fatigue lives of alloy (only) components without having to perform the expensive and time-consuming large number of fatigue tests that would normally be needed for complete fatigue characterizations. In the method of universal slopes, it suffices to perform relatively small numbers of fatigue tests. The data from the fatigue tests are then correlated with tensile-test data by fitting a universal-slopes equation to both sets of data. Thereafter, the universal-slopes equation can be used to predict fatigue lives from tensile properties.

The basic equation of the present method, which is similar to the universal-slopes equation, is

$$Np = A\left(\frac{\sigma ult}{E}\right)^{\alpha}(\varepsilon f)(\varepsilon max)\gamma$$

where N_p is the predicted fatigue life (number of fatigue cycles); ε_{max} is the maximum applied strain; A, α, β, γ and are constants; and E, σ_{ult}, and ε_f are the modulus of elasticity, ultimate tensile strength, and fracture strain, respectively, of the composite material. The ratio σ_{ult}/E can be regarded as the maximum elastic strain that can be applied to the composite, while ε_f is a measure of the ductility of the composite and represents a combination of maximum elastic and inelastic applied strains.

The parameters, A, α, β, and γ are computed by using multiple-regression analysis to fit the equation to tensile-test and low-cycle-fatigue-test data obtained at various temperatures (see Figure 1). Then following an approach similar to that of the universal-slopes method, the equation can be used to predict fatigue lives at different temperatures for which tensile-test data, but not fatigue-test da-

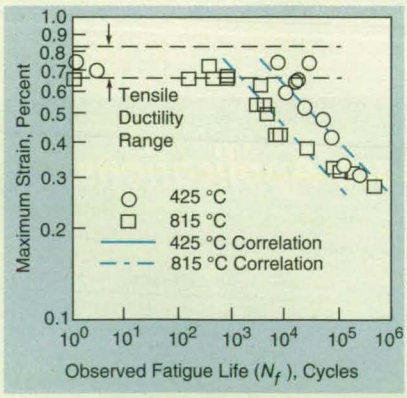


Figure 1. **Observed Fatigue Lives of Three-Ply Specimens** of unidirectional-fiber composites of SiC fibers in a matrix of 65Ti/24Al/11Nb (the numbers represent atomic percentages) at two temperatures were correlated with data from tensile tests of these specimens at the two temperatures, by use of the universal-slopes-like equation.

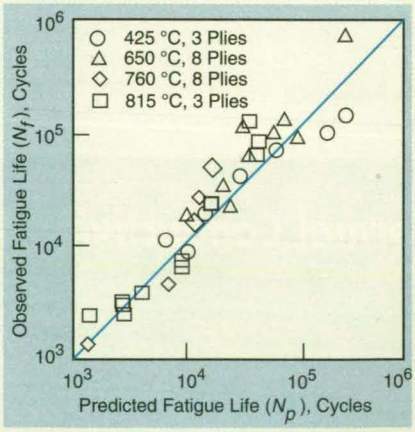


Figure 2. **Predicted Fatigue Lives** of eight-ply specimens of the unidirectional-fiber SiC/(65Ti/24Al/11Nb) composite at 650 and 760 °C are compared with actual fatigue lives. Also shown are correlations of test data from three-ply specimens at 425 and 815 °C. A point on the solid line would fit the universal-slopes-like equation perfectly.

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ta, are available. In making such a prediction, the values of E, σ_{ult}, and ε_f used in the equation are those obtained in tensile tests at the temperature in question, while the values A, α, β, and γ are those obtained previously from the multiple-regression fit. Figure 2 presents an example of fatigue lives as observed and as predicted by this method.

This work was done by Paul A. Bartolotta of **Lewis Research Center**. *For further information,* ***write in 48*** *on the TSP Request Card.*
LEW-15676

Improved PMR Polyimides for Heat-Stable Laminates

Resins with improved thermo-oxidative stability result from the replacement of the nadic-ester end cap by p-aminostyrene.

Lewis Research Center, Cleveland, Ohio

Second-generation PMR-type polyimides (PMR-II polyimides) of enhanced thermo-oxidative stability can be prepared by the substitution of para-aminostyrene (PAS) end caps for the nadic-ester (NE) end caps used in prior PMR-II polyimides, experiments have shown. Laminates unidirectionally reinforced with graphite fibers and made with the PAS-capped resins exhibited thermo-oxidative stabilities significantly greater than those of similar laminates made with NE-capped PMR-II resins. One of the new laminates exhibited high retention of weight and strength after 1,000 h of exposure to air at 371°C.

In these experiments, PMR-II resins of the older type were prepared from (a) n moles of HFDE — the dimethyl ester of 4,4'-(hexafluoroisopropylidene)-bis(phthalic acid), (b) $n + 1$ moles of para-phenylenediamine (PPDA), and (c) 2 moles of the nadic ester, which is the monomethylester of 5-norbornene-2,3-dicarboxylic acid. The newer polyimide resins end-capped with PAS — called "V-CAP" for "vinyl-capped addition polyimide" — were formed from $n + 1$ moles of HFDE, n moles PPDA, and 2 moles of PAS (see figure) Methanol solutions (40 to 50 percent solute by weight) were prepared at $n = 9$ and $n = 14$ in both resin systems.

Prepreg laminate tapes were prepared by brush application of resin solutions onto graphite fibers wound on a drum and calculated to contain 55 volume percent fiber after curing. Each prepreg was allowed to dry on the drum, under quartz lamps, to a volatile content of 11 to 12 weight percent, then removed from the drum and cut into plies of 7.62 cm by 20.32 cm. Plies were stacked unidirectionally to yield laminates destined to be 0.23 to 0.25 cm thick after curing. The laminates were laid up in a vacuum bag and cured in a press by use of a simulated autoclave process. After curing, the laminates were cured without pressing: some in air, others in nitrogen. For air, the curing-temperature schedule was ambient to 260°C at 20°C/min, then 260°C to 385°C at 1°C/min, with a 2-h holds at 316 and 343°C followed by a 20-h hold

at 385°C. The schedule for nitrogen was similar except that the maximum temperature was 399°C.

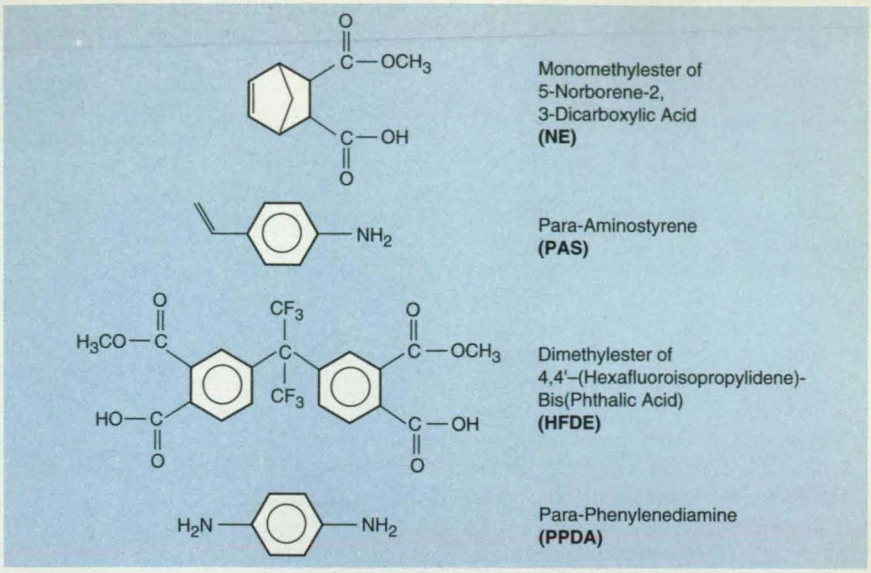
Flexural and interlaminar-shear-strength (ILSS) tests were performed on laminate specimens before and after exposure to air at 371°C. The weights lost by laminate specimens exposed to the atmosphere at 371°C were also measured.

The results of these experiments led to the following conclusions:

- The use of para-aminostyrene as an end cap in high-molecular-weight PMR-II-type resins (V-CAP resins) significantly increases thermo-oxidative stability.
- Postcuring in nitrogen can significantly increase in the thermo-oxidative stabilities of high-molecular-weight PMR-II-type laminate materials.
- Postcuring of laminates made of high-molecular-weight PMR-II resins yields higher glass-transition temperatures than does postcuring in air.
- Laminates made of V-CAP ($n = 14$) resin and graphite fibers exhibit excellent retention of both weight and mechanical properties after exposure to air at 371°C for as long as 1,000 h.

This work was done by R. D. Vannucci, D. C. Malarik, D. S. Papadapoulos, and John F. Waters of Case Western Reserve University for **Lewis Research Center**. *Further information may be found in NASA TM-103233 [N90-27874/TB], "Autoclavable Addition Polyimides for 371°C Composite Applications."*

Copies may be purchased (prepayment required) from the NASA Center for Aero-Space information, Linthicum Heights, Maryland, Telephone No. (301) 621-0394.



These Monomers were used to prepare the older (NE-capped) and newer PAS-capped (V-CAP) PMR-II polyimides.

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Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center [see page 22].
Refer to LEW-15303.

Poly(arylene ether)s That Resist Atomic Oxygen

These polymers, which contain phosphine oxide, have favorable physical and mechanical properties.

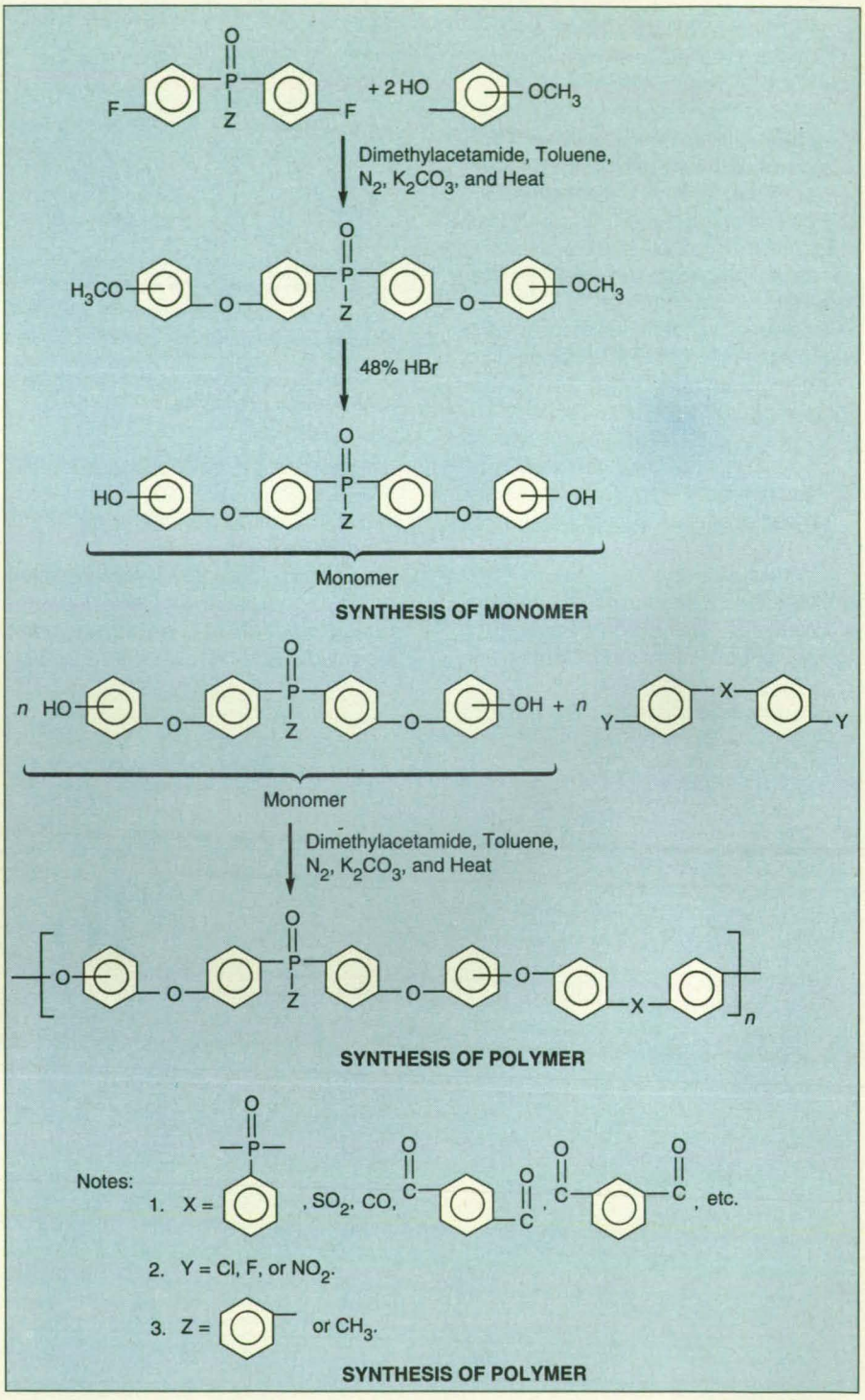
Langley Research Center, Hampton, Virginia

Novel poly(arylene ether)s containing phosphine oxide (PAEPO's) have been made via aromatic nucleophilic displacement reactions of activated aromatic dihalides (or, in some cases, activated aromatic dinitro compounds) with new bisphenol monomers that contain phosphine oxide. The new PAEPO's exhibited a favorable combination of physical and mechanical properties and resistance to monatomic oxygen in an oxygen plasma environment. These PAEPO's could be useful as adhesives, coatings, films, membranes, moldings, and composite matrices.

Phenylphosphine oxide bisphenol monomers either meta or para were prepared by reacting hydroxyanisole with bis(4-fluorophenyl)-phenylphosphine oxide [or, in some cases, bis(4-fluorophenyl)methylphosphine oxide] in N, N-dimethyl acetamide, followed by demethylation by use of hydrobromic acid. The PAEPO's were then synthesized by the nucleophilic displacement reactions of the monomers with activated aromatic dihalide (or, in some cases, dinitro) compounds (see figure).

The inherent viscosities of the PAEPO's ranged from 0.57 to 0.75 dL/g, and the glass-transition temperatures (T_g's) ranged from 171 to 213°C. Thermogravimetric analysis at a heating rate of 2.5°C/ min showed no loss of weight at temperatures below 300°C in air or nitrogen, and a weight loss of 5 percent occurred at about 465°C in air and at about 500°C in nitrogen. The average tensile strength, tensile modulus, and elongation at break at 23°C for unoriented thin films were 11.0 kpsi (75.8 MPa), 325 kpsi (2.24 GPa), and 95 percent, respectively.

After exposure to an oxygen plasma for 23 h under vacuum, PAEPO films with areas of 0.25 $in.^2$ ($6.5 \cdot 10^{-4}$ m^2) and thicknesses of 1 to 2 mils (0.025 to 0.051 mm) lost weight at rates of 0.0025 to 0.0355 mg/h. In comparison, a similar Kapton® (polyimide from DuPont) film lost weight at a rate of 0.88 mg/h.

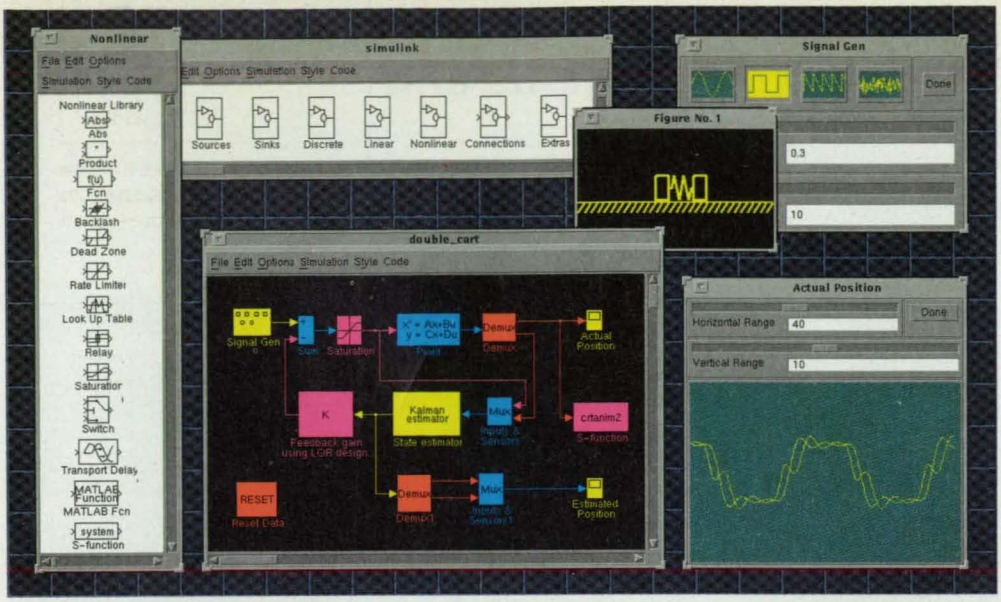


Poly(arylene ether)s That Contain Phosphine Oxide were made in this sequence of reactions.

This work was done by John W. Connell and Paul Hergenrother of **Langley Research Center** *and Joseph G. Smith, Jr., of the University of Akron. For further information,* ***write in 90*** *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 22].

Refer to LAR-15054.



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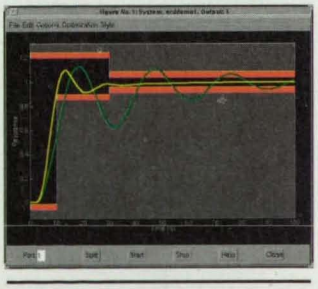

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Phenylethynyl End-Capping Reagents and Reactive Diluents

These reagents transform arylene ether oligomers and polymers into readily processable reactive materials that can be converted thermally to thermosets.

Langley Research Center, Hampton, Virginia

Compounds that contain the phenylethynyl group can serve as thermally reactive polymer end caps and reactive diluents. These compounds could be useful in the preparation of adhesives, composite matrices, and molding compounds. The top part of Figure 1 illustrates the synthesis of 4-phenylethynyl-4'- fluorobenzophenone, which can be used as an end-capping agent to transform aromatic dihydroxy compounds into reactive materials that can be converted thermally into thermosets. One can also synthesize end-capping agents that behave similarly to 4-phenyl-4'-fluorobenzophenone by substituting Cl or NO_2 for F and SO_2 or another activating group for CO. The middle and bottom parts of Figure 1 illustrate the synthesis of 4-phenoxy-4′-phenylethynylbenzophenone, a model compound and bis(4-phenylethynylbenzoyl-4'-phenoxy)-ethyl ether, a reactive diluent. The reactive diluent decreases the melt viscosities of high-molecular-weight phenylethynyl-terminated oligomers and subsequently reacts with the oligomers to increase crosslink densities in the cured material.

The phenylethynyl group has been found to offer several unexpected advantages over the ethynyl-based analog. In an experiment in which 4-phenylethynyl-4'-fluorobenzophenone was treated with phenol in the presence of an alkali-metal base (potassium carbonate) in a polar aprotic solvent at a temperature of 160°C, the expected 4-phenoxy-4'-phenylethynylbenzophenone was afforded in nearly quantitative yield. However, when 4-ethynyl-4'-fluorobenzophenone was used in the same procedure, the result was a mixture of products with a total yield of 60 percent. Several variations in the procedure were tried, but the resulting product was not exclusively the expected ethynyl arylene ether. These results indicate that when the phenylethynyl end-capping compound is used to terminate an aromatic dihydroxy compound, the reaction should yield the expected phenylethynyl-terminated reactive oligomer exclusively, whereas if the ethynyl adduct is used, the reaction will yield a variety of products.

Figure 2 shows results of differential scanning calorimetry on the model compound, 4-phenoxy-4'-phenylethynylbenzophenone. This compound is relatively stable at a temperature of 200°C, as evidenced by little reaction after 20 h at 200°C, but it reacts in 1 h at 350°C. This thermal stability is unusual,

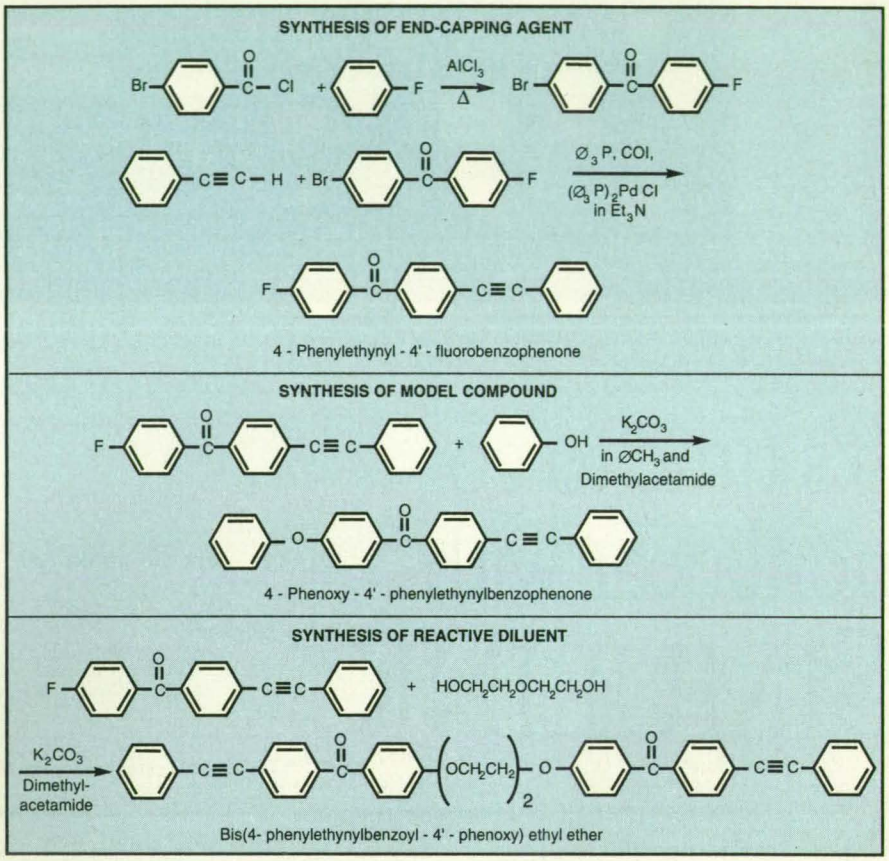


Figure 1. **Compounds That Contain Phenylethynyl** are synthesized for subsequent use in making thermoset polymers.

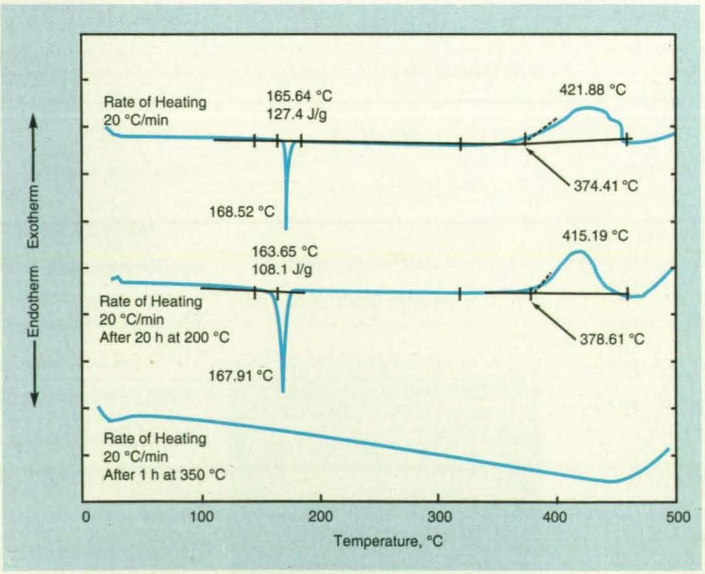


Figure 2. **Differential Scanning Calorimetry** of the model compound 4-phenoxy-4'-phenylethynylbenzophenone indicates that it is relatively thermally stable at 200°C but cures when held for 1 h at 350°C.

given that ethynyl-terminated arylene ethers cure at temperatures between 160°C and 250°C during intervals of 0.5 to 1.5 h.

Since the phenylethynyl compounds display such unique thermal behavior, several low-melting bis(phenylethynyl)-arylene ethers were synthesized for use as reactive diluents. One diluent, bis(4-phenylethynylbenzoyl-4'-phenoxy)ethyl ether, which melts at ~127°C, was used to decrease the melt viscosities of relatively high glass-transition-temperature phenylethynyl-terminated obigomers, thereby improving their compression moldability. This diluent was blended with a phenylethynyl-terminated arylene ether at levels of 10 and 30 percent by weight. The melt viscosities of the resulting blends at 200°C were significantly lower than that of the oligomer alone.

This work was done by Robert G. Bryant, Brian J. Jensen, and Paul M. Hergenrother of **Langley Research Center**. *For further information,* ***write in 26*** *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 22]. Refer to LAR-14796.

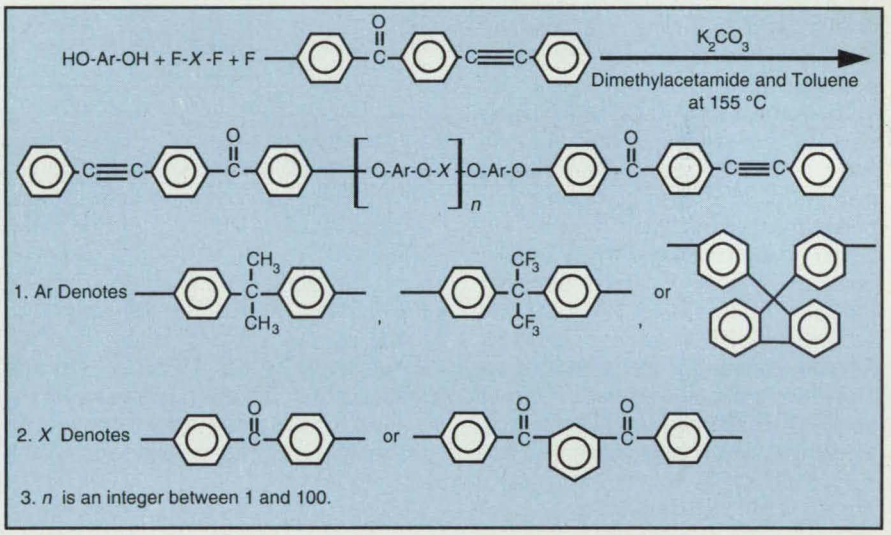
Phenylethynyl-Terminated Poly(Arylene Ethers)

These can be thermally cured to provide materials that are crosslinked and insoluble in common organic solvents.

Langley Research Center, Hampton, Virginia

Phenylethynyl-terminated poly(arylene ethers) have been synthesized in a wide range of molecular weights by adjusting the monomer ratios and adding appropriate amounts of 4-phenylethynyl-4'-fluorobenzophenone to the monomers to end-cap the oligomers during polymerization. The resulting phenylethynyl-terminated poly(arylene ethers) have low molecular weights and accordingly low melt viscosities, and therefore are easily processed as adhesives, composites, and moldings. When heated to ~350 °C, the phenylethynyl groups react with one another to provide chain extension, branching, and crosslinking. When compared with the corresponding uncrosslinked polymers, these materials exhibit increased resistance to solvents, greater tensile moduli, and better high-temperature properties. The phenylethynyl-terminated poly(arylene ethers) are useful as adhesives, composite matrices, and moldings, especially in applications in which a combination of toughness and resistance to solvents is needed.

The general reaction scheme to synthesize the phenylethynyl-terminated poly(arylene ethers) is shown in the figure. After curing for 1 h at 350 °C, the resulting polymers are crosslinked and insoluble in common organic solvents. Polymers with molecular weights of both 3,000 g/mole and 6,000 g/mole have been synthesized in experiments; in principle, polymers of essentially any molecular weight from about 500 to about 20,000 g/mole can easily be prepared by adjusting the monomer stoichiometry. Several different phenylethynl-terminated poly(arylene ethers) were synthesized at both 3,000 and 6,000 g/mole theoretical-number average molecular weights. With a phenylethynyl-terminated arylene ether having a theoretical-number average molecular weight of 6,000 g/mole, titanium to titanium tensile shear specimens were readily fabricated under 50 psi at 350°C for 1 hour. Average tensile-shear strengths were 4,300 psi at room temperature and 4,000 psi at 177 °C.



Phenylethynyl-Terminated Poly(Arylene Ethers) are formed in this reaction sequence, then thermally crosslinked. The resulting polymers are insoluble in common organic solvents.

This work was done by Brian J. Jensen, Robert G. Bryant, and Paul M. Hergenrother of **Langley Research Center**. *For further information,* ***write in 46*** *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 22]. Refer to LAR-14797.

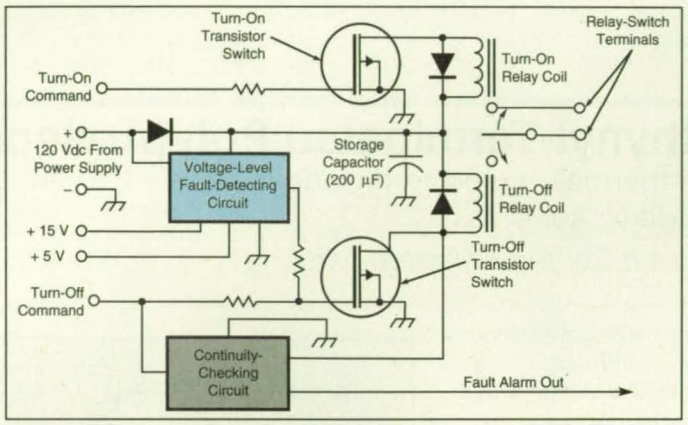
Latching-Relay Driver and Continuity Checker

Average power consumed is reduced by about 15 W.

Lewis Research Center, Cleveland, Ohio

A driving circuit and an associated continuity-checking circuit enable the use of a latching relay switch instead of a nonlatching relay switch in a 120-Vdc power-distribution system. The nonlatching relay consumes about 15 W of power in sustaining closure of the switch contacts. The latching relay consumes no power in sustaining opening or closure, but does consume about 60 W in moving between the "open" and "closed" positions during a switching interval of about 20 ms. The nonlatching relay automatically opens upon failure of the supply voltage, but the latching relay does not. Thus, the nonlatching relay offers the advantage of a fail-safe operating mode, while the latching relay offers the advantage of 15 W less consumption of power most of the time.

The driving circuit and the associated continuity-checking circuit (see figure) make it possible to combine the advantages of both relays by providing fail-safe features for the latching relay. The driving circuit includes a turn-off transistor switch and a turn-on transistor switch, which allow current to flow in the turn-on relay coil or turn-off relay coil, respectively, upon receipt of a turn-on or turn-off command from external circuitry. The driving circuit also includes a voltage-level fault-detecting circuit, which generates a turn-off command when either the main 120-Vdc supply, a 5-Vdc supply, or a 15-Vdc supply fails. A 200-μF storage capacitor in the driving circuit sustains enough switching power for a long enough time after detection of a fault to switch the relay to the "off" position.



The **Latching-Relay Driver and Continuity Checker**, shown here in simplified form, provide automatic turnoff of the relay when the power fails, or an alarm that indicates a discontinuity in the turn-off circuit, respectively.

The continuity-checking circuit tests for continuity of the path from the turn-off coil through the turn-off transistor switch to ground. It performs this test repeatedly: once every second. When it detects a fault, it puts out an alarm signal.

This work was done by Thomas A. Kachelski of Rockwell International Corp. for **Lewis Research Center**. *For further information,* ***write in 28*** *on the TSP Request Card. LEW-15159*

Ion Accelerator With Negatively Biased Decelerator Grid

Sputter erosion of the accelerator grid is reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure depicts a three-grid ion accelerator in which an accelerator grid is biased at a negative potential (typically, –200 Vdc) and a decelerator grid downstream of the accelerator grid is biased at a smaller negative potential (typically, –80 Vdc). This grid and bias arrangement reduces the frequency of impacts, upon the accelerator grid, of charge-exchange ions produced downstream in collisions between the accelerated ions and the atoms and molecules of the background gas. As a result, sputter erosion of the accelerator grid is reduced.

Reduction of sputter erosion of an accelerator grid is desirable because such erosion is the major factor that limits operating life of an ion accelerator. If an accelerator is to be used in an industrial process like ion-beam etching or micromachining, reduction of such erosion is also desirable to reduce contamination of the target with the accelerator-grid material. Of course, the life of an accelerator grid can be extended and the contamination of any target material can be reduced by operating the accelerator at lower background pressure (higher vacuum), but maintenance of a high vacuum on Earth during a long operating time can be expensive. Thus, if an ion accelerator is to be used eventually in outer space as an ion engine or on Earth in a high vacuum, it could be tested on Earth in a lower vacuum and it would survive longer (as though it were in a higher vacuum) if it were equipped with the new grid and bias arrangement.

The potentials on the accelerator and decelerator grids are tied to the potential on the neutralizer cathode, which is typically maintained at –15 Vdc with respect to the ion-beam plasma to enable electrons to be drawn from the neutralizer cathode into the beam. The decelerator grid collects most of the charge-exchange-ion current that would otherwise strike the accelerator grid, resulting in a corresponding decrease in erosion of the accelerator grid. Although there is some ero-

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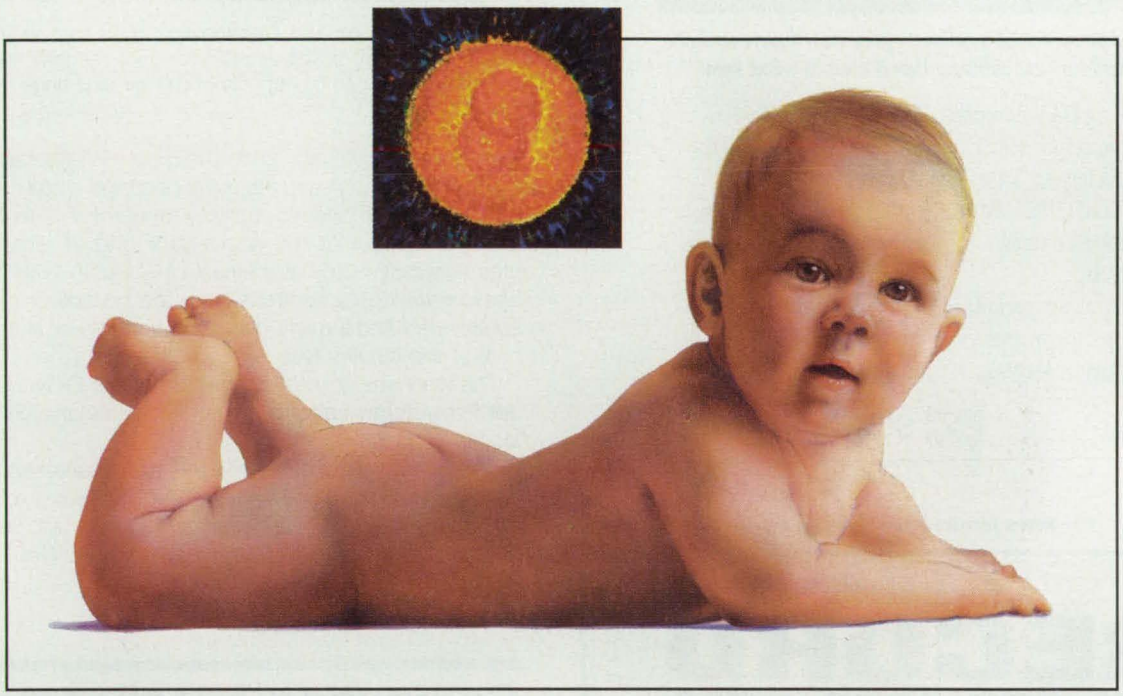

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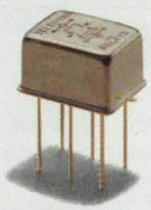

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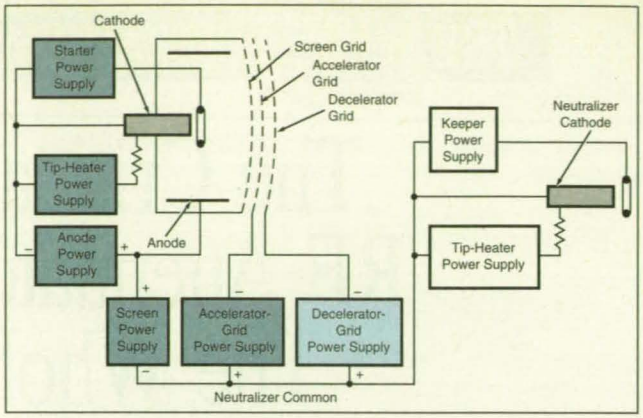

Negative Bias on the Decelerator Grid (but at a magnitude smaller than that of the accelerator grid) reduces the erosion of the accelerator grid by impacts of charge-exchange ions.

sion of the decelerator grid, it is much smaller because of the smaller bias voltage and the correspondingly smaller sputter yield.

An additional benefit of this arrangement is that it makes it possible to operate the accelerator grid at smaller negative bias (typically, –200 V instead of –300 V) without incurring backstreaming of electrons from the neutralizer cathode. The sputter yield and the rate of erosion are smaller (in this case, by half) at the smaller bias.

This work was done by John R. Brophy of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 99*** *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 22]. Refer to NPO-18391

Computing Misalignments From Measured Contact Resistances

The flange resistance of an aligned contact is multiplied by a semiempirical factor.

NASA's Jet Propulsion Laboratory, Pasadena, California

Misalignments of contacts in integrated circuits can be computed, and measured contact resistances can be corrected for the effects of misalignments by use of a method based on a relatively simple mathematical model of measured contact resistance. The method is particularly useful in estimating the effects of misalignments on four- and six-terminal (Kelvin-tap) contact-resistance measurements taken with L-shaped test structures.

The figure illustrates part of a four-terminal Kelvin-tap cross-contact chain that includes two misaligned square contacts between a thin semimetal strip of finite resistivity and a metal strip (above the page, not shown) of nominally zero resistivity. The strips (called the "flanges" in the industry) must be made wider than the contacts to allow for misalignment. Because some parasitic currents flow in the flanges, the measured contact resistance R_K exceeds the true contact resistance R_I by an amount known as the flange resistance R_F; that is,

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Electrical Ceramics: we talk the language at

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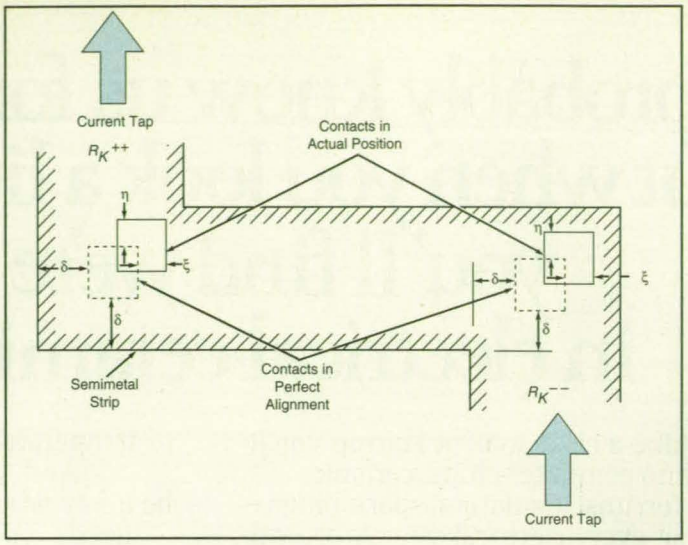


Two **Square Contacts** are displaced horizontally by ξ and vertically by η from perfect alignment.

$$R_K = R_I + R_F$$

R_F depends on the geometry and sheet resistances of the flanges and weakly on R_I; it can be computed to the desired precision by use of a suitable mathematical model of the electrical current in a thin film. According to the simplified mathematical model of the present method, R_F varies approximately as a quadratic function of the misalignments ξ and η shown in the figure. The resulting equations for the "left" and "right" contact resistances R_K^{++} and R_K^{--} respectively) are

$$R_K^{++} = R_J + R_{F0}\left[1-\alpha_1\left(\frac{\xi+\eta}{\delta}\right)+\alpha_2\left(\frac{\xi+\eta}{\delta}\right)2\right]$$

and

$$R_K^{--} = R_J + R_{F0}\left[1+\alpha_1\left(\frac{\xi+\eta}{\delta}\right)+\alpha_2\left(\frac{\xi+\eta}{\delta}\right)^2\right]$$

where R_{F0} is the precise computed value of R_F for perfectly aligned contacts, δ is the flange width shown in the figure, and α^1 and α^2 are obtained by fitting this equation to the precise computed values of R_F.

Taking half the sum and the difference of "left" and "right" contact resistances,

$$\frac{(R_K^{++}+R_K^{--})}{2} = R_I + R_{F0}\left[1-\alpha_2\left(\frac{\xi+\eta}{\delta}\right)^2\right]$$

$$\frac{(R_K^{++}-R_K^{--})}{2} = -\alpha_1 R_{F0}\left(\frac{\xi+\eta}{\delta}\right)$$

As a first-order approximation, one could neglect the term associated with α_2. In that case, the equation justifies the previous practice of computing R_I by averaging "left" and "right" measured four-terminal resistances and subtracting R_{F0}. The difference equation enables a simple estimate of the misalignment from the differences between measured "left" and "right" four-terminal resistances.

A six-terminal Kelvin tap enables four independent four-terminal measurements on the same contact, with different orientations of the current-injecting tap. Equations similar to those shown above for the four-terminal case can be derived and manipulated into sum and difference equations in which one can take advantage of the different orientations to estimate ξ and η separately.

This work was done by Udo Lieneweg and Hoshyar Sayah of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 20*** *on the TSP Request Card.*
NPO-18691

Low-Heat-Leak Electrical Leads for Cryogenic Systems

High-temperature superconductors are deposited on thermally insulating substrates.

Langley Research Center, Hampton, Virginia

Electrical leads that offer high electri Electrical leads that offer high electrical conductivity and low thermal conductivity are being developed for use in connecting electronic devices inside cryogenic systems to power supplies, signal-processing cir-

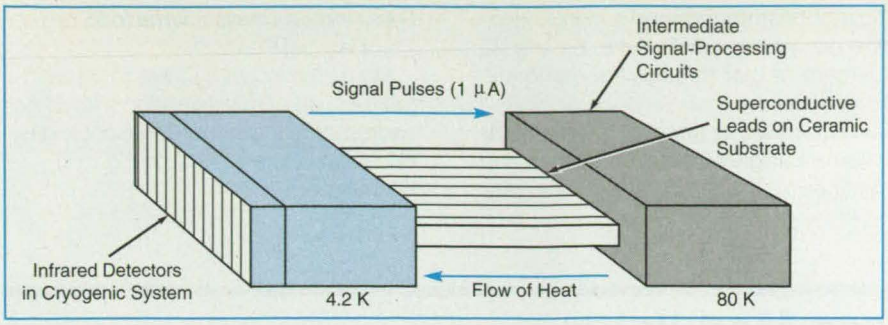
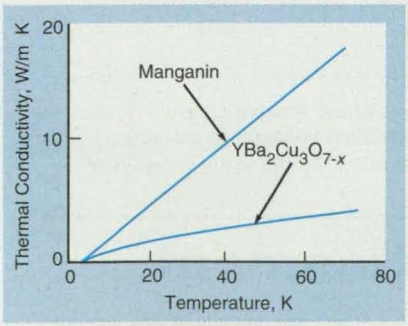


Figure 1. A **Strip of Superconductive Leads** on a ceramic substrate, similar to ribbon cable, connects infrared detectors at the temperature of liquid helium with warmer circuitry.

cuits, and other circuitry located in nearby warmer surroundings (see Figure 1). These leads are made of thick films of $YBa_2Cu_3O_{7-x}$ or other high-temperature superconductors formed in the required conductive patterns on low-thermal-conductivity ceramic substrates. Typically, multiple parallel line conductors are formed in strips similar to ribbon cables.

The electrical leads that bridge the thermal gradient at the boundary of a cryogenic system should be designed both to minimize the conduction of heat from the surroundings through the leads into the system and to minimize resistive heating caused by electrical currents flowing in the leads: this is necessary to minimize the rate of boiloff of liquid helium or other cryogen. Leads made of a high-temperature superconductor are particularly well suited for this purpose because (1) resistive heating of the leads can be eliminated by cooling them below the superconducting-transition temperature (typically, 93 K in the case of $YBa_2Cu_3O_{7-x}$) and (2) in comparison with other electrically conductive materials like normally conductive metals, the high-temperature superconductors have lower thermal conductivities (see Figure 2).



The **Thermal Conductivity of $YBa_2Cu_3O_{7-x}$** is less than that of manganin (an alloy of 84 percent Cu, 12 percent Ni, and 4 percent Mn), which has been used previously to make electrical leads for cryogenic instrumentation. High-temperature superconductors based on Bi and Tl exhibit even lower thermal conductivity.

A strip of leads is formed in the required pattern by screen-printing of the thick high-temperature superconductor onto the ceramic substrate. The substrate and deposited leads are then heat-treated at a temperature between 800 and 950 °C. The substrate material must be chosen not only for its low thermal conductivity but also for chemical compatibility with the superconductive material during heat treatment. Suitable substrate materials include yttria-stabilized zirconia and fused silica.

To illustrate the advantage of the superconductive leads on ceramic sub-

strates, the flow of heat from a location at 80 K along a 15-cm manganin connecting wire to a location at 4 K was computed, as was the flow of heat along a comparable lead of $Bi_2Sr_2Ca_2Cu_3O_x$ superconductor (critical temperature = 110 K) on a fused-silica substrate. The flow of heat through the superconductive connection was found to be only 20 percent of that through the manganin connection.

This work was done by Stephanie A. Wise of **Langley Research Center**, *and Matthew W. Hooker of Clemson University.*

For further information, ***write in 55*** *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 22].
Refer to LAR-14964

Wideband Linear Phase Modulator

Constant-γ varactor diodes provide for nearly linear variation of phase with voltage.

NASA's Jet Propulsion Laboratory, Pasadena, California

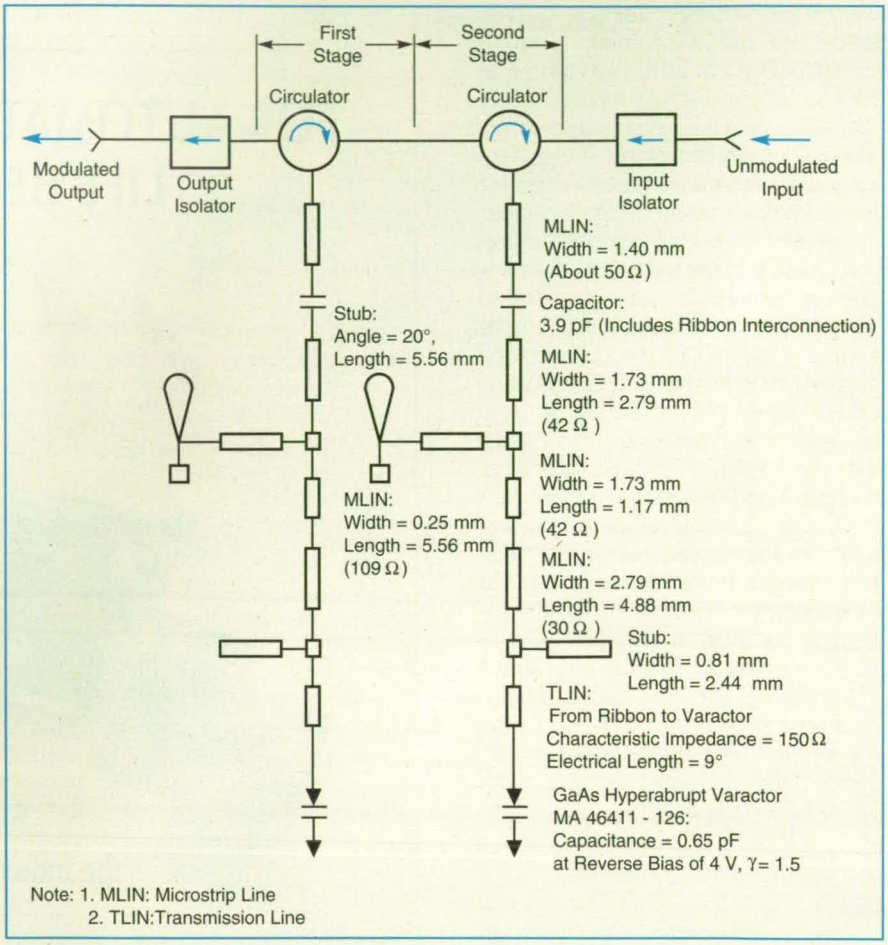
A phase modulator for transmission in the X band provides a large phase deviation that remains nearly linear with voltage over a relatively wide range. The modulator operates with low loss over a wide frequency band and with stable characteristics over a wide temperature range. At a carrier frequency of 8,415 MHz, the phase shift is ±2.5 radians, varying linearly with voltage within ±8 percent, and the insertion loss is 6.35 dB. The 3-dB bandwidths at temperatures of –35, +25, and 85°C are 92, 84, and 75 MHz, respectively.

The phase modulator is a cascaded reflection phase shifter with two stages coupled via circulators (see figure). The unit is packaged in an 81- by 61- by 14.3-millimeter module. Components are interconnected by transmission lines and microstrip lines on a dielectric substrate.

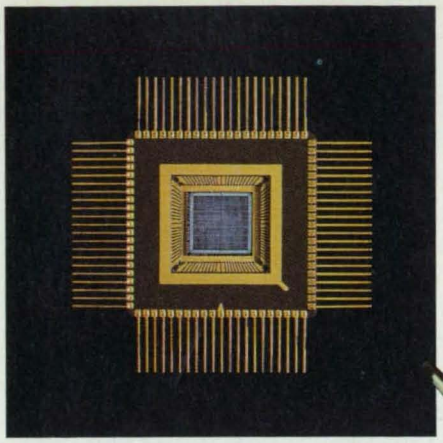
The phase-shifting elements are two hyperabrupt varactor diodes. Heretofore, varactor diodes have not been well suited to use as phase shifters, even though variations of phase that can be obtained by use of them are large, because these variations in phase are highly nonlinear functions of applied voltage. However, recent developments in processing make it possible to build varactors that exhibit constant γ over a limited range of bias voltage. (γ is the slope of the curve of logarithm of capacitance versus logarithm of applied voltage. Constant γ is needed to obtain the desired linearity.) The varactor diodes in the phase modulator exhibit $\gamma \approx 1.5$ at reverse biases from 1.5 to 8.5 volts.

An associated drive circuit sums and amplifies the modulation input signals and provides a composite drive voltage to the varactor diodes. A wideband operational amplifier in the drive circuit processes modulation signals at frequencies from 1 kHz to 20 MHz.

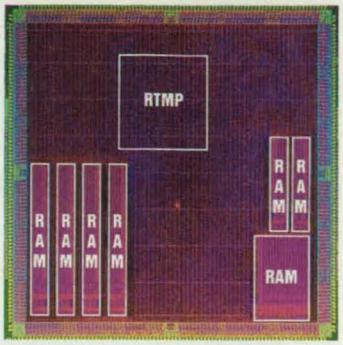
This work was done by Narayan R. Mysoor and Robert O. Mueller of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 108*** *on the TSP Request Card.*
NPO-18602



The **Phase Modulator** contains two varactor-diode phase shifters coupled via circulators. A separate drive circuit (not shown) applies modulating voltages to the varactor diodes. The modulation voltages are varied in accordance with the input to the drive circuit.



UTMC integrates MIL-STD-1773 functions as macros on ASICs



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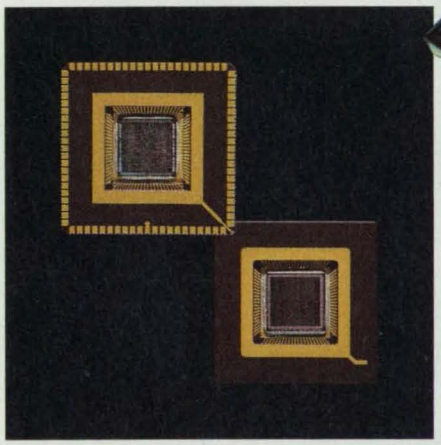

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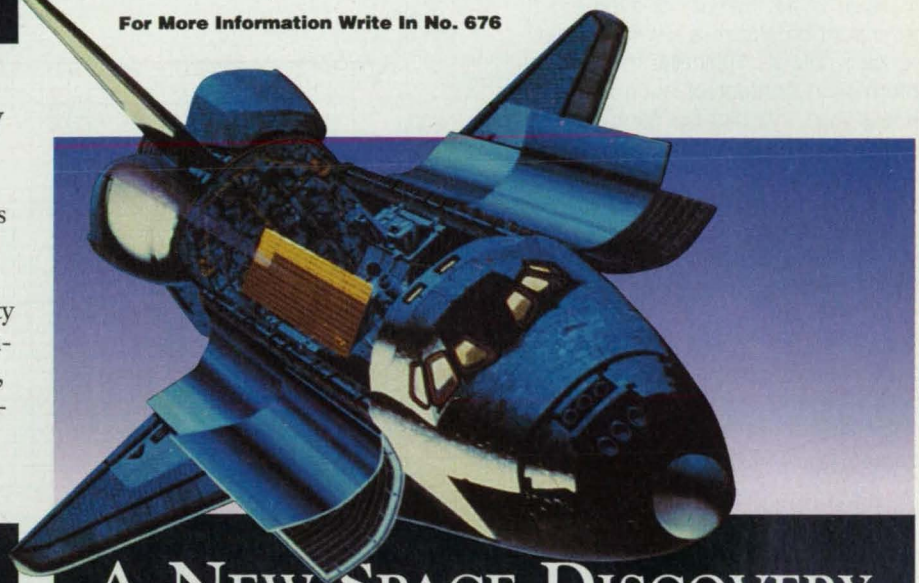

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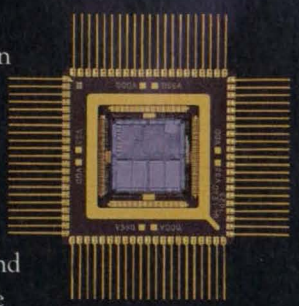

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Coding for Compression of Low-Entropy Data

Algorithms can be implemented in relatively simple circuits.

Goddard Space Flight Center, Greenbelt, Maryland

An improved method of encoding digital data provides for efficient lossless compression of the partially or even mostly redundant data from a low-information-content source. Typically, the average information content of such a source is less than 1½ bits per sample. Such a source could be, for example, an image of a small, grey object on an otherwise large, bright background (see Figure 1), and the data samples are the digitized brightness levels of pixels. This method of coding can be implemented in relatively simple, high-speed arithmetic and logic circuits. This method of coding also increases the coding efficiency beyond that of the established Huffman coding method in that the average number of bits per code symbol can be less than 1, which is the lower bound for a Huffman code.

The derivation of the method begins with a set of N nonnegative source symbols, $S = \{s_0, s_1, s_2, ..., s_{N-1}\}$, where $s_i = i$ represents a pixel brightness level or a mapped difference between two brightness levels, $N = 2^n$, and n is the number of bits to which the brightness levels are digitized. The pixel brightness levels are digitized sequentially in a raster scan, and the difference between the brightness levels of two successive pixels is mapped into symbol set S.

Consecutive symbols in S are paired or grouped in threes, forming a new symbol set, $\Gamma = \{\gamma_0, \gamma_1, \gamma_2, ..., \gamma_M\}$, where $M = N^2$ for twosomes or N^3 for threesomes, Γ is said to be the second or third extension of S (depending on whether twosomes or threesomes are used), and the code is denoted the second- or third-extension code accordingly. The second-extension code is optimal from about 0.75 to about 1.5 bits per sample; the third-extension code is optimal at approximately....≤ 0.75 bit per sample.

The twosomes or threesomes are mapped into a comma code — a code in which every code word ends with the same code pattern, as though the pattern denoted a comma or other, equivalent separation mark. In this comma code, the code word for an integer m is m zeros followed by a one; for example, the comma code for symbol $\gamma_4 = 4$ fol-

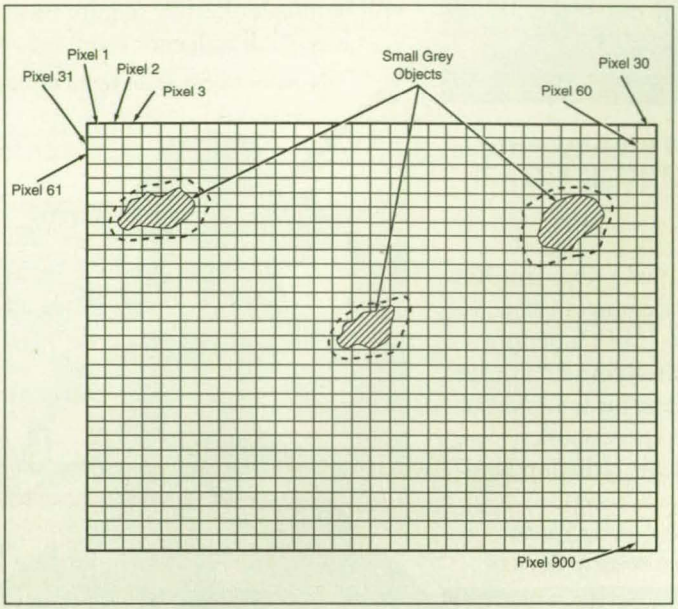


Figure 1. **On the Average, Each Pixel Contains Little Information** because the brightness levels of most pixels are the same. Only the pixels within the dashed outline contain changes in brightness levels.

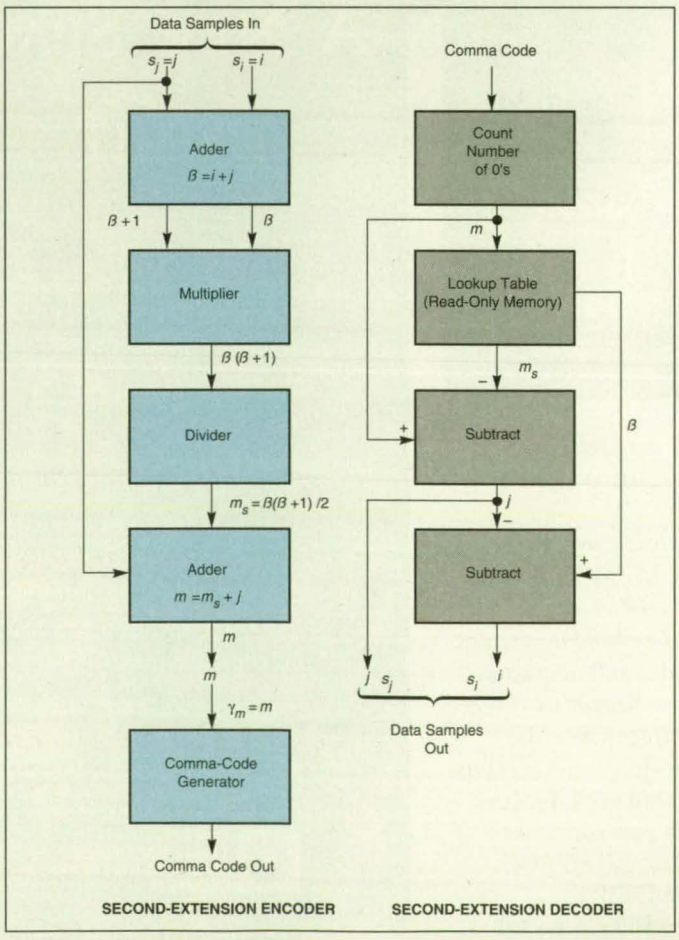
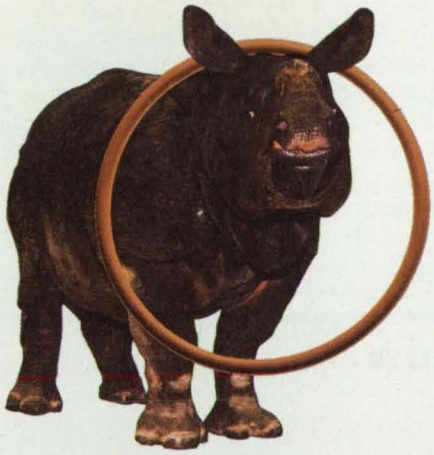


Figure 2. **Relatively Simple Arithmetic and Logic Circuits** can be used to implement the coders and decoders.

Seal Problems?

Too Large?



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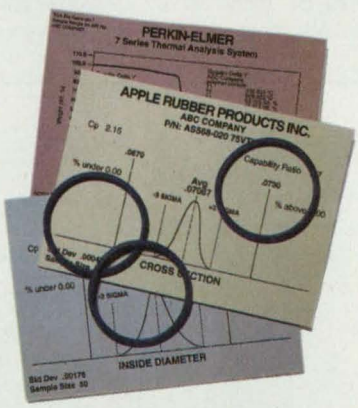

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lowed by symbol γ_2 = 2 is 00001001. This scheme enables the coding of the n-bit differences between successive pixel brightness levels without the need for codebooks.

Figure 2 shows block diagrams of second-extension encoding and decoding circuits. Each successive pair of consecutive data samples is presented to the adder in the encoding circuit. The adder generates the sums ß and ß+1. These sums are multiplied, then divided by 2 (for example, by use of a shift register) to obtain m_s. A second adder computes $\gamma_m = m = m_s + j$. Then $\gamma_m = m$ is fed to a comma-code generatator.

At the input end of the decoding circuit, $\gamma_m = m$ is obtained by counting zeros in the comma code. Then m_s is generated from m by use of lookup-table data from a read-only memory. A subtractor then computes $j = m - m_s$. A second subtractor computes ß–j to obtain i. Thus, the input data symbols $s_i = i$ and $s_j = j$ are reconstructed. The arithmetic units in the coder and decoder can be configured according to a "pipeline" dataflow concept, using registers. The circuits can be designed and constructed according to well-known methods.

This work was done by Pen-Shu Yeh of **Goddard Space Flight Center**. *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, Goddard Space Flight Center [see page 22].
Refer to GSC-13486.

Windowless Airplane With a View

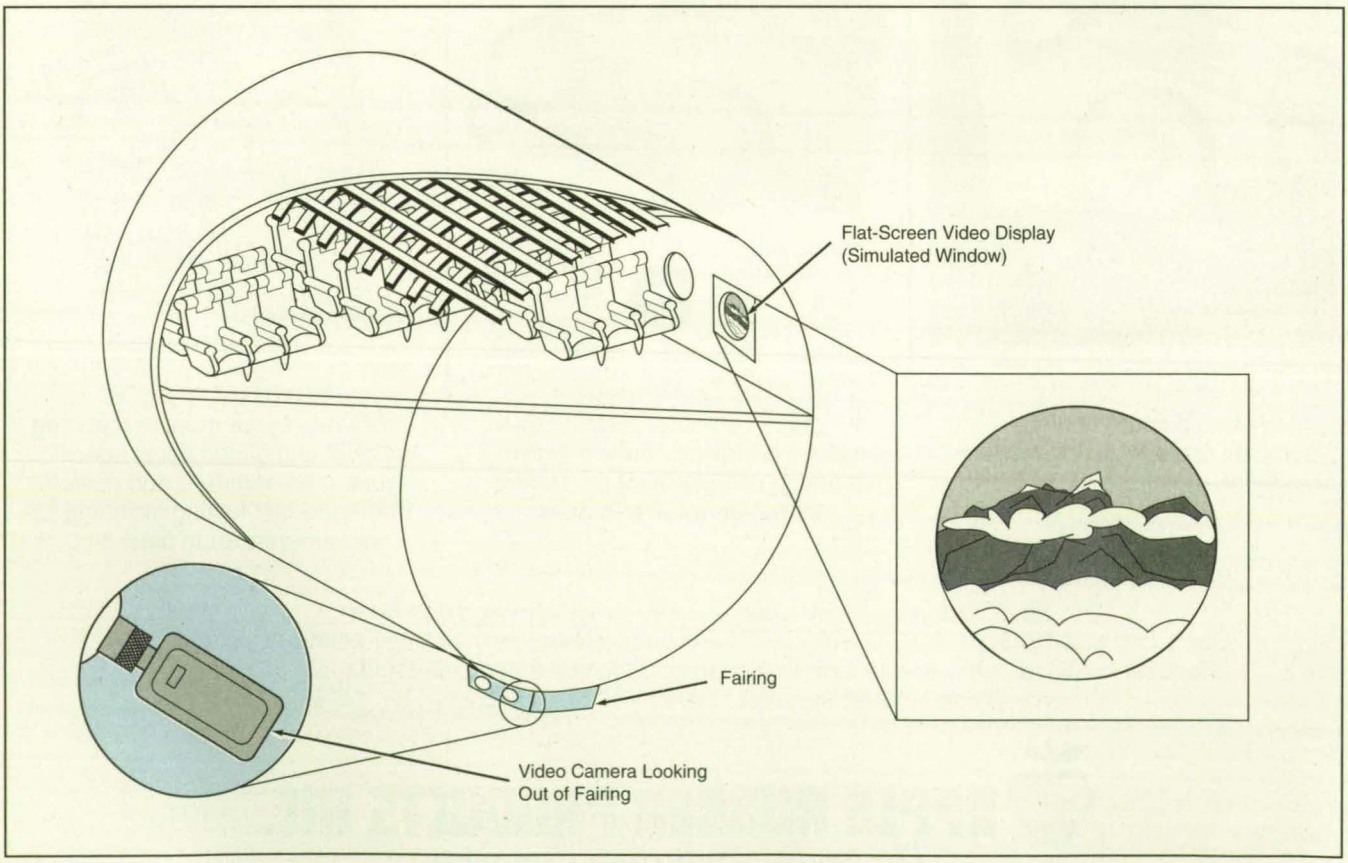
Television would replace windows.

Langley Research Center, Hampton, Virginia

A proposed windowless passenger airplane would give passengers views of the outside but would be stronger, weigh less, and cost less than does a conventional airplane of equivalent capacity. The ordinary see-through windows of today's commercial aircraft would be replaced by flat-panel color television screens connected to outward-looking video cameras in the fuselage.

Ordinary see-through windows involve many openings in the fuselage — openings that weaken it and create opportunities for leakage of air from the cabin. Seals are needed to prevent leakage, and the openings around the windows must be reinforced to neutralize concentrations of stresses. Windowed aircraft are also more difficult to design, fabricate, and test.

In the windowless airplane, high-resolution flat video displays would be placed at passenger positions throughout the cabin. They would display views from any of several cameras aimed in various directions from the air-



Video Cameras and digitizing equipment in an aerodynamic fairing would provide images for artificial windows placed around an aircraft cabin.

craft. Without the window openings, it would be easier to make the fuselage out of such advanced materials as metal composites or filament-wound composites.

Remote-viewing schemes are already in use in public transportation. Several airlines have experimented with providing passengers with television views of runways during takeoffs and landings.

This work was done by Huey D. Carden of **Langley Research Center**. *No further documentation is available. LAR-14880*

Video Game Adapts to Brain Waves

Children with attention-deficit disorder are trained to be more attentive.

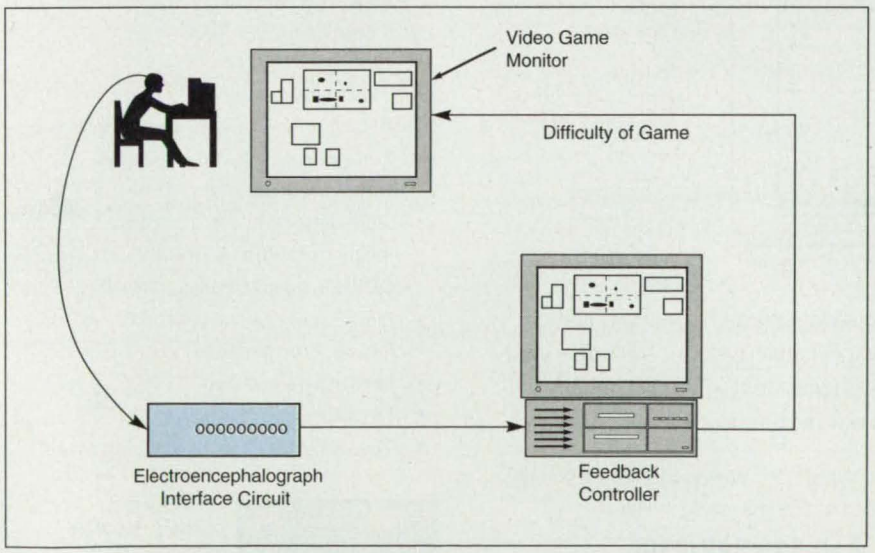
Langley Research Center, Hampton, Virginia

An electronic training system based on a video game is being developed to help children afflicted with attention-deficit disorder (ADD) learn to prolong their attention spans. (Children who have ADD are unable to sustain their attention long enough to do schoolwork or join in organized play.) This training system is an outgrowth of a biocybernetic system that has been used to assess the best mixture of automation and pilot control in a flight-control system — a mixture that can hold the pilot's attention without creating an overload of tasks. This training system might be useful in augmenting biofeedback training for ADD. It would enable trainees to demonstrate and improve skills learned in earlier biofeedback training.

This training system uses a combination of electroencephalography (EEG) and adaptive control (see figure) to encourage attentiveness. The system monitors the trainee's brain-wave activity: if the EEG signal indicates that attention is waning, the system increases the difficulty of the game, forcing the trainee to devote more attention to it.

The game is designed to make trainees want to win and, in so doing, learn to pay attention for longer times. It presents an outer-space battle scenario in which the player pilots a fighter ship in an attempt to reach and explode an enemy base while warding off attacks from the defenders of the base. The video screen displays the action in a window with crosshairs and presents data on speeds, distances to targets, and statuses of weapons. The trainee uses a joystick to aim at and fire upon targets.

At first, the adaptive control makes the game virtually impossible to win because of the overwhelming number of defenders and their evasive maneuvers. However, as the player concentrates and focuses attention, the game is made more manageable. This is done by programming the number and movement of targets as a function of a numerical index, derived from the components of the player's EEG signal in three frequency bands, that increases



The **Difficulty of the Game** is adjusted according to the player's attentiveness: an index of attentiveness is computed from the player's EEG signals.

with the degree of the player's mental engagement.

The player learns that winning is contingent on maintaining attention, even as the game becomes less compelling. The attentive state is explained to the player as a special mental power; that is, being attentive invokes the power to win.

The EEG signal is sensed at a single scalp site and conditioned by an inexpensive circuit before it is fed to the serial port of the game computer. Frequency analysis, computation of the mental-engagement index, and control of the game are done by software.

This work was done by Alan T. Pope of **Langley Research Center** *and Edward H. Bogart of Lockheed Engineering & Sciences Co. For further information,* ***write in 12*** *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 22].
Refer to LAR-15022.

Electronic, Hand-Held, Wireless Text-and-Graphics Viewer

This device would electronically present information in newspaper format.

Langley Research Center, Hampton, Virginia

A proposed electronic, hand-held, wireless viewer would present written material to the reader in a way that closely resembles that of paper reading material. The viewer would present text and graphics like those normally found in books, newspapers, and magazines. Its hand-held and wireless features would enable it to be used in positions and areas where books and magazines are normally used, thus contributing to the general acceptance of this device by the public at large.

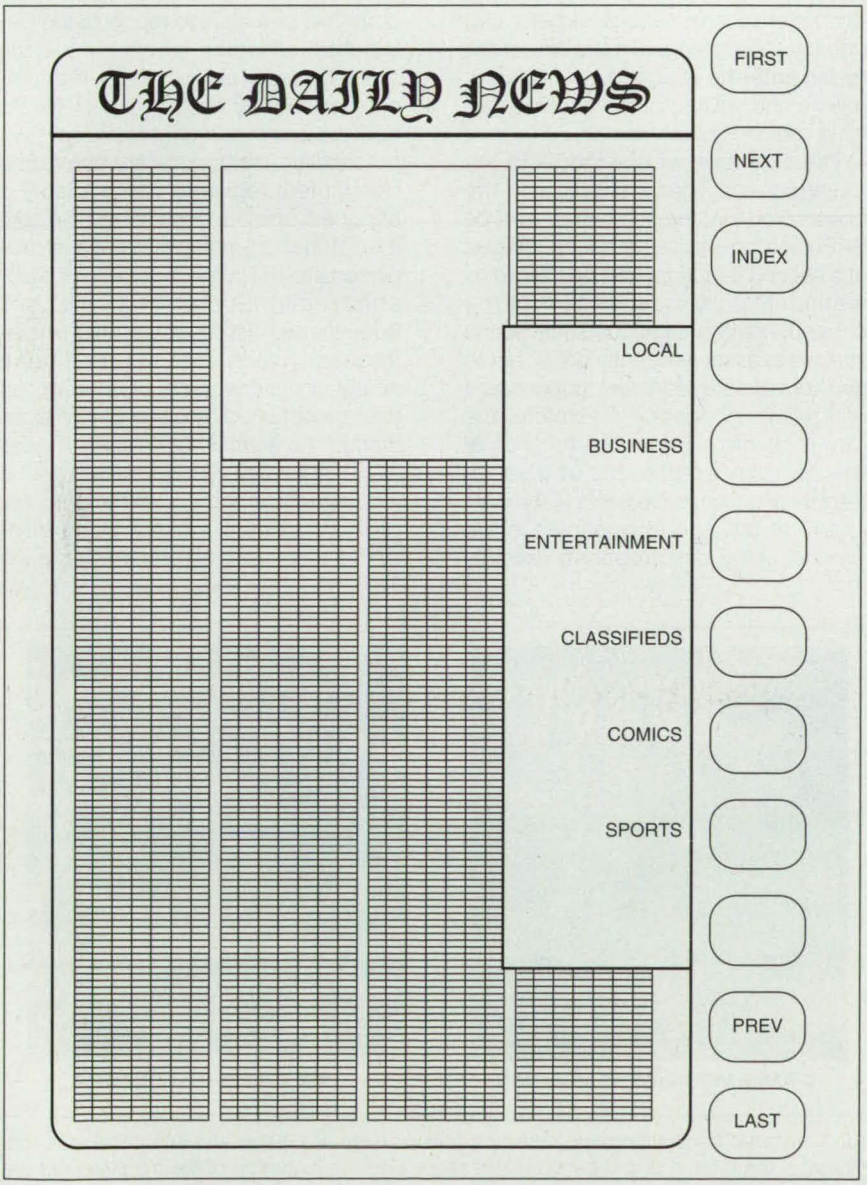
The device would consist primarily of two parts: the receiver/information store and the viewing screen. The receiver/information store would receive, decode, and store text and graphics that would be transmitted over a television channel and received through either cable or an antenna. The viewing screen would communicate over a wireless channel (either radio-frequency, ultrasound, or infrared) with the receiver/information store. A prime example of the use of this device would be the viewing of an "electronic newspaper." When the newspaper was ready to "print" its edition, the material would be transmitted over cable television lines or over standard broadcast channels. The subscriber's receiver/information store would decode and store this transmission for viewing at the subscriber's convenience.

When a subscriber wished to read the news, the subscriber would use the viewer, which would be designed with a large, clear, liquid-crystal screen.

Controls along the right side of the viewer would enable the user to "page" through the material as though looking through the pages of a newspaper. The controls would provide such functions as FIRST, LAST, NEXT, PREVIOUS, and a section of indexing keys. For example, the keys could be used to "turn" to section C. The wireless link would enable the user to take the viewer to other rooms and read the material in much the same way as in reading a piece of paper. The viewer would also provide animated graphics: this feature would be of significant interest to advertisers.

All elements of the technology necessary to construct this device are already available. The device would differ from a conventional laptop computer/modem combination in that it would be designed specifically to display text and graphics in a manner that resembles as closely as possible the written material this device is to replace. Entry of data by the user would be limited to selections from menus and tables. The receiver/information store would enable this device to monitor the information channels continuously so that no special action by the user would be necessary to capture a transmission. The wireless connection would enable the viewer to be used in many rooms of the home or office. This concept of having nonvolatile local information storage via the television network appears quite attractive and should have widespread application in the future.

This work was done by Daniel L. Palumbo of **Langley Research Center**. *No further documentation is available.*
LAR-14727



A **Simple Menu of Familiar Selections** would enable the user to "turn" to the desired section of the electronic newspaper.

Segmentation of Multifrequency Complex-Amplitude SAR Data

Speckle and the grouping of region labels are modeled on physical and probabilistic bases, respectively.

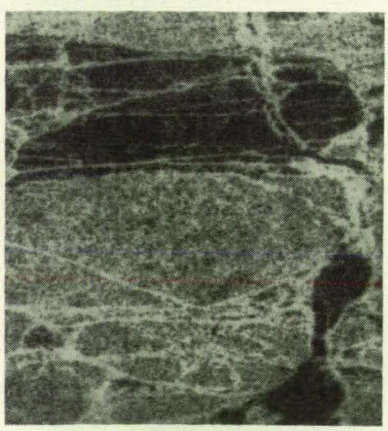
NASA's Jet Propulsion Laboratory, Pasadena, California

Several mathematical models and associated algorithms implement a method of segmenting a multifrequency, highly speckled, high-resolution, complex-amplitude (amplitude and phase) synthetic-aperture-radar (SAR) digitized image into regions, within each of which radar backscattering characteristics are similar or homogeneous from place to place. Typically, each region represents a different type of terrain or other surface; e.g., forest, agricultural land, sea ice, or water.

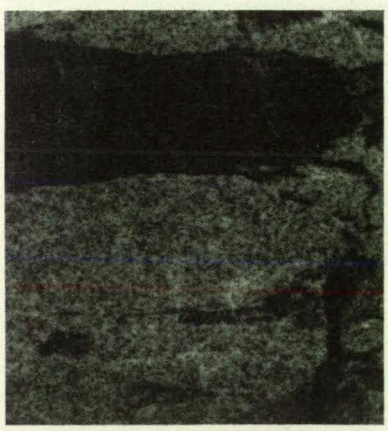
This method of segmentation of the SAR scene into regions is a product of generalization, to the multifrequency case, of the single-frequency method described in "Algorithms for Segmentation of Complex-Amplitude SAR Data" (NPO-18524), *NASA Tech Briefs,* Vol. 17, No. 6 (June, 1993), page 28. One of the mathematical models used in that single-frequency version and in the present multifrequency version is that of speckle, which is a form of noise that manifests itself in a granular appearance of an SAR image and which degrades radiometric resolution. Speckle is caused by interferences among coherent radar returns from multiple scatterers within each affected resolution element. The mathematical model of speckle is based on the physics of the SAR transmitting, receiving, and return-signal-processing subsystems. This model accounts for the impulse-response function of the synthetic-aperture antenna (as modified in processing of the return signals to reduce sidelobes), the backscattering characteristics of various targets, and uncontrolled changes in the aim of the radar antenna (caused by pitching, rolling, and yawing of the airplane carrying the SAR equipment).

The extension of this model to the multifrequency case begins with the observation that the complex-amplitude SAR data on the same scene imaged at a second frequency can be treated as mathematically independent of the corresponding data on the same scene imaged at a first frequency because the two sets of data represent independent realizations of speckle. Therefore, the joint probability distribution function of the complex amplitudes of a set of neighboring picture elements in the SAR image at the two frequencies is the product of the joint probability distribution function of the complex amplitudes for the first frequency and that for the second frequency. The joint probability distribution functions include determinants of correlation matrices that are derived from the physical models of speckle at the two frequencies.

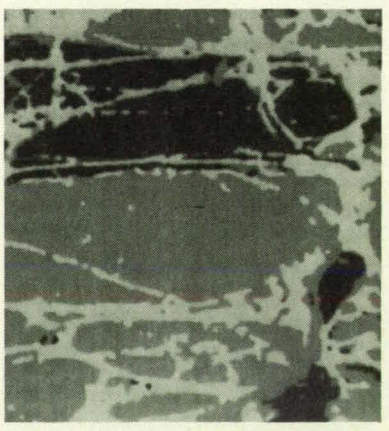
As in the prior single-frequency version of the method, the model of speckle is combined with a Markov-random-field probabilistic model of the distribution of region labels across the scene by use of Bayes' rule. In the combination model, each group of neighboring picture elements for which joint probability distributions are computed constitute a region to which a label is assigned, and the conditional probability distribution of region labels is proportional to the product of the joint probability distributions for the two frequencies. Also as in the prior single-frequency version of the method, a nearly optimal labeling of regions can then be obtained by either of two algorithms: the iterative conditional modes (ICM) algorithm, which optimizes the reconstruction of the underlying scene; or the maximum posterior marginal (MPM) algorithm, which maximizes the



L-BAND, HORIZONTAL POLARIZATION



C-BAND, VERTICAL POLARIZATION



ICM CLASSIFICATION MAP

Ice on the Beaufort Sea was detected by SAR in horizontal transmitting and receiving polarizations at L-band and in vertical transmitting and receiving polarizations at C-band. Brightness in the L-band and C-band images represents the logarithm of the magnitude of the comples SAR amplitude. The ICM classification map produced from the complex-amplitude SAR data contains three classes or region types. In order of decreasing brightness, they represent ridges, multiyear ice, and first-year ice, respectively.

expected number of correctly classified picture elements. The figure presents an example of a classification map obtained by use of the ICM algorithm.

This work was done by Eric J. Rignot and Ramalingam Chellappa of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 80*** *on the TSP Request Card. NPO-18516*

Improved Bubble-Point Test

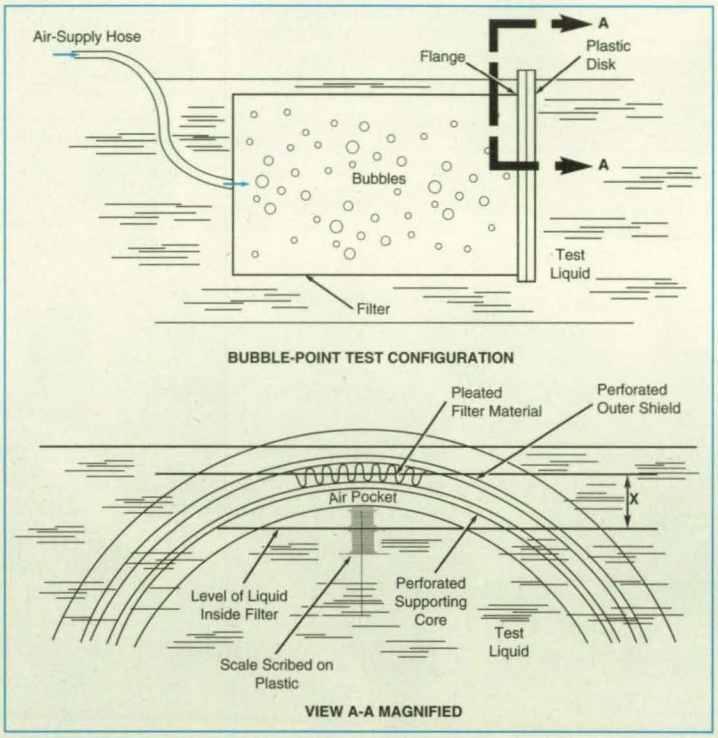
Sizes of pores in filters are determined more accurately.

John F. Kennedy Space Center, Florida

An improved bubble-point test has been devised for large pleated filter elements. (In a bubble-point test, one measures the pressure needed to bubble air or another gas through a wet filter element, then infers the size of the largest pore in the filter element from the known relationship between the surface tension of the wetting liquid, the size of the pore, and the pressure needed to overcome the capillary force created by the surface tension.) The improved bubble-point test method replaces an older test that was accurate for pore sizes of 20 microns or less, but was subject to gross inaccuracy for filter elements with pores of 70 microns or larger. For example, the older test applied to one large diameter (30 cm) 175-micron filter element yielded a pore-size value of only 21 microns.

In the improved test (see figure), the filter element to be tested is first immersed in a liquid in a test tank and becomes totally wetted. A clear plastic disk, on which a depth scale has been scribed, is placed on one end of the filter element. A tube from a pressurized air supply is connected to a small central hole at the other end of the filter element.

The filter element is gradually pressurized with air until a stream of bubbles just begins to emerge from its pores (the bubble point). At this moment, the height of the air pocket within the filter element is read from the scale on the plastic disk. This height is proportional to the bubble-point pressure. Then the measured height of the air pocket multiplied by the specific gravity of the test fluid results in standard bubble-point pressure. Pore size can then be computed by dividing the resultant standard bubble-point pressure into the bubble-point constant published for the particular type of filter under test.



The **Clear Plastic Disk** seals one end of the saturated filter element. The scribed scale indicates height of the pressurized air pocket. The pore size as a function of this height can then be computed.

Unlike in the older test, no measurement of pressure is necessary. Thus, one avoids errors that could be caused by liquid in pressurizing and/or pressure-measuring probe tubes. Also unlike in the older test, there is no need to estimate the average depth of the filter-element pleats below the surface of the liquid.

This test can also be carried out as a go/no-go inspection: The immersed filter element is pressurized to form a pocket of air of a specific depth. The filter element is then rotated 360° about its axis in the liquid. If no bubbles appear, then the filter element is deemed to have pores no larger than the size associated with the bubble-point pressure at the preset depth.

This work was done by Peter J. Welch and Russell E. Rhodes of **Kennedy Space Center** *and Robert Aman and Zoltan Nagy of Wiltech Inc. For further information,* ***write in 62*** *on the TSP Request Card. KSC-11512*

Using Distributed Targets To Determine SAR Antenna Patterns

Computations include subtraction of noise, a test for uniformity, and a least-squares estimate.

NASA's Jet Propulsion Laboratory, Pasadena, California

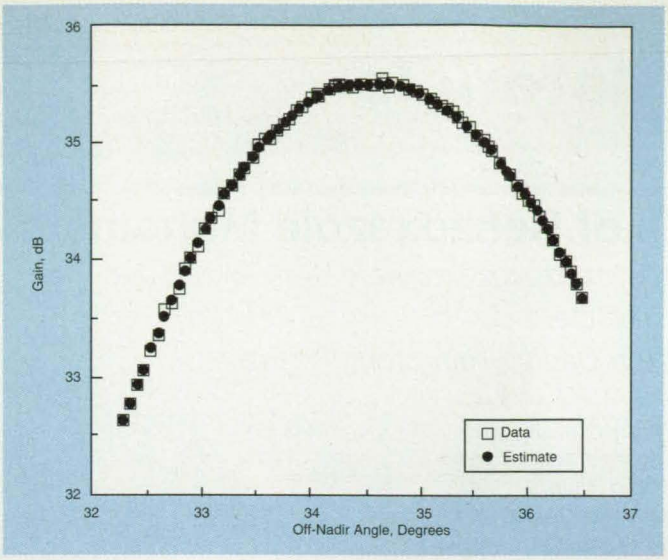
An improved method of determining the radiation pattern of a synthetic-aperture radar (SAR) antenna with respect to the elevation-angle coordinate (angle of roll about the flight path) has been devised. The essence of the method is to solve the radar equation in such a way as to enable the extraction of the antenna pattern from SAR images of uniform distributed targets. Such a method of determining the radiation pattern from in-flight measurements is needed

because electromagnetic interactions between the antenna and the aircraft or spacecraft surface on which it is installed, plus deformations of the antenna during installation and flight, can alter the radiation pattern; that is to say, the radiation pattern in flight can differ from that observed in a laboratory test of the antenna.

With respect to SAR targets distributed over a given area, "uniform" here means that the coefficients of backscattering by the targets are either independent of angle of incidence or else vary in a known way as a function of this angle; by extension, "uniform" also means that every SAR image datum within the given area is distributed statistically according to the same specific distribution function. The first step of the method is to divide an SAR image of interest into small cells and to analyze the image textures in the cells by use of a c^2 similarity test. Only those cells found to be uniform by this test are retained; those found to be nonuniform are excluded from the subsequent computations.

The second step of the method is to subtract the estimated noise from the image data in the solution of the radar equation. The third step is to estimate the antenna pattern stochastically as the solution of a maximum-likelihood estimation problem; essentially, this involves an iterative least-squares estimation procedure.

The method was tested by applying it to selected SAR images from the Spaceborne Imaging Radar B (SIR-B) mission, including tropical and arboreal forests and temporate-zone farmland. The best fit for the estimated antenna gain as a function of angle was obtained with data from the Amazon rain forest (see figure).



The **Estimated Gain** of the antenna as a function of angle, as fitted to these data, exhibits a residual error of less than 0.08 dB.

This work was done by Anthony Freeman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in70*** *on the TSP Request Card.*

NPO-18744

Synthesis of Benzoxazole Monomers and Polymers

Di(hydroxyphenyl)benzoxazoles were synthesized and then polymerized with aromatic dihalides.

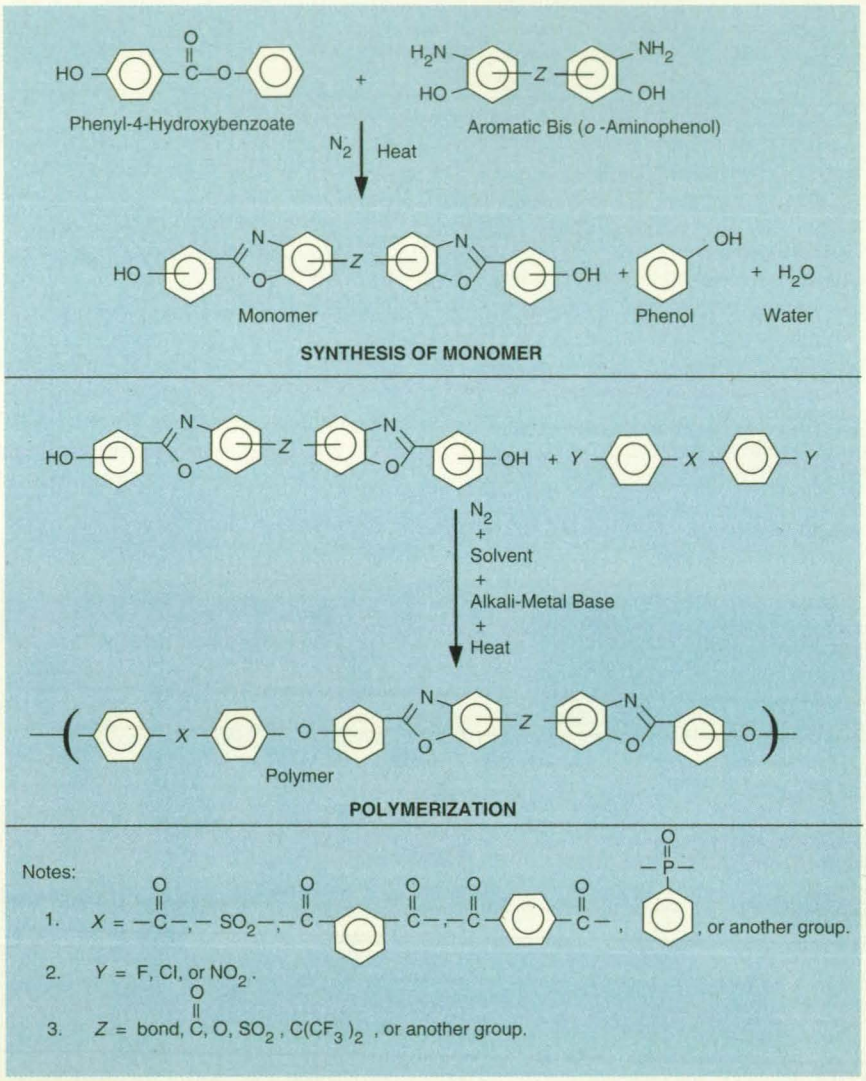
Langley Research Center, Hampton, Virginia

Di(hydroxyphenyl)benzoxazole monomers have been synthesized by the condensation reaction of phenyl-4-hydroxybenzoate with aromatic bis(*o*-aminophenol)s. The monomers were then polymerized by nucleophilic-displacement reactions between them and activated aromatic dihalides to produce new polybenzoxazoles. In comparison with previous routes to the synthesis of polybenzoxazoles, this one is simpler and more economical. The new polybenzoxazoles may prove useful as adhesives, coatings, films, membranes, molding compounds, and composite matrices.

The inherent viscosities of the newly synthesized polybenzoxazoles ranged from 0.25 to 1.04 dL/g, and the glass-transition temperatures ranged from 214 to 285 °C Differential scanning calorimetry revealed that several of the polymers have crystalline melting temperatures that range from 373 to 446 °C. Thermogravimetric analysis of these polymers at a heating rate of 2.5 °C/min showed no loss of weight below 300 °C in air or nitrogen, and a 5-percent loss of weight at about 485 °C in air, and at about 500 °C in nitrogen.

As indicated schematically in the upper part of the figure, 1 mole of each monomer is prepared by reacting 2 moles of phenyl-4-hydroxybenzoate with 1 mole of a specific aromatic bis(*o*-aminophenol) while heating the reaction mixture in a nitrogen atmosphere. The products of the reaction are water, phenol, and the monomer.

The lower part of the figure schematically illustrates the nucleophilic-displacement reaction in which polybenzoxazoles are produced from the monomers. The best results are obtained when the leaving group (*Y*) is F or Cl, although the leaving group can also be NO_2. The most effective solvent for this reaction is either N,N-dimethylacetamide or diphenylsulfone, although one could use any other polar aprotic solvents such as N-methylpyrrolidinone, sulfolane, N-cyclohexylpyrrolidinone, or dimethylsulfoxide. The alkali-metal base can be potassium carbonate, sodium carbonate, potassium hydroxide, or sodium hydroxide. Especially good results are obtained if *Z* is either nothing or $C(CF_3)_2$ and if *X* is among the groups specifically indicated in the figure.



Di(hydroxyphenyl)benzoxazoles were synthesized in reactions like the one shown at the top, then polymerized in reactions like the one shown at the bottom.

This work was done by Paul M. Hergenrother and John W. Connell of **Langley Research Center** *and Joseph G. Smith, Jr., of the University of Akron. For further information,* ***write in 65*** *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 22].

Refer to LAR-14606.

Metal-Ion Additives Reduce Thermal Expansion of Polyimides

Reductions range from 11 to over 100 percent.

Langley Research Center, Hampton, Virginia

Polyimides have become widely used as high-performance polymers because of their excellent thermal stability and toughness. However, their coefficients of thermal expansion (CTE's) are greater than those of metals, ceramics, and glasses. Decreasing the CTE's of polyimides would increase their usefulness for aerospace and electronic applications in which dimensional stability is required. Accordingly, research was performed at NASA Langley Research Center to develop polyimides that have low CTE's.

The CTE's of conventional polyimides range from 30 to 60 parts per million (ppm)/°C. Heretofore, lower CTE's were obtained by linearizing polymer molecular structures or by use of controlled orientations of molecules in polyimide films. In this research, the CTE's of polyimide films and coatings have been lowered by the incorporation of additives that contain metal ions.

The preparation of a polyimide film or coating material that contains metal ions involves the addition of an additive that contains metal ions to either (1) a polyamic acid resin prepared by the room-temperature reaction, in a solvent, of an aromatic diamine with an aromatic dianhydride or (2) a solution of a soluble polyimide. The additive that contains metal ions can be added immediately following the addition of the dianhydride or after the polymerization of the polyamic acid is complete.

The following additives that contain metal ions were used in this research:

- The chlorides of the following lanthanides: terbium ($TbCl_3$), dysprosium ($DyCl_3$), erbium ($ErCl_3$), and thulium ($TmCl_3$).
- Other compounds that contain lanthanide metals, including holmium acetate [$Ho(OOCCH_3)_3$], erbium N-phenylphthalamate [$Er(nppa)_3$], and erbium acetylacetonate [$Er(C_5H_7O_2)_3$ or $Er(acac)_3$].
- Other metal-ion-containing additives that resulted in reduced CTE's, including tin chloride ($SnCl_2$) and aluminum acetylacetonate [$Al(C_5H_7O_2)_3$].

Successful results were obtained with additives in the concentration range of 4 to 30 weight percent.

The incorporation of metal ions resulted in reductions in the CTE's of the polyimides, ranging from 11.8 percent with the addition of $DyCl_3$ to over 100 percent with the addition of $TmCl_3$ (resulting in a negative CTE). Actual values are shown in the table. It is anticipated that these low-CTE polyimides will prove useful as film and coating materials for both industrial and aerospace applications in which dimensional stability, mechanical strength, and thermal stability are required.

Polyimide	Additive	Percent of Additive	Coefficient of Thermal Expansion, ppm/°C
Made from polyamic acid resin prepared by reaction of diamine and dianhydride	None	None	35.7
	$TbCl_3$	11.3	20.5
	$DyCl_3$	11.4	31.5
	$ErCl_3$	11.6	18.2
	$TmCl_3$	11.6	–23.4
Commercial soluble polyimide powder	None	None	50.7
	Ho $(OOCCH_3)_3$	13.4	38.9
	Er $(nppa)_3$	28.6	31.6
	Er $(acac)_3$	17.3	26.4

Additives That Contain Metal Ions reduce the coefficients of thermal expansion of polyimides.

This work was done by Diane M. Stoakley, Anne K. St. Clair, Burt R. Emerson, Jr., and George L. Willis of **Langley Research Center**. *For further information,* ***write in 95*** *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 22].

Refer to LAR-14538.

Computer Programs

COSMIC: Transferring NASA Software

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

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Physical Sciences

Modified SEAGULL

This program analyzes two-dimensional, hypersonic flows of real gases.

The SEAGULL computer program was originally developed to model internal and external inviscid, perfect-gas supersonic flow fields. Utilizing a floating shock-fitting technique, it gives a quick and accurate evaluation of flow-field geometries to determine performances of supersonic inlets and nozzles to first order.

The original version of this program was incorporated into the program SRGULL (LEW-15093) for use on the National Aero-Space Plane project, its duty being to model the forebody, inlet, and nozzle portions of the vehicle. However, the real-gas chemistry effects in hypersonic flow fields limited the accuracy of that version, because it assumed perfect-gas properties. Particularly, the nozzle calculations were constrained, inasmuch as the program was unable to account for those variations in properties of flows that are attributable to the presence of products of the combustion of hydrogen.

As a result, SEAGULL has been modified according to a real-gas equilibrium-chemistry methodology. The governing equations have been modified to incorporate real-gas equilibrium variations of specific heat and molecular weight in the flow field. Also, new shock and expansion routines have been incorporated to account for changes in the affected properties of gases encountered. Finally, a chemistry routine has been added to provide properties of air as well as to account for products of the combustion of hydrogen. This modified version of SEAGULL maintains as much of the original program as possible, and it retains the ability to execute the original perfect-gas version.

SEAGULL is written in FORTRAN 77 and can operate on IBM PC series computers or compatibles running MS-DOS 2.1 or higher. The executable code included on the distribution medium was created with the IBM FORTRAN/2 compiler and requires a math coprocessor and 236K of main memory. The source code has been successfully compiled by use of Lahey FORTRAN. The program source code and executable code are compressed by use of the PKWARE archiving tools. The utility to unarchive the files, PKUNZIP.EXE, is included. SEAGULL was developed in 1990.

IBM PC is a registered trademark of International Business Machines Corp. MS-DOS is a registered trademark of Microsoft Corp. Lahey is a registered trademark of Lahey Computer Systems, Inc.

This program was written by M. D. Salas of Langley Research Center and was modified by M. S. Kuehn of Propulsion Research and Simulation for **Lewis Research Center**. *For further information,* ***write in 15*** *on the TSP Request Card.*
LEW-15326

Computing Thermodynamic and Transport Properties of Air

EQAIRS computes properties from an 11-species, curve-fit mathematical model.

The EQAIRS computer program is a set of FORTRAN 77 routines for computing the thermodynamic and transport properties of equilibrium air for temperatures from 100 to 30,000 K. EQAIRS computes these properties at pressures from 10^{-4} to 10^{2} atm (about 10 Pa to 10 MPa). The properties computed include enthalpy, total specific heat, compressibility factor, viscosity, and the total values of thermal conductivity and Prandtl number.

The various properties are calculated through the use of temperature-dependent curve fits for the pressure range mentioned above. The curve fits are based on mixture values calculated from an 11-species mathematical model of air. Those properties of individual species that are used in computing the properties of the mixture were obtained from a recent study by the authors of the program. It is desirable to compute these properties of equilibrium air by curve fits rather than to use tabulated values because curve fits generally enable more-efficient computation for analyses of flow fields. In addition, for accurate calculations, it is preferable that the thermodynamic and transport properties be computed in a self-consistent manner from the same set of data as in the present case.

The EQAIRS routines were written in the form of FORTRAN subroutines for easy adaptation to existing programs. The subroutines are commented and can be easily modified to suit the user's needs. In an attempt to maintain generality, a total of six separate subroutines are available for use: (1) ENTHLPY (specific enthalpy); (2) SPECIFC (total specific heat at constant pressure); (3) COMPRES (compressibility factor); (4) VISCSTY (viscosity); (5) CONDUCT (total thermal conductivity; and (6) PRANDTL (total Prandtl number).

EQAIRS has been successfully implemented on a DEC VAX-series computer running VMS, a Sun4-series computer running SunOS, and an IBM PC-com-

patible computer running MS-DOS. Sample input/output and a sample driver program are provided. The standard distribution medium for EQAIRS is one 5.25-in. (13.34-cm), 360K diskette in MS-DOS format. This program is also available on a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format. EQAIRS was developed in 1991.

This program was written by Richard A. Thompson and Roop N. Gupta of **Langley Research Center** *and Kam-Pui Lee of Vigyan, Inc. For further information,* ***write in 66*** *on the TSP Request Card.*

LAR-14760

Machinery

Program for Optimization of Nuclear Rocket Engines

NOP predicts the minimum weight for a specified performance.

A significant amount of time can be spent trying to estimate accurately the weight of a nuclear rocket engine to arrive at the minimum weight for the desired engine performance. This estimation process not only requires the engineer to be knowledgeable about the major dimensions of nuclear rocket engines, but also demands familiarity with the weight characteristics of such engines. NOP is a versatile digital-computer program developed for the parametric analysis of beryllium-reflected, graphite-moderated nuclear rocket engines. The program facilitates the analysis of the performance of an engine with respect to such considerations as specific impulse, engine power, type of engine cycle, and engine-design constraints that arise from complications of fuel loading and internal gradients of temperature.

NOP examines the effects of the principal engine variables and design constraints on the weight or thrust-to-weight ratio of an engine. The program can analyze the effect of specific impulse, engine power or thrust, nozzle-expansion ratio, nozzle-chamber pressure, pressure drop in the core, and diameter of coolant channels on the weight of a nuclear rocket engine. In addition, NOP analyzes an engine that operates on either a hot-bleed cycle, a full topping cycle, or a partial topping cycle. In addition to predicting the minimum weight, NOP produces a variety of preliminary engine designs that readily indicate the weight penalties associated with nonminimum-weight engine designs.

NOP was originally written in FORTRAN and was recently updated to FORTRAN 77 to be machine-independent. It has been successfully implemented on a Sun computer running SunOS, an IBM PC running MS-DOS, and a DEC VAX computer running VMS. It required 95K of random-access memory under SunOS 4.1.1, 163K of random-access memory under MS-DOS 5.0, and 368K of random-access memory under VMS 5-4.3. A sample MS-DOS executable code is provided on the distribution medium. The standard distribution medium for NOP is a set of two 5.25-in. (13.34-cm), 360K diskettes in MS-DOS format. It is also available on a 3.5-in. (8.89-cm) diskette in UNIX tar format. The program was developed in 1965.

SunOS is a trademark of Sun Microsystems, Inc. IBM PC is a trademark of International Business Machines Corp. DEC VAX and VMS are trademarks of Digital Equipment Corp. MS-DOS is a registered trademark of Microsoft Corp. UNIX is a trademark of Bell Laboratories.

This program was originally written by R. K. Plebuch, J. K. McDougall, and F. Ridolphi of TRW, Inc., for **Lewis Research Center**. *It was updated to FORTRAN 77 by James T. Walton. For further information,* ***write in 56*** *on the TSP Request Card. LEW-15474*

Lever-Arm Pin Puller

A puller handle also serves as a retaining spring.

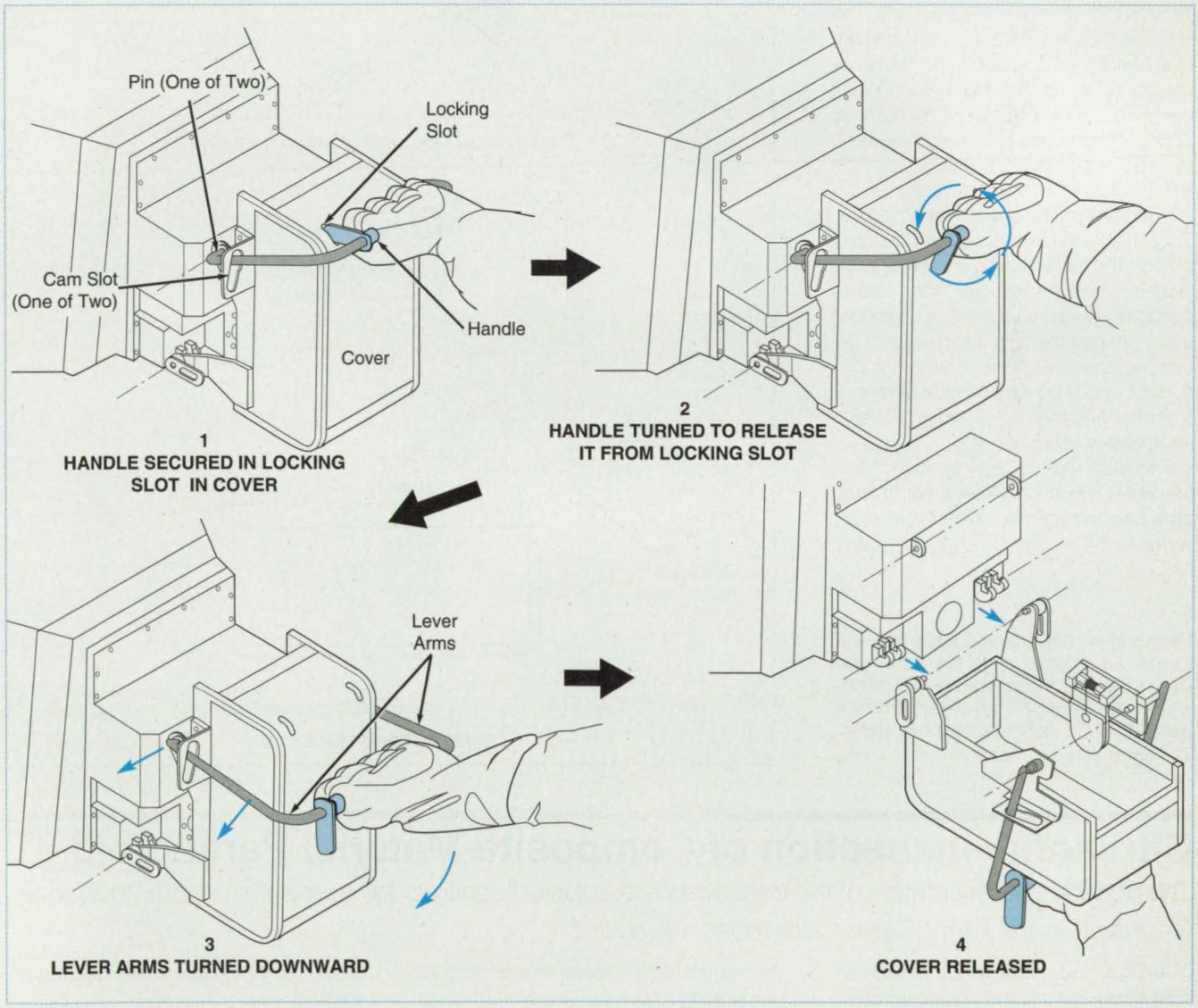
NASA's Jet Propulsion Laboratory, Pasadena, California

A mechanism holds retaining pins in place except when it is actuated to release the pins quickly. The mechanism is an integral part of a cover that is designed to be removed with a simple downward motion of a hand. Before removal, the mechanism secures the cover in place. After removal, the mechanism holds the retaining pins for reuse.

The mechanism includes a U-shaped handle device with two lever arms attached to the retaining pins. The lever arms ride in cam slots (see figure). In the closed position, the spring force of the arm holds the pins in holes in the object to which the cover is attached. To remove the cover, the handle is grasped and pulled downward. This action rotates the lever arms, moving them along the cam slots. This motion causes the pin ends of the arms to spread apart, thereby pulling the retaining pins out of their holes. With further rotation, the cover falls away from the object to which it was attached.

This work was done by Malcolm MacMartin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 92*** *on the TSP Request Card.*

NPO-18788



The **Handle Is Pulled Downward**, causing the lever arms to move in the cam slots. This movement forces the ends of the lever arms outward, and the pins are thereby extracted.

Pin-Retraction Mechanism on Quick-Release Cover

The cover is pivoted until its hinge pins are withdrawn.

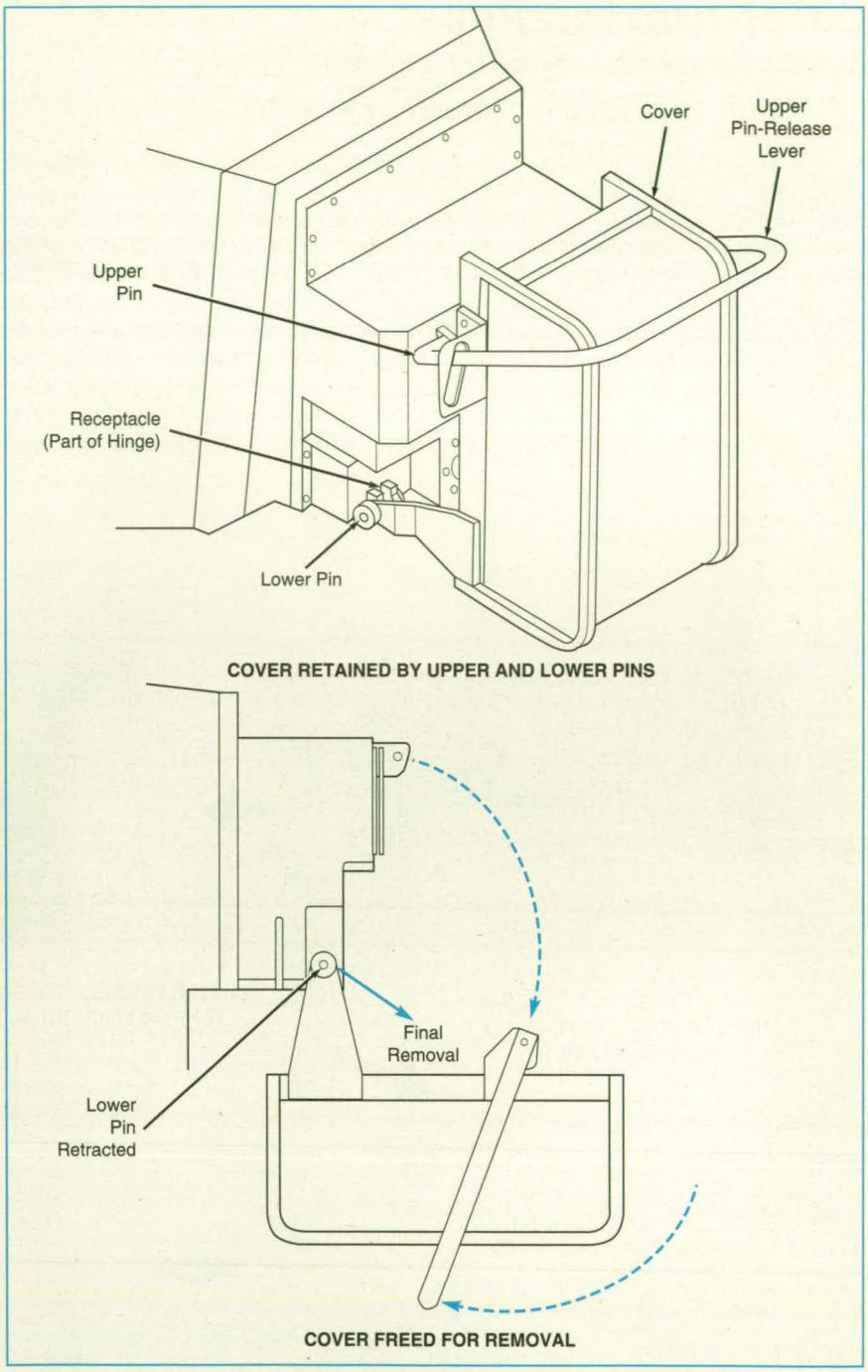
NASA's Jet Propulsion Laboratory, Pasadena, California

A quick-release cover includes a pin-retraction mechanism that releases the cover quickly from the lower of two sets of pin connections that hold the cover. These lower pins are parts of hinges. As the upper end of the cover is rotated away from the object to which the cover is attached, the lower pins automatically disengage from the receptacles on the object. The entire release operation can be done with a thickly gloved hand in a continuous motion.

While the cover remains closed and attached to the object, the pins extend into receptacles in the object, securing the corners of the cover. The cover is released at the top by pulling a lever as described in the preceding article, "Lever-Arm Pin Puller" (NPO-18788). The cover is then free to pivot on the lower pins (see figure). The pivoting of the cover causes a tab on the end of each lower pin to rotate to a slot in its receptacle. Springs pull the tabs out through the slots, thereby withdrawing the pins from the receptacles and freeing the cover.

After release, the cover retains the pins. To reattach the cover, a technician simply pushes the lower hinge pins through the slots into their receptacles, then rotates the cover upward so that the springs once again preload the pins. Mechanisms like this one could be used on cabinet doors. A door could be swung downward or sideways and then detached to give easier access to the cabinet.

This work was done by Malcolm MacMartin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 84*** *on the TSP Request Card.*
NPO-18787



Removal of the Cover begins when a technician or robot pulls the upper-pin-release lever. The cover swings downward until tabs on the lower pins are pulled through slots in their receptacles. The lower pins are then free.

Ultrasonic Inspection of Composite-Material Paraboloid

The position and orientation of the transducer are adjusted continuously to maintain normal incidence.

Goddard Space Flight Center, Greenbelt, Maryland

An ultrasonic imaging system that can scan three-dimensional curved surfaces is being developed. In the original intended application, the system is to be used to determine the integrity of a composite-material paraboloidal reflector and its supporting structure. The system could also be used to inspect composite-material structures with curved surfaces other than paraboloids, provided that the surfaces can be described by mathematical functions.

In ultrasonic imaging to detect subsurface flaws, a specimen is mechanically scanned point by point. The scan plan

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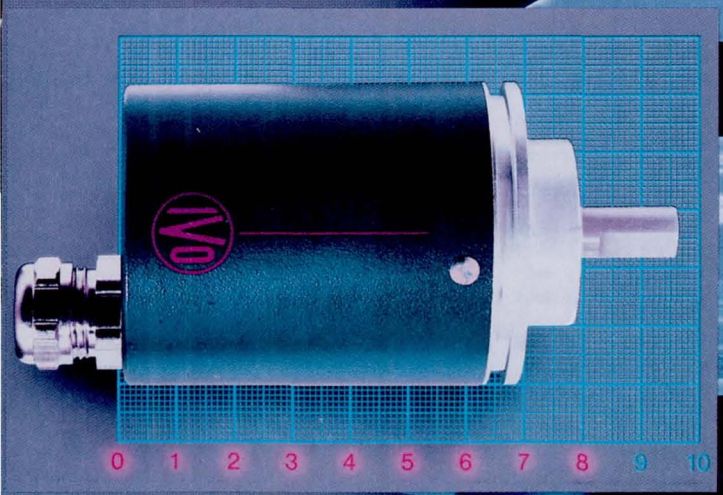

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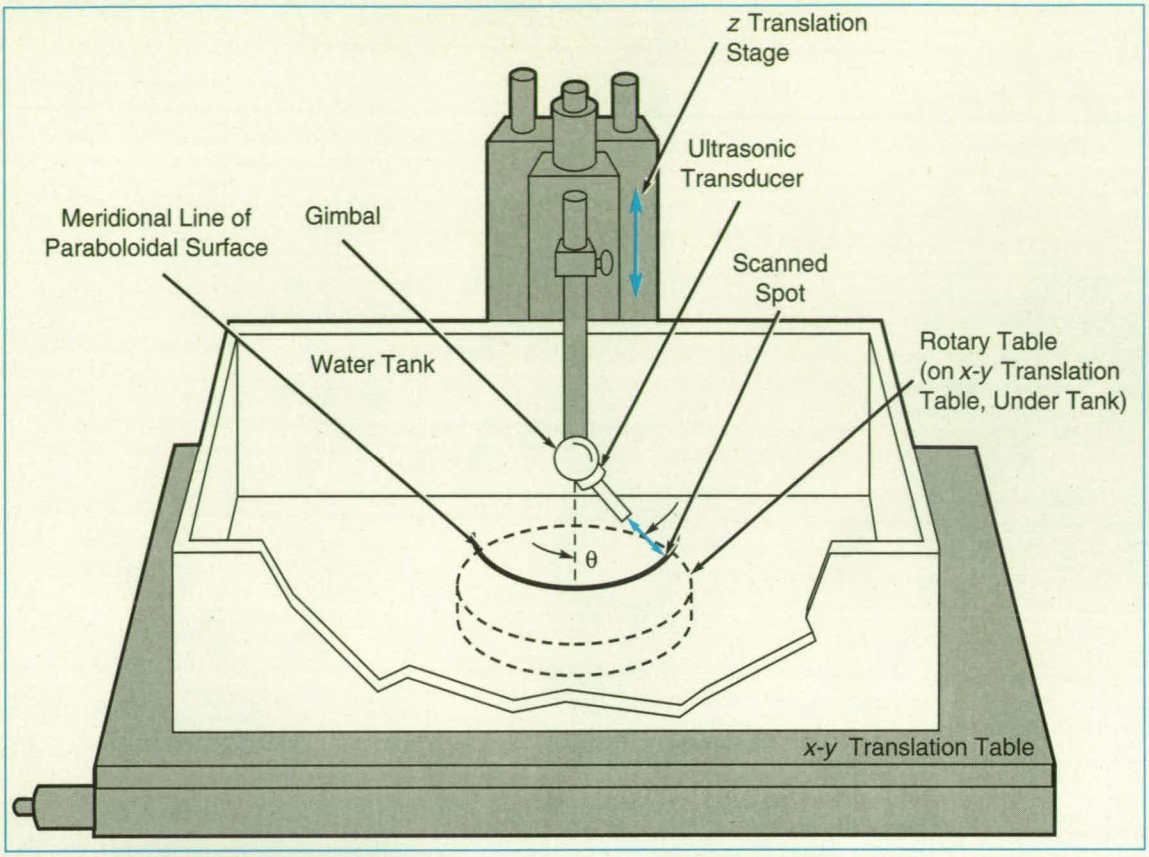


The **System Translates the Transducer** in *z* and orients it in θ while the paraboloidal reflector is rotated.

is straightforward in two-dimensional scanning of a flat specimen: the ultrasonic transducer is moved in two perpendicular directions in a plane parallel to the surface of the specimen while it is held a constant distance from the specimen. However, in three-dimensional scanning of a curved specimen, the position of the transducer must be varied in as many as three dimensions relative to the surface while keeping the transducer aimed along a line perpendicular to the surface at the scanned spot.

In the developmental system, the paraboloid to be scanned is mounted, with its axis vertical, in a tank of water on a rotary table on a horizontal (*x*–*y*) translation table. The ultrasonic probe is mounted on a gimbaled manipulator on a vertical (*z*-axis) translation stage. A computer that controls the system uses the equation that describes the paraboloidal surface to calculate the *z* distance between the transducer gimbal and the vertex of the parabola, the angle off vertical at which the probe must be oriented for normal incidence on the paraboloidal surface, and the distance from the transducer to the paraboloid surface, each as a function of the distance of the scanned spot from the *z* axis. The transducer scans the mirror as the rotary table turns. The system thus generates an ultrasonic-C-scan image of the paraboloidal reflector structure.

This work was done by E. James Chern of **Goddard Space Flight Center**. *For further information,* ***write in 43*** *on the TSP Request Card.*
GSC-13557

Twisted Vanes Would Enhance Fuel/Air Mixing in Turbines

Paint sprayers could also operate with better atomization at lower pressures.

Lewis Research Center, Cleveland, Ohio

Computations of flow have shown that the performance of a high-shear airblast fuel injector in a gas-turbine engine would be enhanced by the use of appropriately proportioned twisted (instead of flat) dome swirl vanes. The resultant more nearly uniform fuel/air mixture would burn more efficiently, emitting smaller amounts of nitrogen oxides. Twisted-vane high-shear airblast injectors could

also be incorporated into paint sprayers, where they would provide the advantages of both the low pressure drop characteristic of airblast injectors in general and the finer atomization of an advanced twisted-blade design.

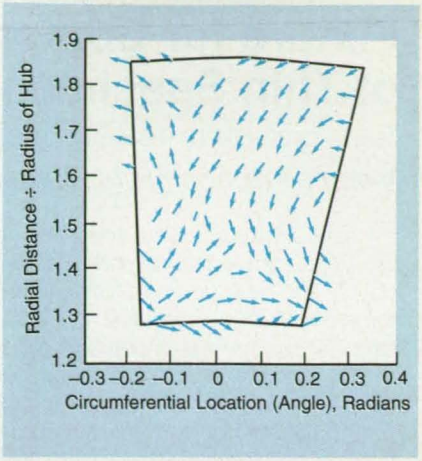
Two low-loss, highly turning twisted-vane designs were selected and analyzed by use of techniques of computational fluid dynamics. Even prior to this analysis, it was known that in comparison with pressure/atomizing fuel injectors, high-shear airblast injectors produce better atomization and mixing, with smaller pressure drops. The performances of the injectors depend upon the details of complicated three-dimensional flows, which had not been represented accurately in the approximate mathematical models of one-dimensional, incompressible, inviscid flow used previously.

To satisfy the need for greater accuracy, this analysis was divided into three stages of increasing complexity. In the first stage, an analysis based on one-dimensional, isentropic, compressible flow was performed to establish the basic design parameters. In the second stage, the vane-to-vane flow field was analyzed in two-dimensional, viscous/inviscid-interaction approximation. This stage yielded results that could be used to avoid separation of flow on the suction surfaces of the vanes, thereby minimizing the pressure drop, while maximizing swirl, maximizing the speed at the exit from the vanes, and obtaining uniform exit-velocity profiles with high turning.

In the third stage, the full three-dimensional inviscid flow field was computed. The results of this stage of the analysis showed that desirable three-dimensional characteristics of the flow field could be enhanced by twisting the vanes. One such desirable characteristic includes secondary-flow vortices that would increase turbulence and thereby enhance atomization (see figure). Another desirable characteristic is a radial component of velocity that would increase the size of the recirculation zone and thereby produce a more-stable flame zone, with increased efficiency of combustion and decreased emission of nitrogen oxides.

This work was done by H. Lee Nguyen of **Lewis Research Center** *and Gerald J. Micklow and Anju S. Dogra of the University of Florida. Further information may be found in NASA TM-103195 [N90-25289], "Effect of Vane Twist on the Performance of Dome Swirlers for Gas Turbine Airblast Atomizers."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15392



This **Computed Secondary Flow Pattern** in part of the exit plane of a vane assembly includes a pair of vortices configured to promote turbulence and mixing.

Fixture for Compression-After-Impact Tests of Thin Specimens

Tests give more-realistic measures of tolerance to damage.

Marshall Space Flight Center, Alabama

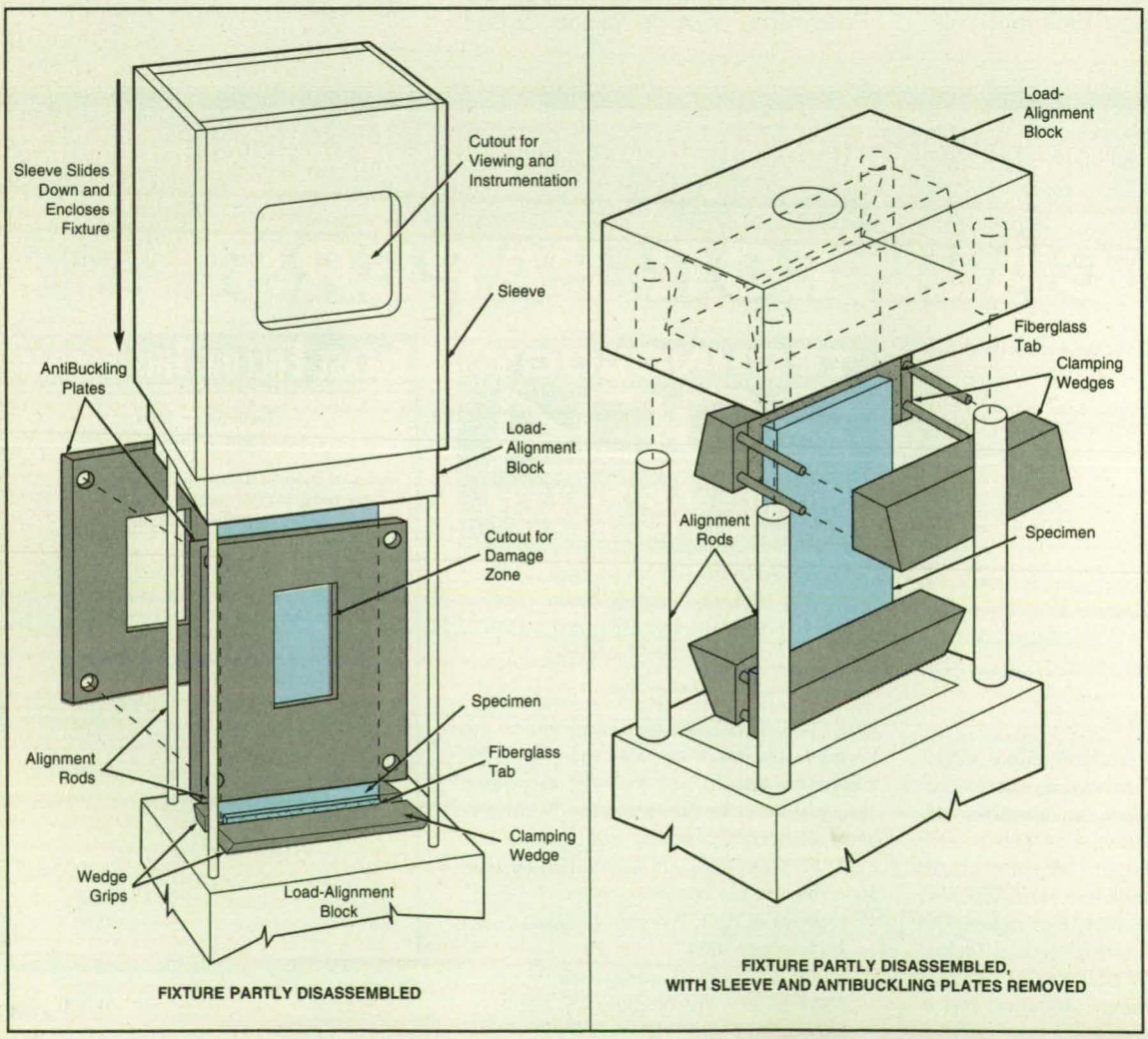
A special fixture holds a specimen of laminated composite material in a 20-klb (89-kN) or larger load frame for a compression-after-impact test. In preparation for such a test, the specimen is first damaged by dropping a weight on it at a known kinetic energy. During the test, the specimen is loaded in compression, and the load is measured, until the specimen fails. The measurement data can be used to characterize the compressive strength of the specimen after impact — an important indicator of the ability of structural components made of the composite material to tolerate damage.

This fixture holds specimens that are long [7 in. (17.8 cm)] and wide [3 in. (7.6 cm)] enough to contain the entire impact-damaged regions. Specimens of the exact thicknesses of production parts can be tested on this fixture; typical thicknesses range from 8 plies [0.04 in. (1 mm)] to 16 plies [0.08 in. (2 mm)]. In contrast, older compression-after-impact test fixtures are designed for much thicker (typically, 48-ply) specimens. Inasmuch as impact-damage characteristics depend strongly on thickness, this ability to hold thinner specimens is advantageous in that the resulting test data are more nearly representative of the strengths of practical impact-damaged structural components. Also, inasmuch as the composite materials to be tested are often expensive and in short supply because they are still experimental, the ability to use thinner specimens can save time and money in the fabrication of the specimens.

The fixture holds the specimen with its long axis oriented vertically (see figure). The upper and lower ends of the specimen are covered with fiberglass tabs and placed between self-tightening wedge grips. These grips apply the load in the form of relatively low shear stresses distributed across the gripped faces: end loading is eliminated, thereby preventing failure via "brooming" of fibers of the composite material at the loaded ends.

The gauge length of the specimen (between the end grips) is clamped between two aluminum plates to prevent buckling of the specimen under load. A cutout in the middle of each of these plates accommodates protruding fibers and other features of the impact damage. The effect of the frictional force between these plates and the specimen (caused by straining of the specimen under load) has been found to be negligible in comparison with the effect of the applied compression load.

To ensure valid test results, it is nec-



This **Fixture Holds a Specimen** of impact-damaged laminated composite material for compression testing.

essary to orient the specimen properly with respect to the applied load. Proper orientation is especially important for unidirectional-fiber composites, because they are highly sensitive to loads that are not aligned along the fibers. The only major disadvantage of the fixture is that, as a result of this requirement, positioning of the specimen in the fixture can be time consuming. It is also important to take care to ensure that the aluminum antibuckling plates are clamped on snugly.

This work was done by Alan T. Nettles, Andrew J. Hodge, and David G. Lance of **Marshall Space Flight Center**. *For further information,* ***write in 76*** *on the TSP Request Card.*
MFS-28735

Changing Stiffnesses of Truss Members for Vibration Tests

The effective stiffnesses of active members would be changed to excite different vibrational modes.

NASA's Jet Propulsion Laboratory, Pasadena, California

An extension of the active-member method of vibration testing of trusses and similar structures has been proposed to obtain additional data for refinement of finite-element mathematical models of the vibrational properties of the structures. According to the proposal, active truss members (in conjunction with suitable control systems) would not only be used in vibration tests to excite and measure vibrations of the structures, but would also be made to have different effective stiffnesses in some tests: thus, the structures would be effectively modified, enabling the excitation of different vibrational modes that would yield additional data.

Aspects of the active-member method of vibration testing were described previously in several articles in *NASA Tech Briefs* including "Two Techniques for Suppressing Vibrations in Structures" (NPO- 17889), Vol. 15, No. 12 (December 1991), page 60; "Active Suppression of Vibra-tions in a Truss" (NPO-18305), Vol. 16 No. 10, (October 1992), page 88; and "Active Members Excite and Measure Vibrations in Trusses" (NPO-18353), Vol. 17 No. 6 (June 1993), page 95. Heretofore, a typical test has involved measurement of a limited number of modes that are regarded as the best (according to some quantitative or semiquantitative criterion) available in the structure. Then analytical sensitivity coefficients have been developed, and a least-squares technique has been used to modify the mathematical model of the structure to fit the measurement data best. The inadequacy of this method and the need for the proposed extension arise from the fact that the number of parameters of the model typically far exceeds the number of data obtained in the test.

The proposed extended test method would yield more and better data. As the number of active members increases, the number of permutations of them would grow exponentially, so that many more data could be obtained. Thus, statistically, the data would yield better estimates of the dynamical characteristics of the structure. In addition, the sensitivity coefficients previously determined by analysis could be measured directly in experiments; the change in the frequency or shape of a vibrational mode could be measured directly as the stiffness of each active member is modified. The information thus obtained might also be useful in inferring the sensitivity coefficients of the inactive members. Similarly, the damping and

effective-mass parameters of the structure could be changed, and sensitivity modal and response information could be developed to help update the mathematical model.

This work was done by Ben K. Wada of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 60*** *on the TSP Request Card.*
NPO-18907

Opposed Bellows Would Expel Contents of Tank

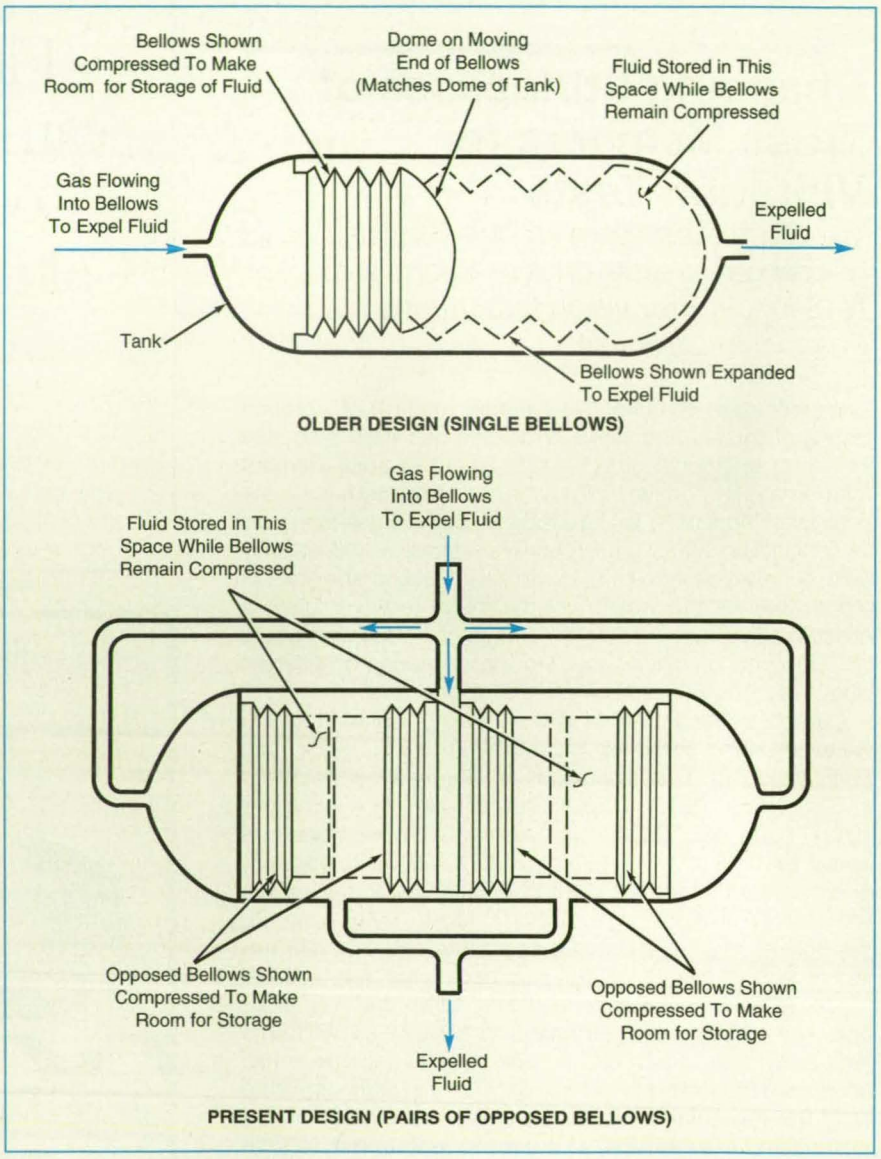
Four bellows would offer greater stability.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed storage tank would contain two pairs of opposed bellows that would be used to expel its contents. The storage and expulsion volumes of this tank would be the same as those of an older version of the tank equipped with a single bellows. Because each bellows in this tank would have one-fourth the length and one-fourth the weight of the single bellows in the older tank, the natural vibrational frequency and the instability pressure of this tank would be 4 and 16 times, respectively, those of the older tank. Therefore, this tank would be less vulnerable to vibrations.

The bellows would be arranged so that fluid would be stored in expansion spaces between them (see figure). When the bellows were pressurized with a gas, they would compress the fluid between them, driving the fluid from the tank. Conceived for storage and discharge of fluids in outer space, both the single- and the opposed-bellows tanks might also be useful in terrestrial applications in which gravitation cannot be depended on to draw liquids from tanks. Such applications could include automobile cooling systems and gasoline-powered tools like chain saws and leaf blowers.

This work was done by Willie Whitaker of McDonnell Douglas Corp. for **Johnson Space Center**. *For further information,* ***write in 41*** *on the TSP Request Card.*
MSC-22050



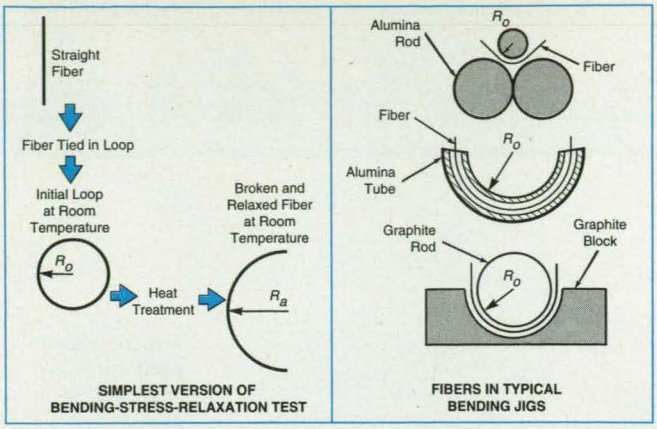
Two Pairs of Bellows would be pressurized to expand them, thereby expelling the fluid outside them but inside the tank.

Simple Creep Test for Ceramic Fibers

Degree of relaxation of the bend stress is determined from radii of curvature.

Lewis Research Center, Cleveland, Ohio

A simple bend-stress-relaxation test yields information on the creep-related properties of polycrystalline ceramic fibers. Determination of these properties is an important part of efforts to develop ceramic composite materials that retain mechanical strength and resistance to creep at high temperatures. Creep can be measured under tensile loading, but it is especially difficult and expensive to perform tensile tests on thin ceramic fibers, which are often degraded in air at



An **Initially Straight Fiber Is Bent**, heated in the bent condition, cooled to ambient temperature, then released. The curvature that remains after release is a measure at the relaxation of bend stress.

high temperatures and can be easily fractured by handling or the application of stress and strain sensors. The present test can measure the effects of time, temperature, and applied strain on the creep-related relaxation of bend stress in a ceramic fiber of almost any diameter in almost any environment, without the need for contact sensors.

The first step of this test is to impose an elastic bend strain on an initially straight fiber. In the simplest version of the test, this is done by tying the fiber into a loop (see figure). The loop is heated to the specified test temperature and held there for the specified test time, then cooled to room temperature. The diameter of the loop is measured; then the applied strain is removed by breaking the loop at one point.

If the fiber has remained completely elastic during the heat treatment, then it straightens out completely when the loop is broken. However, if there has been any relaxation of bend stress as a result of creep, the fiber retains a curvature when the loop is broken. The radius of this curvature is measured. Starting from basic relationships between elastic stress and strain, it can be shown that for a polycrystalline ceramic fiber, the ratio between the final and initial stresses at the test temperature is

$$1 - \frac{R_o}{Ra}$$

where R_o is the radius of the loop and R_a is the radius of curvature after the loop is broken. This ratio is essentially the fraction of initial stress that remains after the heat treatment; in principle, it depends only on time and temperature, and is a direct measure of the ability of the material to resist creep at high temperature. It can be used, for example, to evaluate and rank creep resistance for various fiber types or to monitor prcessing improvements in a single fiber type.

In practice, available fibers may be too short to be tied into loops. In that case, fibers can be bent in jigs, as shown at the right side of the figure: a fiber to be tested in air can be bent between alumina rods of suitable diameter or bent by insertion in a curved alumina tube. A fiber to be tested in a nonoxidizing environment (e.g., vacuum or argon gas) can be bent in a rod-and-groove graphite jig.

This work was done by James A. DiCarlo of **Lewis Research Center** *and Gregory N. Morscher of Case Western Reserve University. For further information,* ***write in 24*** *on the TSP Request Card. LEW-15523*

Inchworm Actuator

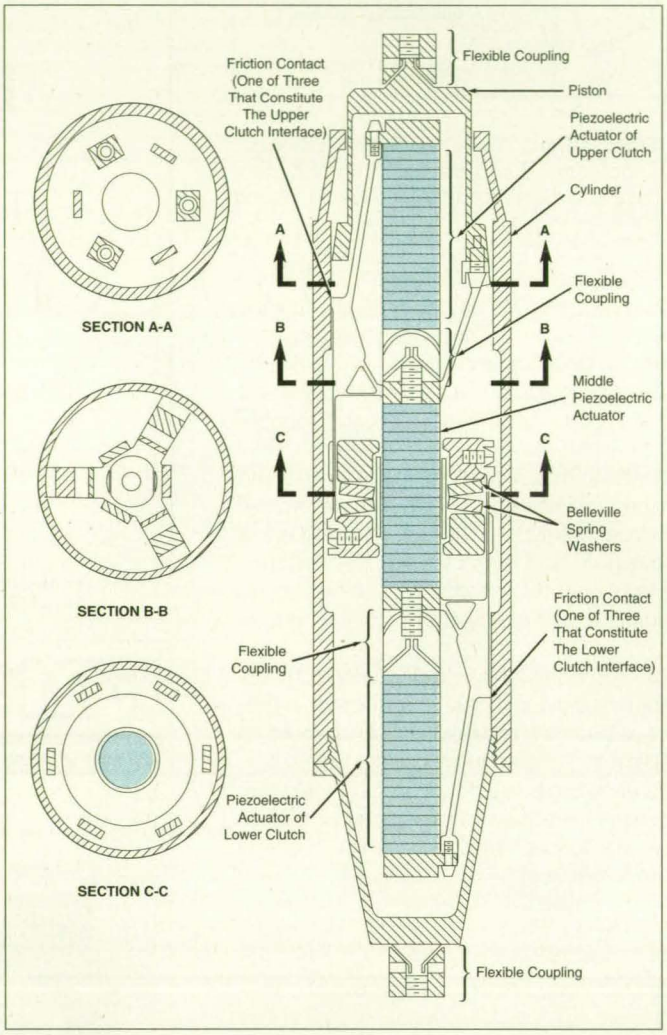
This actuator would serve as an active truss member.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed inchworm actuator could be used as an active truss member, the length of which could be varied slowly to change the configuration of the truss rapidly or to counteract vibrations. The overall stroke of the actuator could range from about 3 cm at a frequency of 1 Hz down to 0.002 cm at a frequency of 1 kHz. The length of the stroke could be controlled with an accuracy of 0.0001 cm.

The inchworm actuator would incorporate three piezoelectric actuators (see figure). The upper and lower piezoelectric actuators would unlock normally locked clutches. The middle piezoelectric actuator would enforce small variations of the distance between the clutches.

Belleville washers would apply a compression preload to the piezoelectric actuators and the clutches, isolating the piezoelectric devices from tensile stress and keeping the clutches normally locked so that they would maintain the overall length of the actuator without power. A bearing would position the actuator piston laterally in the cylinder. Usually, at least one of the clutches would remain locked. This would prevent the piston from rotating in the cylinder. Flexible couplings and tripod piston supports in the clutches would accommodate misalignments and fabrication tolerances when the clutch was locked, any bending loads on the piston would be carried primarily through a direct load path to the cylinder, and only a fraction of the bending load would be carried through the piezoelectric devices. The use of the clutch as a lateral support for the piston would also reduce the clutch stroke needed to accommodate fabrication tolerances in the clutch interfaces.



This **Inchworm Actuator** would hold its position (that is, it would neither extend nor retract) when electrical energy was not supplied. The maximum end-to-end stroke (extension or retraction of the piston with respect to the cylinder) would be 3 cm.

This work was done by Robert M. Bamford of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 104*** *on the TSP Request Card.*

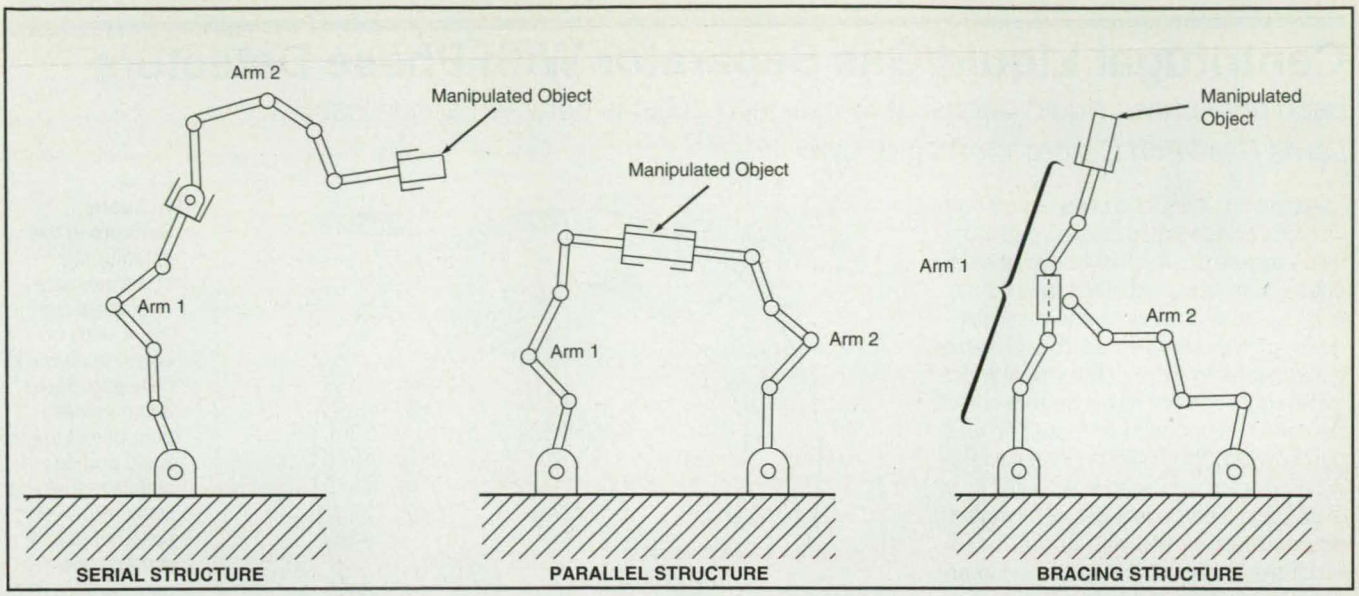
NPO-18917

Self-Reconfigurable Two-Arm Manipulator With Bracing

Structure can be altered dynamically to suit changing tasks.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed two-arm robotic manipulator would be capable of changing its mechanical structure to fit a given task. Heretofore, the structures of reconfigurable robots have been changed by replacement and/or reassembly of modular links. In the proposed manipulator, there would be no reassembly or replacement in the conventional sense: instead, the arms would be commanded during operation to assume any of a number of alternative configurations, which were described briefly in "Dynamic Coordination of a Two-Arm Robotic Manipulator" (NPO-



Alternative Structures of Cooperating Manipulator Arms can be selected to suit changing tasks.

18816), *NASA Tech Briefs*, Vol. 18, No. 1 (January 1994), page 75.

The configurations (see figure) are generally classified as follows: (1) serial structure, in which the base of arm 1 is stationary, the tip of arm 1 holds the base of arm 2, and the tip of arm 2 holds the manipulated object; (2) parallel structure, in which the bases of both arms are stationary and the tips of both arms make contact with the manipulated object at two different points; and (3) the bracing structure, in which the bases of both arms are stationary and the tip of arm 2 grasps some intermediate point along the length of arm 1. The serial and parallel structures can be regarded as special cases of the bracing structure. Optionally, each configuration could involve locking of one or more joints of either or both arms, and the bracing contact between the two arms could be at a fixed position of arm 1 or else allowed to slide along a link of arm 1.

The performances of the various configurations can be quantified in terms of quantities called "dual-arm manipulabilities," and "dual-arm resistivities." Dual-arm manipulabilities are defined on the basis of kinematic and dynamic constraints; dual-arm resistivities are defined on the basis of static-force constraints. These quantities serve as measures of how well such dextrous-bracing actions as relocation of the bracing point, sliding contact, and locking of joints affect the ability of the dual-arm manipulator to generate motions and to apply static forces.

Theoretical study and computer simulation have shown that dextrous bracing yields performance characteristics that vary continuously and widely as the bracing point is moved along the braced arm. In general, performance characteristics lie between those of the serial and parallel structures. Thus, one can select configurations dynamically, according to their performance characteristics, to suit the changing requirements of changing tasks.

This work was done by Sukhan Lee and Sungbok Kim of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 103*** *on the TSP Request Card.*
NPO-18815

Centrifugal Liquid/Gas Separator With Phase Detectors

Each pure phase (liquid or gas) at its assigned outlet is detected acoustically.

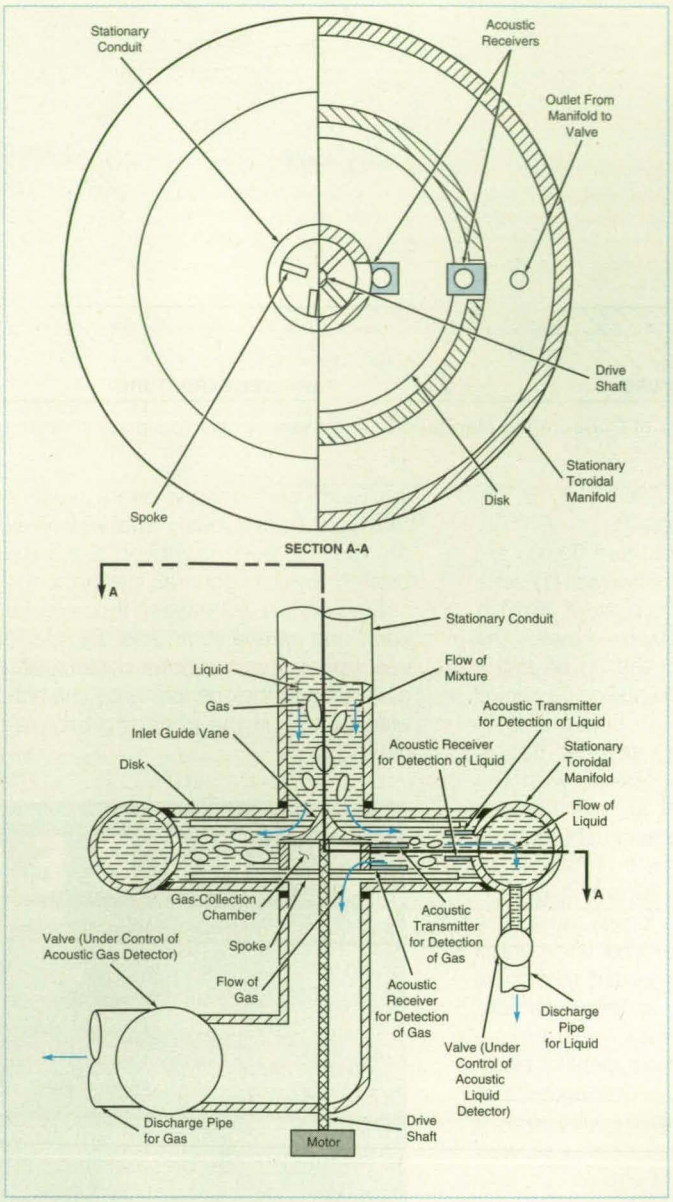
Lewis Research Center, Cleveland, Ohio

A centrifugal liquid/gas separator that includes phase (liquid or gas) detectors helps ensure the exclusiveness of each phase at its assigned outlet (see figure). It is desirable to ensure the exclusiveness of the phases at the outlets because, for example, (1) residual liquid (which is not meant to be vented) could be vented along with an outlet flow of gas in which the liquid is entrained, (2) drops of liquid entrained in an outlet flow of gas could damage a gas compressor downstream of the gas outlet, or (3) residual bubbles of gas entrained in an outlet flow of liquid could cause vapor lock in a liquid pump downstream of the liquid outlet.

The liquid/gas mixture enters the present centrifugal separator along a stationary conduit. An inlet guide vane directs the incoming flow radially outward into the space between two rotary disks connected via spokes to a drive shaft that is, in turn, driven by a motor. The rotation of the disks is communicated to the liquid/gas mixture, providing the centrifugal effect that drives the liquid radially outward relative to bubbles of gas.

The centrifuged liquid enters a stationary toroidal manifold via an orifice near the periphery of the disks. An acoustic transmitter and receiver mounted on the manifold adjacent to the orifice and operating in conjunction with external circuitry (not shown) measure the speed of sound of the intervening medium; when the speed of sound is that of the liquid (indicating solely liquid at the orifice), the external circuitry opens a valve to let the liquid pass from the toroidal manifold into the discharge pipe for liquid.

The bubbles of separated gas are collected in a stationary gas-collection chamber that is located on the axis of rotation and that is supported by stationary spokes (not shown) connected to the toroidal manifold. Another acoustic transmitter/receiver apparatus measures the speed of sound at the inlet to the gas-collection chamber; when the speed of sound is that of only gas, a valve between the gas-collection chamber and the discharge pipe for gas is opened to allow the gas to flow out.



Acoustic Sensors in this centrifugal liquid/gas separator measure the speeds of sound in nominally pure liquid and nominally pure gas at the liquid and gas outlets respectively. When the speed of sound is that of the pure liquid or gas, a valve is opened to let the liquid or gas flow out.

This work was done by Steven J. Schneider of **Lewis Research Center**. *For further information,* ***write in 72*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 4,911,738). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 22].
Refer to LEW-14844.

Straddle Design of Spiral Bevel and Hypoid Gears

Lengths and radii of shafts can be chosen to prevent undercutting.

Lewis Research Center, Cleveland, Ohio

A computer-assisted method of analysis of straddle designs for spiral bevel and hypoid gears helps to prevent undercutting of gear shafts during cutting of the gear teeth. Figure 1 illustrates a spiral bevel gear of straddle

design, in which the shaft extends from both ends of the toothed surface to provide double bearing support. One major problem in such a design is to choose the length and radius of the shaft at the narrow end (equivalently, the radial coordinate r and axial coordinate u) such that the head cutter that generates the gear teeth does not collide with, and thereby undercut, the shaft.

The analytical method and computer program are based on the equations for the surface traced out by the motion of the head cutter, the equation for the cylindrical surface of the shaft, and the equations that express the relationships among the coordinate systems fixed to the various components of the gear-cutting machine tool and to the gear. The location of a collision between the shaft and the cutter is defined as the vector that simultaneously satisfies the equations for head-cutter-traced and shaft surfaces. The solution of these equations yields the u and r coordinates of the point of collision.

Given input parameters in the form of the basic machine-tool settings for cutting the gear, the computer program finds numerical values of r and u at a representative large number of points along the path of the cutter. These computations yield a family of closed curves (see Figure 2) that are the loci of collision points. The region below the curves is free of collisions: thus, it contains the values of r and u that can be chosen by the designer to avoid collisions between the shaft and the head cutter.

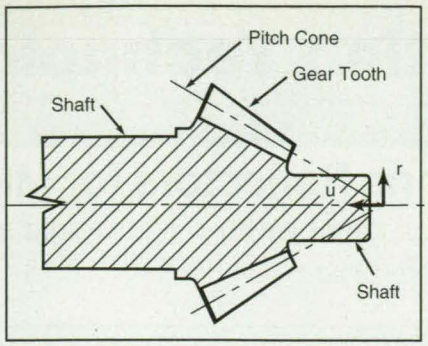


Figure 1. A **Straddle-Design Spiral Bevel Gear** includes two integral shaft extensions, one of which could terminate near or even beyond the apex of the pitch cone.

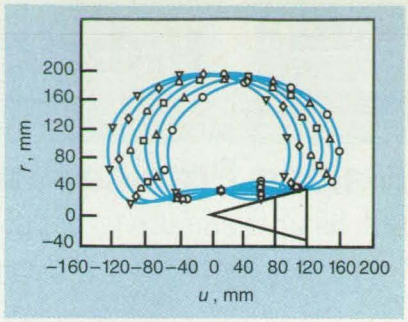


Figure 2. The **Family of Closed Curves** applicable to an example hypoid gear helps the designer to choose the length and radius of the shaft at the narrow end: the region below the curves is free of collisions between the head cutter and the shaft.

This work was done by Robert F. Handschuh of the U.S. Army Aviation Systems Command; Faydor L. Litvin, Chihping Kuan, and Jonathan Kieffer of the University of Illinois at Chicago; and Robert Bossler of Lucas Western, Inc., for **Lewis Research Center**. *For further information,* ***write in 42*** *on the TSP Request Card.*
LEW-15744

Making Precise Antenna Reflectors for Millimeter Wavelengths

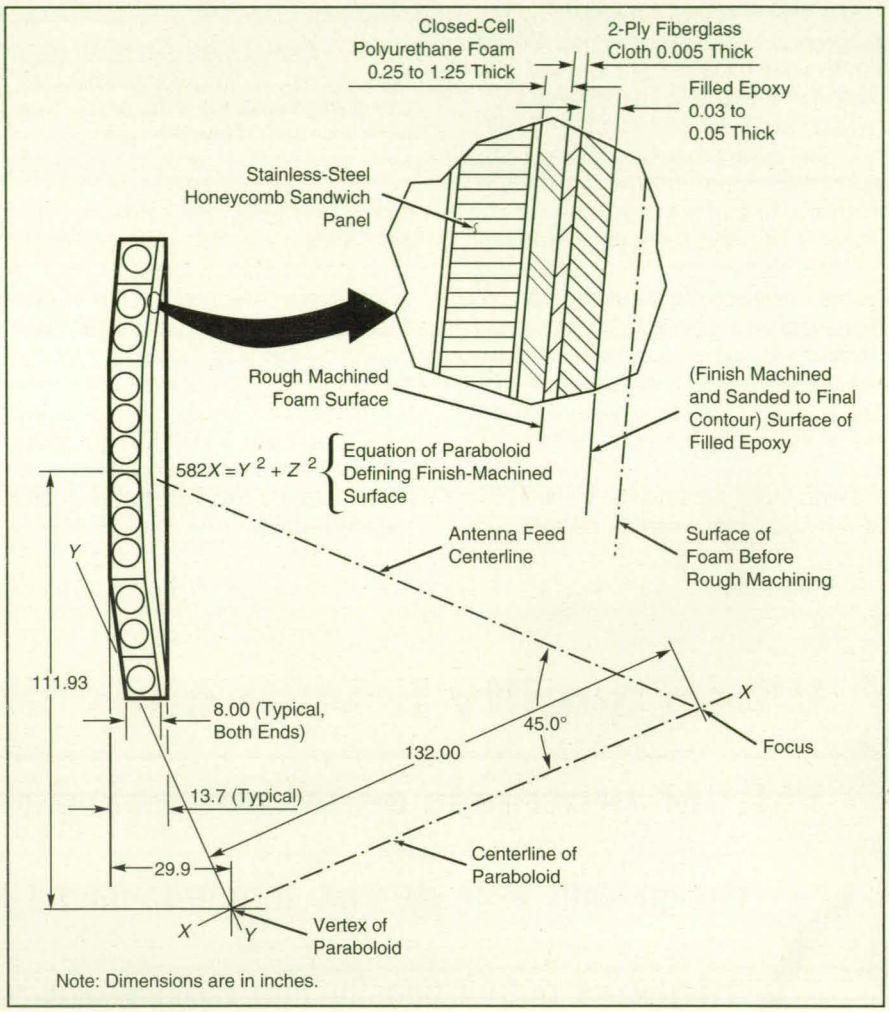
Machinable surface layers are supported by rigid, lightweight structures.

Lewis Research Center, Cleveland, Ohio

In an improved method of fabrication of precise, lightweight antenna reflectors for millimeter wavelengths, the required precise contours of the reflecting surfaces are obtained by computer numerically controlled machining of surface layers that have been bonded to lightweight, rigid structures. The achievable precision is greater than that of an older, more-expensive fabrication method that involves multiple steps of low- and high-temperature molding, in which some accuracy is lost at each step.

An antenna reflector with a diameter of 2.7 m and a root-mean-square deviation of 0.015 mm from a desired paraboloidal surface was fabricated by this method. The supporting structure included a frame made of thin-gauge stainless-steel channels. On this frame, flat panels of stainless-steel honeycomb sandwich were mounted to form an approximately paraboloidal surface. Panels of polyurethane foam were adhesively bonded to the honeycomb panels (see figure). The polyurethane was then machined under computer control to roughly the final contour.

Fiberglass cloth was bonded to the polyurethane to provide a firm foundation for a thin surface layer of filled epoxy. This surface layer was machined to the final contour; then a reflective film of aluminum 2,000 Å thick was vacuum-deposited on it. (The layer of fiberglass cloth helped to prevent outgassing from the polyurethane during the vacuum deposition.) The aluminum was covered with a layer of silicon dioxide 500 Å thick to prevent oxidation.



The **Lightweight Thin-Gauge Stainless-Steel Structure** has approximately the desired offset paraboloidal shape and supports composite layers, the outermost of which is machined to the precise desired paraboloidal shape.

This work was done by G. Richard Sharp and Joyce S. Wanhainen of **Lewis Research Center** *and Dean A. Ketelsen of the University of Arizona. Further information may be found in NASA TP-3078 [N91-21183], "A New Fabrication Method for Precision Antenna Reflectors for Space Flight and Ground Test."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15490

Flexible Heating Head

An induction heating coil conforms to curved surfaces.

Langley Research Center, Hampton, Virginia

The United States Air Force is investigating a method of repairing aircraft by use of adhesive bonding with induction heating to cure the adhesive. A fast-acting and reliable induction heating device that is lightweight, portable, and easy to use is needed for such applications. The device must be able to generate heat reliably and

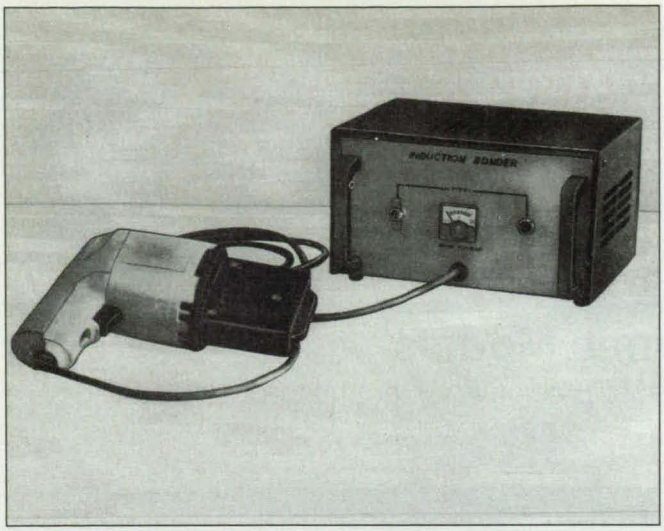


Figure 1. The **Toroid Joining Gun** concentrates heat in local areas through induction heating

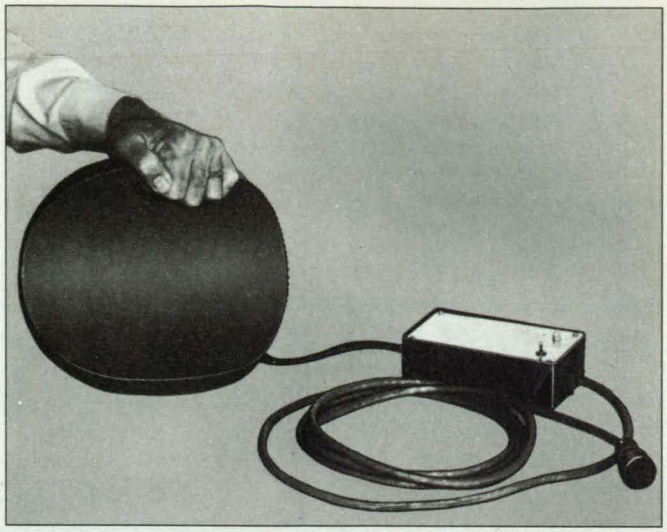


Figure 2. The **Flexible Heating Head** can generate high temperatures evenly over large, curved surfaces.

effectively under all weather conditions. The device must be capable of heating bond surfaces up to a temperature of 600°F (about 300°C) over areas up to 18 in. (about 46 cm) in diameter. In addition, heat must be generated evenly throughout a curved as well as a flat bond surface.

The induction heating devices used heretofore include heating heads with rigid magnetic cores that focus the heat-generating alternating magnetic fluxes to specific areas. Because they are rigid, the cores cannot conform to curved surfaces; as a result, curved surfaces are heated unevenly. In addition, the weights of these heating heads [up to 20 lb (about 9 kg) each] make them awkward to operate.

A newly developed flexible heating head is lightweight and can conform to complex, curved surfaces. The flexible heating head incorporates the principles and circuitry of the toroid joining gun (shown in Figure 1), which was described in "Toroid Joining Gun for Fittings and Couplings" (LAR-14278), *NASA Tech Briefs,* Vol. 16, No. 12 (December 1992), page 77. The toroid joining gun can concentrate heat in a local area through induction heating. The flexible heating head (shown in Figure 2) contains a tank circuit, which is connected via a cable to a source of power. The inductive coil of the tank circuit is wound in a flat "pancake" manner. The cable is 12 ft (3.7 m) long, and the coil is 9 in. (23 cm) in diameter. The coil is completely encapsulated in a high-temperature-resistant, flexible material so that a coat of this material $\frac{1}{8}$ in (3.2 mm) thick covers the coil completely.

The coat protects the coil from heat generated in the bonding surface and ensures that when the heating head is placed on an uneven surface, all windings remain equidistant from the surface. The two ends of the coil extend from the head and are attached to a capacitor, which completes the tank circuit. The flexible heating head weighs about 4 lb (1.8 kg).

When the tank circuit is connected to an Inductron Corp. Torobonder T-4000 power supply, approximately 2,000 watts of power are produced by the heating coil. When the flexible heating head is placed against a magnetic surface (susceptor), enough heat is generated to cure adhesive bonds over large areas in a single operation. The flexible heating head can conform to complex shapes common to aircraft structures; for example, windscreens and wing surfaces.

This flexible heating head is por-

table and provides rapid, reliable heating in any environment. It is well suited for flight-line and depot maintenance, battlefield repairs, and aircraft or automotive assembly lines.

This work was done by Robert L. Fox and Samuel D. Johnson of **Langley Research Center** *and Robert H. Coultrip and W. Morris Phillips of Inductron Corp. No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 22].
Refer to LAR-14418.

Improved Slip Casting of Ceramic Models

Wet shell molds can be peeled off models to ensure precise and undamaged details.

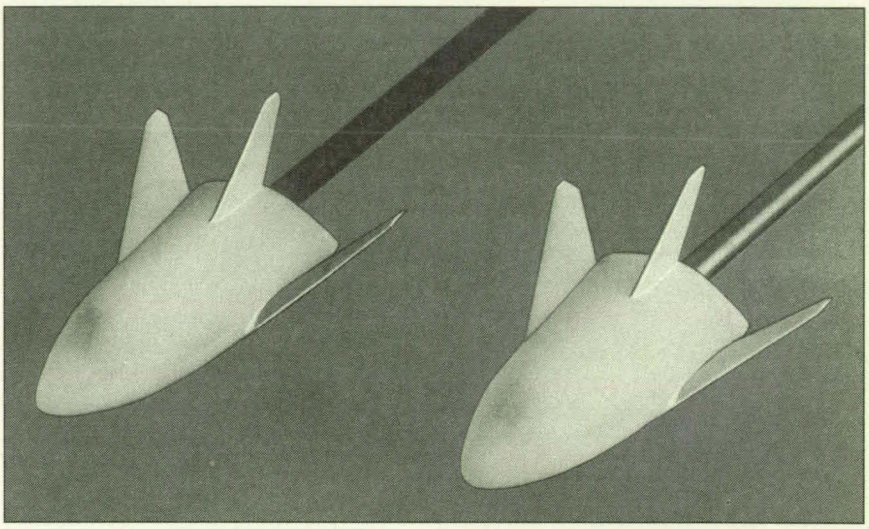
Langley Research Center, Hampton, Virginia

An improved technique of investment slip casting has been developed for making precise ceramic wind-tunnel models. Precise models are needed in wind-tunnel experiments to verify predictions of aerothermodynamical computer codes. Ceramic materials are used for these models because of their low heat conductivities and ability to survive high temperatures.

Slip-casting techniques for the fabrication of such models were developed at NASA Langley Research Center in the 1960's. These techniques provide the capability for net-form, precise casting of highly pure ceramic materials from aqueous solutions. The present improved slip- casting technique enables the casting of highly detailed models from aqueous or nonaqueous solutions.

In older slip-casting techniques, block or flask molds made of plaster of paris are used to draw liquid from the slip material. Upon setting, parts are removed from the flask molds and cured in kilns at high temperatures. Casting detail is usually limited with this technique because the molded parts are extremely delicate in the uncured state, and flask molds are inflexible, so that detailed parts are frequently damaged upon separation from flask molds. Ceramic surfaces are also marred by "parting lines" caused by separation of molds. This can adversely affect the aerodynamic qualities of surfaces as well.

The present technique involves the innovative use of a material that was intended originally for use in flask molding of nonferrous metals. The material, R&R 909 Investment™, is a calcium sulphate-bonded investment compound that contains silica, fiberglass, and other specially graded refractory materials. This material has been found to draw liquid from aqueous slips, similarly to plaster of paris. Also, in its cured state, this mold material draws liquid from nonaqueous slips as well, inasmuch as the material does not contain water as does typical plaster.



These **Cast Ceramic Models**, made with the improved investment slip-casting technique, were tested in wind tunnels at Langley Research Center.

In the present technique, the investment material is applied as a stucco, or shell mold. This material withstands much higher temperatures than plaster does. It also becomes weak when wetted, and its behavior in this regard is the opposite of that of plaster. By unconventional use of this material, as both a shell mold (as opposed to a flask mold) and for slip casting of ceramics (instead of nonferrous metals), the desired castings are achieved.

A typical casting procedure begins with the use of a lost-wax technique to create a shell mold. The investment compound is then applied to the wax pattern, dried, and cured to vaporize the wax from the mold. The mold is then cooled to room temperature and used for slip casting. While still wet, the investment-compound shell can be peeled off the molded part to free such delicate details as nose tips, fins, or winglets.

The technique enables casting of complete, precise models with details (see figure). The models do not have parting lines or surface impurities caused by separation of or from molds. While developed to fabricate models for wind-tunnel tests, the technique can also be used to cast complex parts in a precise manner. For example, the technique has been used at NASA Langley Research Center to form superconducting ceramic components from nonaqueous slip solutions. The technique will have many more applications when ceramic materials are developed further for such high-strength/ temperature components as engine parts.

This work was done by Gregory M. Buck, Peter Vasquez, and Lana P. Hicks of **Langley Research Center**. *For further information,* ***write in 107*** *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 22].
Refer to LAR-14471.

Algorithm for Integer Cosine Transforms

Computation is simpler than it is for discrete cosine transforms.

NASA's Jet Propulsion Laboratory, Pasadena, California

An algorithm computes the coefficients of integer cosine transforms, which contain only integer coefficients approximately proportional to the floating-point coefficients of discrete cosine transforms. Used in compression of image data in blocks of $N \times N$ pixels, discrete cosine transforms involve large amounts of computation, typically amounting to 80 percent of the computational load in a data-compression scheme. In constructing integer approximations, the competing requirements are to obtain data-compression and data-decompression performances comparable to those of the corresponding discrete cosine transforms while taking advantage of the simplicity afforded by integer arithmetic to reduce the complexity and amount of computation.

The coefficients of an $N \times N$ discrete cosine transform constitute an $N \times N$ matrix $A = [a_{kn}]$ that is orthonormal; that is $AA^t = I$ (where I is the identity matrix and t denotes transpose). The elements of A are given by

$$a_{kn} = \begin{cases} \frac{1}{\sqrt{N}} \text{ when } k = 0 \text{ and } 0 \le n \le N-1 \\ \text{or} \\ \sqrt{\frac{2}{N}} \cos \frac{\pi(2n+1)k}{2N} \text{ when } 1 \le k \le N-1 \\ \text{and } 0 \le n \le N-1 \end{cases}$$

Similarly, the coefficients of a corresponding $N \times N$ integer cosine transform constitute a matrix $C = [c_{kn}]$, which is orthogonal (but not orthonormal); that is, $CC^t = \Delta$, where Δ is a diagonal matrix. C is required to have the following three additional properties:

1. The integer property: c_{kn} are integers for $0 \le k, n \le N-1$.
2. The orthogonality property: Rows (or columns) of C are orthogonal to each other.
3. Relationship with the discrete cosine transform:
   (a) $sgn(c_{kn}) = sgn(a_{kn})$ for $0 \le k, n \le N-1$.
   (b) If $a_{kn} = a_{st}$, then $c_{kn} = c_{st}$ for $0 \le k, n, s, t \le N-1$.

The integer property eliminates the need for many multiplications and additions in computing the transform. The orthogonality property ensures that the inverse integer cosine transform has the same transform structure as does the integer cosine transform. Although C is required to be orthogonal (but not orthonormal), it can be made orthonormal by multiplying it by an appropriate diagonal matrix. This operation can be incorporated in the quantization (or dequantization) stage of the compression (or decompression), thus sparing the integer cosine transform or its inverse from floating-point arithmetic operations. The relationship between integer and discrete cosine transforms guarantees efficient energy packing and allows the use of any fast discrete-cosine-transform technique in implementing the integer cosine transform.

The algorithm, which computes C according to the foregoing requirements, includes the following steps (see figure):

1. Generate the $N \times N$ discrete cosine transform matrix A.
2. Construct an $N \times N$ matrix B (as a precursor to C) by substituting the N possible absolute values in A with N symbols, and preserve the signs of the elements in A.
3. Evaluate BB^t, and generate a set of independent algebraic equations that force BB^t to be a diagonal matrix.
4. Find a set of N numbers that satisfy the set of algebraic equations generated in step 3.

The number of independent equations that must be solved in step 4 can be reduced substantially by setting the most-frequently-occurring symbol in B equal to an integer like 1 or 2. The equations can be generated and solved conveniently by use of a symbolic-manipulation computer program like Mathematica (or equivalent). In order to obtain good compression performance, the set of $N - 1$ integers that constitute the re-

Coefficients of 8 × 8 Discrete Cosine Transform (Matrix A)

0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354
0.490	0.416	0.278	0.098	−0.098	−0.278	−0.416	−0.490
0.462	0.191	−0.191	−0.462	−0.462	−0.191	0.191	0.462
0.416	−0.098	−0.49	−0.278	0.278	0.49	0.098	−0.416
0.354	−0.354	−0.354	0.354	0.354	−0.354	−0.354	0.354
0.278	−0.49	0.098	0.416	−0.416	−0.098	0.490	−0.278
0.191	−0.462	0.462	−0.191	−0.191	0.462	−0.462	0.191
0.098	−0.278	0.416	−0.49	0.49	−0.416	0.278	−0.098

Matrix B, Showing Structure of Integer-Cosine-Transform Matrix

1	1	1	1	1	1	1	1
a	b	c	d	−d	−c	−b	−a
e	f	−f	−e	−e	−f	f	e
b	−d	−a	−c	c	a	d	−b
1	−1	−1	1	1	−1	−1	1
c	−a	d	b	−b	−d	a	−c
f	−e	e	−f	−f	e	−e	f
d	−c	b	−a	a	−b	c	−d

Coefficients of an Integer Cosine Transform (Matrix C)

1	1	1	1	1	1	1	1
5	3	2	1	−1	−2	−3	−5
3	1	−1	−3	−3	−1	1	3
3	−1	−5	−2	2	5	1	−3
1	−1	−1	1	1	−1	−1	1
2	−5	1	3	−3	−1	5	−2
1	−3	3	−1	−1	3	−3	1
1	−2	3	−5	5	−3	2	−1

Coefficients of Another Integer Cosine Transform (a Binary-Multiplication-Free Version of Matrix C)

1	1	1	1	1	1	1	1
4	2	2	0	0	−2	−2	−4
4	2	−2	−4	−4	−2	2	4
2	0	−4	−2	2	4	0	−2
1	−1	−1	1	1	−1	−1	1
2	−4	0	2	−2	0	4	−2
2	−4	4	−2	−2	4	−4	2
0	−2	2	−4	4	−2	2	0

These **Matrices Are Generated** by the integer-cosine-transform algorithm.

maining solutions of the equations must have a magnitude profile similar to that of the corresponding $N - 1$ floating-point elements of A. Furthermore, if a multiplication-free property is desired in binary representation, the set of N integers must be restricted to powers of 2. Some ad hoc techniques are usually needed to simplify the calculations of these integers. The results of computer simulations for $N = 16$ show that the performance of the integral cosine transforms implemented by this algorithm are comparable (in terms of mean-square error as a function of the number of bits per pixel) to the performance of the discrete cosine transform.

This work was done by Fabrizio Pollara, Kar-Ming Cheung, and Mehrdad Shahshahani of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 44*** *on the TSP Request Card.*

NPO-18564

Neural Network Classifies Teleoperation Data

The neural network identifies phases of tasks.

NASA's Jet Propulsion Laboratory, Pasadena, California

A prototype artificial neural network, implemented in software, identifies phases of telemanipulator tasks in real time by analyzing feedback signals from force sensors on the manipulator hand. This prototype is an early, subsystem-level product of a continuing effort to develop an automated system that assists in training and supervising the human control operator: the system would provide symbolic feedback (e.g., warnings of impending collisions or evaluations of performance) to the operator in real time during successive executions of the same task. Such an automated supervisory system could also simplify the transition between the teleoperation and autonomous modes of a telerobotic system.

The prototype artificial neural network (see Figure 1) is based partly on the concept of the time-delay neural network, which involves preprocessing of a temporal sequence of input signals through a shift register to turn it into a temporal sequence of spatially arrayed input signals. A basic time-delay neural network contains only feedforward connections and does not exhibit adequate learning accuracy because it lacks an adequate temporal representation of the evolution of a task. To obtain better representation of the evolution of a task, the network is made partially recurrent by adding some connections from output nodes to nodes called "context units" that are located in the input layer of neurons. The context units represent the previous state of the neural network, which state, in turn, represents the task phase executed previously.

The network was trained by use of a back-propagation algorithm and training data from experimental teleoperation tasks in which a remote manipulator with a hand instrumented to measure forces and torques was controlled by the human operator via a force-reflecting hand controller and remote video monitoring of the workspace. The tasks included insertion and removal of a peg into and from a hole, insertion and extraction of electrical connectors, and attachment of hook-and-pile pads. The network was then tested by using it to segment a force signal from the peg-in-hole task into task phases. As shown in Figure 2, the network performed the segmentation in real time, albeit with some lags and some errors. On the other hand, the network also exhibited an unexpected ability to recover after misidentifying some phases and to follow tasks, the phase sequences of which differed from those of the training tasks.

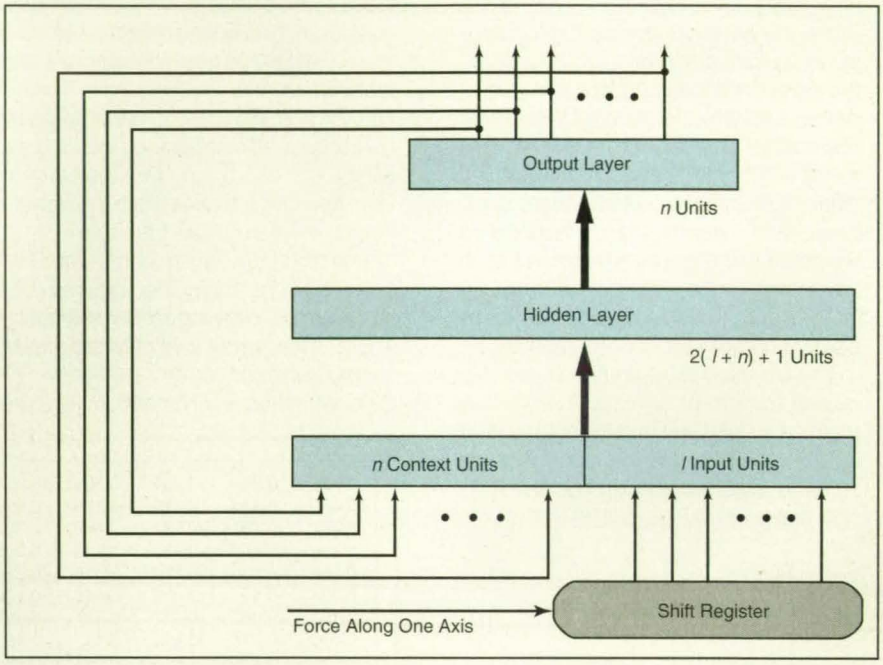


Figure 1. A Partially Recurrent Time-Delay Neural Network with fixed connections can be trained to monitor the evolution of a task by identifying patterns in the force-vs.-time data that represent phases of the task.

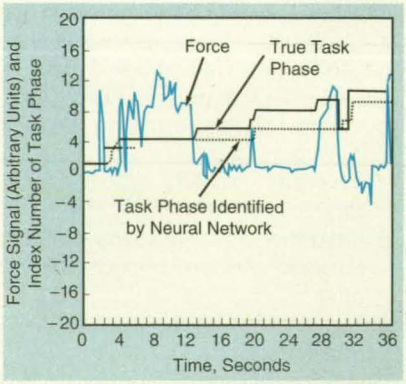


Figure 2. These Results of a Real-Time Experiment show that the neural network was partially successful in segmenting the force signal into task phases.

This work was done by Paolo Fiorini, Antonio Giancaspro, Sergio Losito, and Guido Pasquariello of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 63*** *on the TSP Request Card.* *NPO-19004*

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- Sold as individual components to minimize inventories
- 316L & 316 stainless steel
- Helium leak tested to 4.0 x 10^{-9} atm. cc/sec.
- Pressures — vacuum to 11,000 psi
- Temperatures to 1000°F (537°C)

VCO® Coupling

O-Ring face seal

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- Variety of configurations
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- Sold as individual components to minimize inventories
- Brass & 316 stainless steel
- 1/8″ to 2″
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- Pressures — vacuum to 10,000 psi
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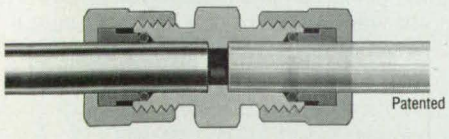
- Fast make-up

Ultra-Torr® Fitting

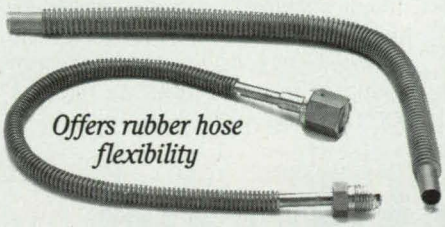
Provides vacuum-tight seal on glass, metal or plastic



Patented

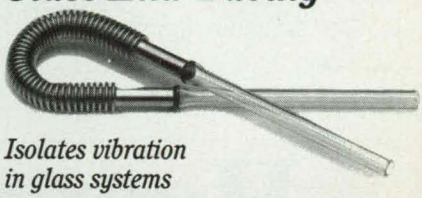
- Quick finger-tight assembly, reuseable
- Helium leak tested to 4.0 x 10^{-9} atm. cc/sec.
- 1/16″ to 1-1/2″
- Use with undersize tubing
- Variety of configurations
- Brass & 316 stainless steel
- Temperatures to 450°F (232°C)

Flexible Tubing



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

Flexible Glass End Tubing



Isolates vibration in glass systems

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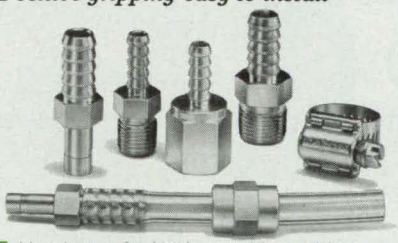
Hose Connectors

Positive gripping-easy to install



- Used on soft plastic or rubber tubing
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Books & Reports

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

Materials

High-Temperature, Self-Lubricating Ceramic/Metal Composites

Four documents provide detailed information on a class of ceramic/metal composite materials that are self-lubricating at temperatures as high as 900°C. These materials are likely to be used in bearings and seals for turbomachines, new energy-efficient automotive engines, power generators, pumps, and furnaces. Components made of these materials and proved successful in tests thus far include the following:

- Coatings for flow-control valve guides for hot gases;
- Backup self-lubricating coatings for high-speed gas bearings;
- High-speed, high-temperature sliding-contact face seals;
- Combustion-chamber linings in rotary engines; and
- Cylinder liners in Stirling-cycle engines.

One of the documents describes the general properties, preparation, and applications of the composite materials, with emphasis on PM 212. Another of these documents discusses the differences and similarities of parts made by sintering with those made by hot isostatic pressing; it states the finding that both processes yield similar friction and wear properties, although those obtained by hot isostatic pressing are slightly more favorable: the fully dense hot-isostatically-pressed material has about 3 times the strength of the sintered material, which is about 80 percent dense.

This work was done by Harold E. Sliney and Christopher DellaCorte of **Lewis Research Center** *and Michael S. Bogdanski and Philip Edwards of Case Western Reserve University. For further information,* ***write in 47*** *on the TSP Request Card.*
LEW-15679

Properties of Soda/Yttria/Silica Glasses

An experimental study of the glass-formation compositional region of the soda/ yttria/silicate system and of selected physical properties of the glasses within this compositional region is part of a continuing effort to identify glasses with high coefficients of thermal expansion and high softening temperatures, for use as coatings on superalloys and as glass-to-metal seals. The glasses within the compositional region of interest were measured to have densities between 2.4 and 3.1 g/cm^3, indices of refraction between 1.50 and 1.60, coefficients of thermal expansion (α_{CTE}) between 7×10^{-6}/°C and 19×10^{-6}/°C, dilatometric softening temperatures (T_D) between 500 and 780°C, and Vickers hardness values (H_V) between 3.7 and 5.8 GPa. Of particular interest are compositions in the vicinity of $25Na_2O{\cdot}5Y_2O_3{\cdot}70SiO_2$, which ex-

hibited high α_{CTE}, high T_D, and high chemical durability (low rate of dissolution in hot water).

This work was done by Paul W. Angel and Raiford E. Hann of **Lewis Research Center**. *For further information,* ***write in 57*** *on the TSP Request Card. LEW-15738*

Mechanical Tests for Monitoring Aging of Composites

An experimental study addresses related topics of thermo-oxidative aging of PMR-15 (polyimide matrix/graphite-fiber composite materials) the strengths of interfacial bonds, the effects of various surface treatments, and the relative merits of mechanical tests that yield measures of the strengths of the materials. More specifically, the study focuses on the utility of a transverse-flexural-strength (TFS) test in measuring the strengths of the interfacial bonds, thereby enabling evaluation of the effects of fiber-surface treatments and thermo-oxidative aging. In this regard, the TFS test is compared with an interlaminar-shear-strength (ILSS) test and a longitudinal-flexure-strength (LFS) test, both of which have been shown in previous studies to yield results that are affected by the interfacial bonds.

This work was done by Kenneth J. Bowles of **Lewis Research Center**. *For further information,* ***write in 17*** *on the TSP Request Card.*
LEW-15731

Tests and Mathematical Modeling of an Adsorbent Bed

Four reports describe various aspects of a mathematical-modeling and experimental study of a solid amine regenerative adsorbent bed. The experimental bed was a laboratory prototype of a larger bed that would remove CO_2 gas and H_2O vapor from air in a life-support system in a spacecraft. These studies were undertaken to develop the physical understanding and data needed to predict adsorption performance under various operating conditions.

This work was done by Marybeth Edeen and Fredrick A. Ouellette of **Johnson Space Center** *and Frank F. Jeng and Robert G. Williamson of Lockheed Engineering & Sciences Co. To obtain a copy of the collection of reports, "Adsorbent Testing and Mathematical Modeling of a Solid Amine Regenerative CO_2 and H_2O Removal System,"* ***write in 97*** *on the TSP Request Card. MSC-21996*

Finding Substitutes for Chlorofluorocarbons

A 450-page document contains information on worldwide efforts to replace chlorofluorocarbons (CFC's) with other fluids. The document contains magazine articles, commercial-product data sheets, technical reports, brochures, advertisements, minutes of meetings, and conference and workshop papers from a variety of sources.

This work was done by J. Wayne McCain of **Marshall Space Flight Center**. *To obtain a copy of the document, "CFC Replacement Critical Area Response,"* ***write in 39*** *on the TSP Request Card.*
MFS-27317

Physical Sciences

Thermal Modeling of a 250-A·h Li/SOCl2 Battery

A report presents an analysis of the anticipated thermal conditions in and around a 250-A·h Li/$SOCl_2$ battery that is being developed for use aboard a Centaur rocket. The battery would be mounted on an exterior surface of the Centaur booster, exposed to the outer-space environment. Heat input to the battery would consist of heat generated within the battery by its discharge, heating by radiation from the Sun and Earth, and heating by impinging free molecules. Heat output from the battery would consist of heat conducted to the skin of the Centaur rocket and heat radiated to both the skin and to outer space.

This work was done by Pradeep Bhandari of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Thermal Modeling of the Honeywell 250 Ah Battery Design,"* ***write in 5*** *on the TSP Request Card.*

NPO-18434

Machinery

Task-Directed Inverse Kinematics for Redundant Manipulators

A paper presents algorithms for use in controlling redundant robotic manipulators in such a way as to exploit redundancy to satisfy task requirements beyond the placement of end effectors at desired positions and orientations. Examples of such requirements include avoidance of obstacles, applying specified forces, avoiding uncontrolled internal motions of the robot, and smooth operation at or near singularities.

This work was done by Mark K. Long of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the paper, "Task Directed Inverse Kinematics for Redundant Manipulators,"* ***write in 69*** *on the TSP Request Card.*

NPO-18680

Life Sciences

Natural and Artificial Ecosystems

A NASA conference publication contains the proceedings of the 27th meeting of the Committee on Space Research (COSPAR) in Espoo, Finland, July 18-29, 1988. It includes papers by scientists from the United States, France, Canada, Japan, and the Soviet Union. COSPAR is devoted to development of bioregenerative life-support systems for use aboard spacecraft. The interests of its members include studies of natural ecological systems, development of biotechnological systems, generation of data on natural and artificial ecosystems by remote sensing, and development of artificial ecosystems.

This publication was edited by Robert D. MacElroy of **Ames**

Multiple Pages Intentionally Left Blank

Research Center, *Brad G. Thompson of the Alberta Research Council, Theodore W. Tibbitts of the University of Wisconsin, and Tyler Volk of New York University. Further information may be found in NASA CP-10040 [N91-24744], "Controlled Ecological Life Support Systems — Natural and Artificial Ecosystems."*

Copies may be purchased (prepayment required) from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12801

Microgravity Flotation Process

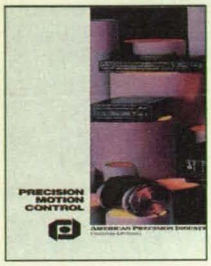
A report presents a study directed toward the development of a microgravitational foam flotation process for the fractionation of large biological molecules and whole cells. Foam flotation in microgravitation offers the potential to separate large particles more effectively than is possible by foam flotation in normal Earth gravitation. Among other things, less surfactant is needed to form the flotation foam in microgravitation. Therefore, microgravitational foam flotation may be applicable to separation of such biological materials as whole cells, proteins, enzymes, and viruses, all of which can be damaged by concentrated surfactants.

This work was done by David A. Noever of **Marshall Space Flight Center**. *To obtain a copy of the report, "Low-Gravity Technology for Foam Fractionation of Large Particles,"* ***write in 22*** *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 22]. Refer to MFS-28650.

LITERATURE SPOTLIGHT

Free catalogs and literature for NASA Tech Briefs' readers. To order, write in the corresponding number on the Readers Information Request Form (page 83).



PRECISION MOTION CONTROL

API's 132 page motor systems catalog is a complete source for motion control technical, application, and product data. Definitions, market applications, comparison charts, specifications and diagrams simplify the selection/application process. API products range from full/half step driver modules to high performance microstep systems. Contact American Precision Industries, Controls Division. Tel: 716-631-9800; Fax 716-631-0152.

American Precision Industries

For More Information Write In No. 300

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 Perm-selective valve, patented by Evans, 33 Eastern Ave., East Providence, RI 02914-2107, Tel: 401-434-5600; Fax: 401-434-6908.

Evans

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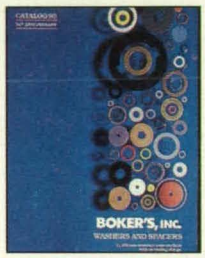

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FREE! Boker's new 32-page Catalog '93 offers 11,000 non-standard sizes with no tooling charges. Outside diameters of 0.080" to 2.631", a wide variety of inside diameters and thicknesses, and 2,000 material variations create millions of possibilities. Materials include low carbon, cold rolled strip and sheet steel; five types of spring steel; stainless steel; aluminum; brass; copper; nickel silver; and such non-metallic materials as Delrin®, Teflon®, Mylar®, and nylon. Metric sizes also.

Boker's, Inc.

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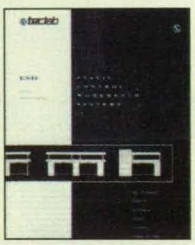

TECLAB ESD WORKSTATION CATALOG

Kalamazoo Technical Furniture's 8-page 4/color brochure details the Teclab line of static protective workbenches, workstation systems, and ESD controlled workstation accessories. Included are color options, product specifications, and various levels of ESD protection available. Teclab also offers a Free Planning and Design Service. Teclab, the "professional's bench." Tel: 1-800-832-5227. Fax: 616-372-6116.

Kalamazoo Technical Furniture

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COLOR WORKSTATION FOR DATA ACQUISITION AND ANALYSIS

The HT600 combines internal math algorithms with high speed, high resolution digitizing of analog signals. A built-in VGA color graphics interface with touch panel, mouse or keyboard entry increases ease of use. It boasts sampling rates from 1 sample/sec. to 200 Megasamples/sec. with memory sizes 2k to 32 Meg and digitizers from 8 bits to 16 bits. From $15,500, depending on digitizers & memory length. Delivery: 30-45 days ARO. Contact: Garry Williams, 1-800-248-1633.

Hi-Techniques, Inc.

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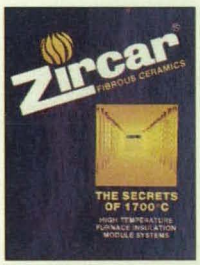

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ZIRCAR's system addresses the severe thermal and mechanical stresses 1700 °C puts on the hot-face insulation layer of 1700 °C rapid-cycle furnaces. ZIRCAR's insulation modules are pre-assembled insulation systems constructed of a graded system of high quality ZIRCAR insulation layers. They provide O.E.M. furnace builders easy entry into the ultra high temperature fiber lined furnace market by extending reliable 1700 °C service into production sized furnaces.

For More Information Write In No. 305

FIBER INSULATED HEATERS

Manufacturers of fiber insulated heaters to 1200 °C (2190 °F) in standard flat heater panels, full and half round cylinders and also custom shapes and sizes. Complete range of accessories are available.

Zircar Products, Inc.
110 North Main Street
P.O. Box 458
Florida, NY 10921-0458.

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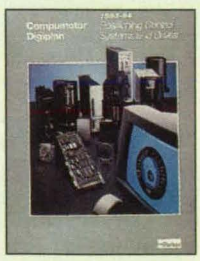

NEW COMPUMOTOR CATALOG! POSITIONING CONTROL SYSTEMS & DRIVES

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.

Parker Hannifin Corporation, Computer Motor Division
Phone: 800-358-9070 Fax: 707-584-8015

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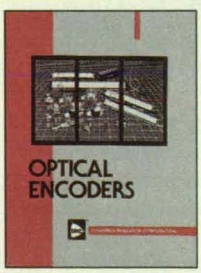

OPTICAL ENCODERS

DRC's 98 page catalog gives detailed mechanical and electrical specifications for their complete line of rotary, linear, and modular optical encoders. Certain stocked configurations can ship in 3 days. We also specialize in customizing standard models for your specific application.

Dynamics Research Corporation

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ABRASIVE BLAST SYSTEM

The Micro-Jet 200 is a miniature, low-cost system for the shockless machining, cutting, and etching of the hardest materials such as glass, ceramics, gem stones, carbides. Employing a pressure feed system for producing the air/abrasive jet, its operational performance is the equal of more expensive competitive systems. Applications include: cutting, drilling and shaping; etching and marking; microdeburring and deflashing; cleaning; surface finishing.

Hunter Products, Inc.

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Mayline's VariTask solves ergonomic problems for intensive computer users. Large work surfaces have power-adjust height and tilt controls. Great for CAD environments where drawing tablet and second monitor are needed. FREE full-color brochure. Video available upon request. Mayline Company, Sheboygan, WI. Tel: 1-800-822-8037.

The Mayline Company

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Seiler Instrument offers state-of-the-art machining and product assembly. Automated CNC machining centers work with steel, aluminum, brass, copper, and stainless steel. In-house R&D and quality control/departments guarantee compliance to strict specifications. For our complete capabilities brochure, call 1-800-489-2282. Fax: 314-968-2637.

Seiler Instrument & Manufacturing Co., Inc.

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SYNTHESIZED FUNCTION GENERATOR

The DS345 offers digitally synthesized waveforms to 30 micro-Hz with 1 mHz resolution, arbitrary waveform and modulated outputs. Outputs can be simple sine, triangle, ramp, or square waves; complex arbitrary signals up to 16,300 points can also be created.

Stanford Research Systems Inc.

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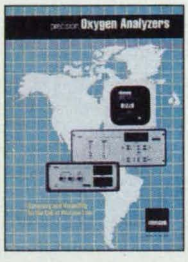

OXYGEN ANALYZERS

A full-color brochure introduces a complete line of oxygen analyzers for the laboratory or process line. They are ideally suited for monitoring the oxygen levels in all types of gas streams. Trace oxygen levels from ppb to 100% are accurately determined by these ruggedly constructed instruments. No periodic maintenance or special operator skills are required. Intrinsically-safe and battery-operated models are also available.

Illinois Instruments Inc.

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GPS-SYNCHRONIZED TIMING PRODUCTS

TrueTime's Precision Timing Products catalog features GPS-Synchronized Clocks in rackmount, portable, and board-level configurations. Includes illustrations and product specifications for our complete line of Synchronized Clocks, Time Code Products, and Remote Displays to fit a variety of time and frequency applications.

TrueTime, Inc.

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Arburg, Inc.

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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.
1700 North Farnsworth Avenue
Aurora, IL 60505
Tel: (708) 851-1734 Fax: (708) 851-2106

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QUIET COMPRESSED AIR!

Jun-Air's new brochure shows you only a few of the possibilities. Compressors range from oil-lube to oil-less, 110v - DC, 0.25 - 3.0 HP, 0.7 - 11.0 cfm, maximum pressure 120 psi. Vacuum pumps and custom designed compressors to customer specifications also featured. Join over 250,000 satisfied customers in over 50 countries worldwide enjoying their Jun-Air compressors. Ask about our line of "Quiet" compressors. Phone 800-4JUNAIR.

Jun-Air USA Inc.

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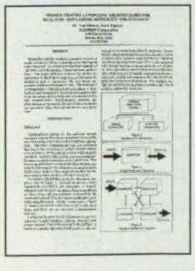

REAL-TIME SIMULATION

The SCRAMNet™ Network combines the real-time speed of replicated shared-memory with the flexibility of a fiber optic LAN to get microsecond response. This FREE tech paper compared SCRAMNet's shared memory networking to the more traditional approaches. Tel: 800-252-5601; Fax: 513-258-2729.

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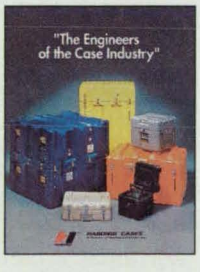

Hardigg Cases offers over 225 standard rotationally molded transit cases, including a full line of 19" EIA rack mount cases, deck cases, and flange-mount cases. Hardigg's expert engineering, manufacturing, and test facilities provide start to finish custom design capability. A complete list of standard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

Hardigg Cases
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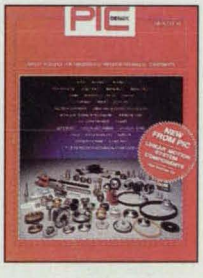

MECHANICAL COMPONENTS CATALOG

PIC Design, manufacturer of precision gears, pulleys, and many other mechanical components, has issued their biggest catalog yet. At 240 pages, Catalog 42 now includes a new section of Linear Motion products covering a range of precision lead screws, precision ground shafting with associated support rails, hangers, and linear bearings. Other new products include Flexible Zero-Backlash Couplings, linear slide guides and economical commercial grade positioning tables with up to 8" of travel. PIC Design, Tel: 203-758-8272; Fax: 203-758-8271.

For More Information Write In No. 321

PROGRAMMABLE MOTION CONTROLLERS

1994 catalog describes full line of servo motion controllers. Includes box-level industrial controllers and multi-axis plug-in boards. PC/XT/AT, STD, VME and RS-232 interfaces available. Linear and circular interpolation, gearing, programmable I/O and memory. Also power amplifiers, servo motors, and support software. Call toll-free: 1-800-377-6329.

Galil Motion Control, Inc.

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ADVANCED COMPOSITE WORKSHOPS —SINCE 1983

The brochure describes eleven different "hands-on" workshops in advanced composite materials technology. These workshops cover fabrication, repair, manufacturing, tooling, blueprint reading, adhesive bonding, engineering design for specialized repairs, and ultrasonic inspection of composites. 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. REFRESHER WORKSHOPS OFFERED. Call toll-free: 1-800-638-8441. Fax 702-827-6599.

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Our *NEW* 85-page catalog describes a full family of pressure and linear position transducers, including a complete line of supporting instrumentation and accessories. A "how to" selection guide, applications and reference sections assist the design engineer in "making the right choice." Send for a copy today, or call us toll-free at 1-800-333-DATA. Tel: 800-333-3282; Fax: 508-263-0630.

Data Instruments Inc.

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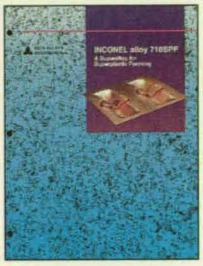

INCONEL® ALLOY 718SPF™

This new publication from Inco Alloys International describes the physical and mechanical properties of Inconel alloy 718SPF, a development of alloy 718, now amenable to superplastic forming techniques.

Inco Alloys International

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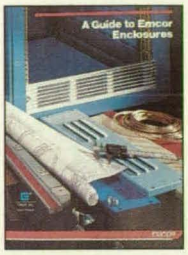

EMCOR'S ELECTRONIC ENCLOSURES GUIDE

"A Guide to Emcor Enclosures" describes design, construction, and component features of all Emcor enclosure systems—ESQ, 10 Series, Emcor I, EMI-RFI shielded cabinets—plus CompuDesk, enclosure cooling accessories, Instant Emcor ship-from-stock program, and modification and custom design capabilities. Free catalog. Emcor Products, 1600 4th Avenue NW, Rochester, MN 55901. Tel: 507-289-3371.

Emcor Products

For More Information Write In No. 326

FREE LIGHT RESEARCH PRODUCT GUIDE

The new Oriel Volume II Product Guide: *Light Sources, Monochromators and Detection Systems*, is a technical reference manual and product catalog in one. This 528 page book features UV to NIR pulsed light sources, nitrogen and tunable dye lasers, calibrated irradiance sources, imaging monochromators/spectrographs with multiple grating turrets, cooled UV-IR detectors, CCDs for spectroscopy. For a free copy, contact Oriel, Tel: 203-377-8282. Fax: 203-375-0851.

For More Information Write In No. 327

ELECTRONIC HARDWARE CATALOG

Broadest selection of hardware for electronic assemblies. 350-page free catalog includes a full range of standoffs, captive screws and nuts, chassis fasteners, handles, ferrules, spacers and washers. Special sections—new, unusual products, metric information and Mil-plating specifications. Full inventory, fast turnaround, samples. Tel: 1-800-237-0013; Fax: 201-661-3408.

Accurate Screw Machine Co.

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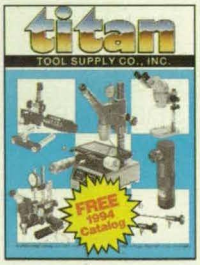

OPTICS FOR METROLOGY

New 1994 Catalog contains 120 pages of information and prices on toolmaker's microscopes, stereo microscopes, alignment microscopes, monocular zoom microscopes, microtelescopes, pocket microscopes, borescopes, micro video lenses, and fiber optic and miniature illumination systems. Also described are centering microscopes, optical cutting tool geometry analyzers, X-Y tables, and micro-finishing equipment. Tel: 716-873-9907; Fax: 716-873-9993.

Titan Tool Supply Co., Inc.

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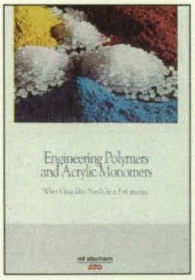

POLYMERS & ACRYLIC MONOMERS

A new, 12-page four-color brochure titled "Engineering Polymers and Acrylic Monomers." Included are polymers and monomers family of products, including Rilsan® 11 and 12 polyimides; Rilsan® powder coatings, Pebax® thermoplastic elastomer resins, Platamid® and Platherm® hot melt adhesives; Platilon® hot melt film, and acrylic monomers. Product description, background, and a sampling of applications are also provided.

Elf Atochem North America, Inc.

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FREE 288-page 1994 Data Acquisition Catalog and Reference Guide featuring Keithley MetraByte's broad line of PC-based, hardware and software solutions for measurement and analysis. Includes Tech Tips, a section on application notes, and an overview of data acquisition software. Detailed specs on data acquisition instruments, IEEE-488.2 interfaces and PC instruments for IBM PC/XT/AT, PS/2 and MicroChannel computers are also covered. Request your FREE copy today! Tel: 800-348-0033 or 508-880-3000; Fax: 508-880-0179.

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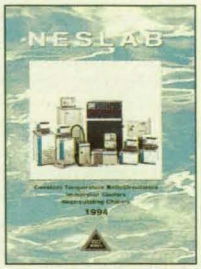

RECIRCULATING CHILLERS

64-page catalog features a complete line of recirculating chillers for cooling water-cooled equipment. These chillers offer steady cooling with heat load removal up to 75 kW, spanning temperature ranges of +5 °C to +35 °C. Chillers feature 1) ozone-friendly refrigeration systems, 2) LED display, 3) operating status gauges, 4) and easy access to internal components. Also available is CFC-free Constant Temperature Equipment. Call toll-free at 1-800-258-0830.

NESLAB Instruments, Inc.

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Use this 92-page source book to gather information on by-pass, auxiliary-air and variable air volume hoods as well as base cabinets, work surfaces blowers and ductwork. Read about safety accessories such as the Guardian™ Air Monitor. Call 800-732-0031.

Labconco

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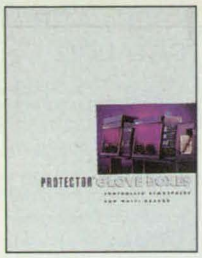

GET YOUR HANDS ON THE PROTECTOR® GLOVE BOXES CATALOG

Thumb through this 28-page, full-color catalog detailing Labconco's controlled atmosphere and multi-hazard glove boxes. Find complete information on built-in options including the automatic pressure controller with foot pedal and purge/fill controller. Call 800-732-0031.

Labconco

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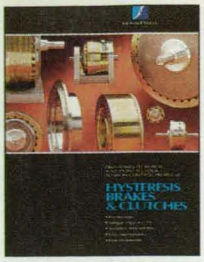

HYSTERESIS BRAKE AND CLUTCH CATALOG

New 24-page magtrol Hysteresis Brake and Clutch Catalog describes the full range of frictionless hysteresis products and their advantages over other forms of tension control devices. Special applications section, sizing and ordering data, rating and dimension tables, and custom design product capabilities are included in the new catalog. Contract: Magtrol, Inc., 70 Gardenville Parkway West, Buffalo, NY 14224. Tel: 1-800-828-7844.

Magtrol, Inc.

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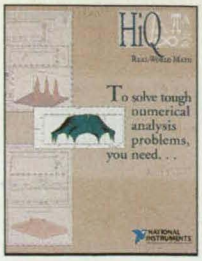

The free demonstration version of HiQ® is based on the full-function numerical analysis software package. It features a demonstration guide that describes HiQ programming concepts and leads the user through hands-on examples that teach how to use the mathematical functions and "Problem Solvers" in real-world analysis applications. National Instruments, 6504 Bridge Point Parkway, Austin, TX 78730. Tel: 512-794-0100; Fax: 512-794-8411.

National Instruments

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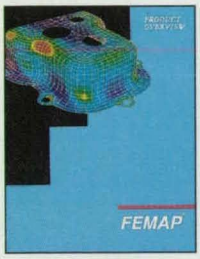

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Enterprise Software Products, Inc.

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320 pages of components, materials and precision tools in hard-to-get small quantities. A single source for a wide variety of **stainless steel** items, such as...miniature gauge 304 & 316 hypodermic tubing, luer fittings, guide wire, and miniature machine screws. Also Tygon® and PEEK tubing, nylon mesh filter material, and noise and vibration isolators.

Cover: Winner of U.S. FIRST Competition

SMALL PARTS, Inc.

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Airpel Division, Airpot Corporation

For More Information Write In No. 339

MODULAR CONTROLLERS HANDLE DOZENS TO HUNDREDS OF SENSORS

Brochure describes the ANAFAZE Modular Loop System (MLS), providing from 8 up to 512 measurement and PID control loops, even for mixed sensor types: thermocouple, RTD, Infrared, mA and mV. Network-ready boardsets and DIN controllers can work autonomously or be linked to ANASOFT (a PC-software package that turns data into information). ANAFAZE, 334 Westridge Drive, Watsonville, CA 95076. Tel: 408-724-3800; Fax: 408-724-0320.

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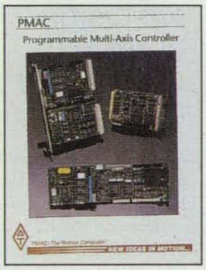


MOTION CONTROL HANDBOOK

Four-color 44-page book sets forth the basic DSP fundamentals; motion controller, servo filters, background PLC, circular interpolation moves, blended moves, cubic spline moves. Includes: 10 programming examples, summarizes PMAC commands and variables with G-code section. Details PMAC's options and accessories, as well as hardware and software.

Delta Tau Data Systems, Inc.

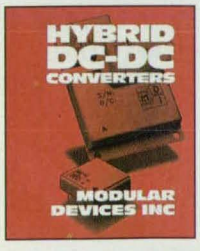
For More Information Write In No. 341

DC MOTOR CONTROLS

New 52p catalog allows you to select optimum control for sub-sub-fractional to 10 horsepower DC motors • Machine Tools • Motorized Machinery • Positioning • Conveyors • Actuators • Packaging Machinery • Exercise Equipment • XY Tables • Elevators/Levelers • Theatrical/Stage. Powr Ups can customize these controls for exact requirements. POWR UPS CORP, One Roned Road, Shirley, NY 11967, Toll-free 1-800-333-POWR or FAX 516-345-3106.

Powr Ups Corporation

For More Information Write In No. 342



HIGH REL HYBRID/DISCRETE DC-DC CONVERTERS

This new 32p catalog describes a full line of hybrid and discrete DC-DC converters for Space, Military and Industrial application; wide range of DC input voltages, output from 3 VDC (for new IC application) to 3 kilovolts, multiple outputs, full EMI filters/other systems type circuitry, Rad Hard versions specified, custom variations available. Tel: 1-800-333-POWR; Fax: 516-345-3106.

Modular Devices Inc.
One Roned Road • Shirley, NY 11967.

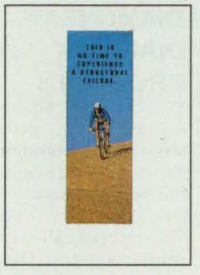
For More Information Write In No. 343

ADHESIVES/ SEALANTS/ COATINGS

Master Bond, Inc. manufactures over 3000 grades of adhesives, sealants, and coatings. Line consists of epoxies, anaerobics, cyanoacrylates, silicons, and acrylics. Both one- and two-part systems. Systems are designed to meet specific requirements. One-on-one assistance available with our highly knowledgeable technical staff. Tel: 201-343-8983; Fax: 201-343-2132.

Master Bond, Inc.

For More Information Write In No. 344



SHAPE OPTIMIZATION MADE SIMPLE, FAST AND AFFORDABLE

Put your designs in the hands of COSMOS/M and with a few short iterations, they can lose the weight but still handle the heavy work load. Minimize cost or weight fast while satisfying design constraints such as stress, temperature, frequency or buckling. Features powerful modeler, automatic mesher, fast solver, and a powerful postprocessor all within an easy to use interface. Start optimizing for as little as $995. Call 310-452-2158 in the west or 412-635-5100 in the east.

For More Information Write In No. 345

GPS TIMING FOR PC VMEBUS

This information folder from Bancomm describes new PCbus and VMEbus board-level Global Positioning System (GPS) Satellite Receivers. These products provide world-wide precision time (100 nanosecond) and frequency (1 part in 10E7) references inside the host computer.

Bancomm

For More Information Write In No. 346

STOP CORROSION

LaQue Center's corrosion engineering services provide testing programs and consulting for failure analysis, material evaluation and selection, environmental-corrosion monitoring, and on-site corrosion inspections. Natural seawater and marine atmospheric exposure sites support component/equipment evaluations. Training course "Fundamentals of Corrosion and Its Control" available for on-site presentation.

LaQue Center for Corrosion Technology Inc.

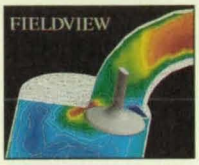
For More Information Write In No. 347

FREE LAMP CATALOG

This catalog features replacement lamps at discount prices for all types of audio visual, photographic, micrographic and graphic arts equipment. 100% guaranteed brand names - toll free ordering - no minimum order - ALL deliveries via UPS Second-Day Air at no extra cost. Also, lamps for medical and electronic instruments, microscopes and video use. Tel: 1-800-772-5267, Fax: 1-800-257-0760. PSC Lamps, Inc. 435 W. Commercial St., E. Rochester, NY 14445.

PSC Lamps, Inc.

For More Information Write In No. 348



ADVANCED CFD POST-PROCESSOR

FIELDVIEW increases engineering productivity with easy to use tools that help you understand complex fluid dynamics data. Direct interfaces for PLOT3D, FLUENT, CFD2000, PHOENICS, FIDAP, FLOW-3D, RAMPANT, STAR-CD and other flow solvers. Runs on most Unix workstations. Call Toll Free in USA and Canada 800-887-8500, or 201-460-4700. Fax: 201-460-0221.

INTELLIGENT LIGHT
1099 Wall Street West, Suite 387
Lyndhurst, NJ 07071

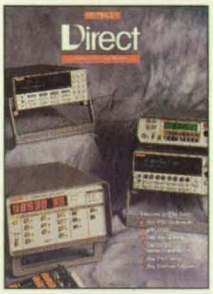
For More Information Write In No. 349

TURBO-MACHINERY ENGINEERING

Free brochure shows how companies that produce or operate compressors, pumps, or turbines can benefit from NREC's advanced engineering consulting expertise, specialized CAE/CAM software, and precision manufacturing services. Phone: 617-937-4655; Fax: 617-935-9052.

Northern Research & Engineering Corp.

For More Information Write In No. 350



NEW KEITHLEY DIRECT CATALOG

Keithley Instruments is offering its new direct marketing catalog of selected test instruments and accessories. Many of the company's DMMs, switches, source-measure units and accessories are included. One of the featured products in this issue is a new electrometer. Call 1-800-552-1115 for your free copy. Keithley Insruments, Inc., 28775 Aurora Rd., Solon, OH 44139.

Keithley Insruments, Inc.

For More Information Write In No. 351

ULTRA-HARD MATERIALS FABRICATION

Insaco's brochure describes the custom manufacture of components in sapphire, ruby, quartz, ceramics of all types including glass-ceramics, alumina, zirconia, carbides, and nitrides. The company routinely fabricates these materials for applications in optics, chemistry, vacuum, bearings, electronics, nuclear, space and medicine. Tolerances are measured in millionths of an inch with surface finishes in angstroms and flatness to fractions of a wavelength. Tel: 800-959-0264; Fax: 800-959-0267.

Insaco, Inc.

For More Information Write In No. 352

PRECISION COUPLING COMPONENTS

Featuring a wide range of coupling devices in a variety of materials, this 32 page brochure is the latest from Berg. Designed to complement the Inch and Metric catalogs it contains Information Transmitting, Shock Absorbing, Misalignment Couplings. All designed and manufactured to meet the exacting demands of modern industry.

W.M. Berg Inc.
Tel: 516-596-1700; Fax: 516-599-3274.

For More Information Write In No. 353

PRECISION LINEAR COMPONENTS

Featuring a wide range of linear devices in a variety of materials, this 32 page brochure is the latest from Berg. Designed to complement the Inch and Metric catalogs it contains Linear Slides, Lead Screws, Linear Bearings and various Mounting Accessories. All designed and manufactured to meet the exacting demands of modern industry.

W.M. Berg Inc.
Tel: 516-596-1700; Fax: 516-599-3274.

For More Information Write In No. 354

DIAMONEX® DIAMOND PRODUCTS

Diamonex's new brochure describes their Polycrystalline and Amorphous Diamond-coated products for manufacturers using advanced technology. Polycrystalline Diamond enhances the performance of high-power FET heat spreaders, hybrid multichips, and laser diodes. Amorphous Diamond coatings for medical implantables, surgical implements, medical packaging, thermal printheads, hard disks and magnetic tapeheads enhance the lifetime and wear of products.

Diamonex, Inc.

For More Information Write In No. 355

LOW-COST DIGITAL VIBRATION CONTROLLERS

Easy to use VTS Expansion Card & Software convert your 386/486 personal computer to powerful Digital Sine or Random Vibration Controller. Frequency ranges—Random 500, 1000, or 2000 Hz. Sine to 6250 Hz. Many other unique features. Free Demo Disk available (learn to operate Controller in less than one hour). Coming Soon—Accelerometer Calibrator & Shock Controller.

Vibration Test Systems

For More Information Write In No. 356

VERSATILE CAM RUNS WITH ANY CAD

Guaranteed CAD/CAM data translators, including IGES Version 5.1 with trimmed NURBS surfaces. Fast and accurate 3D surface design, model, NC programming and machining. Powerful DOS and 32-bit Windows version. Call 800-488-3615 or 818-361-5605; Fax 818-361-1919.

Surfware, Inc.

For More Information Write In No. 357

COUPLINGS FOR EXTREME ENVIRONMENTS

New HFC-35 quick disconnect couplings are made from polysulfone resin for superior resistance to heat, cold, pressure and chemicals used in drinking water systems, food processing, chemical dispensing, pharmaceutical product transfer and equipment cooling. Couplings handle temperature extremes of -40 to 280 °F (-40 to 137.9 °C), repeated autoclaving, boiling water, oxidants and other chemicals. Tel: 612-645-0091.

Colder Products Company
For More Information Write In No. 358

STANDARD METAL ENCLOSURES

Hamilton Electronic Corp., Algo Div., is a specialist in fabricating seamless metal enclosures, panels, chassis, dust covers. MIL-T 27 transformer housings, filter cases, and RFI/EMI shielded enclosures. They provide a full line of standard metal enclosures and specialize in modifying standard parts to customer specs with no tooling charge. Materials include steel, aluminum, stainless steel, copper, brass, and mu-metal. Tel: 201-487-455-; Fax: 201-487-8717.

Hamilton Electronic Corporation
For More Information Write In No. 381

NEW XEROX 3030 ENGINEERING COPIER

A full-color brochure details the 3030, a powerful point-of-need plain-paper copier. The 3030 copies documents up to 36 inches wide by any manageable length at a speed of four D-size copies per minute, and copies from bluelines, CAD originals and cut-and-tape composites onto bond, vellum or film. Roll-fed media loading is quick and easy and the 3030 also features a compact design. Call 1-800-937-7397, ext. 8246 to request a brochure.

Xerox Corporation
For More Information Write In No. 363

WHY COMPROMISE? MSC/NASTRAN POWER NOW AT A DESKTOP PRICE

Now you can afford the world's most comprehensive Predictive Engineering™ software. MSC has integrated the solid modeling, FEM, and FEA pre- and postprocessing of MSC/ARIES with the simply powerful FEA solver, MSC/NASTRAN. *The price for this bundled system? Just $35,000 - **60% off** separate list prices.* Call 1-800-642-7437, ext. 500.

The MacNeal-Schwendler Corp.
For More Information Write In No. 366

New on the Market

The Checkpoint **machine vision system** from Cognex, Needham, MA, combines the company's machine vision tools with a Windows interface to enable users with minimal technical training to solve complex automated visual inspection tasks. The system can measure part dimensions with sub-pixel accuracy, detect the absence or presence of parts at rapid production speeds, align and place components, and verify parts assembly and positioning.

For More Information Write In No. 708

Keithley Instrument Inc., Cleveland, OH, has introduced TestPoint multitasking object-oriented **software to create custom test, measurement, and data acquisition applications** for Windows without conventional programming techniques. TestPoint helps users develop test routines, process and display data, create report files, and exchange information with other Windows applications such as spreadsheet and word processing packages.

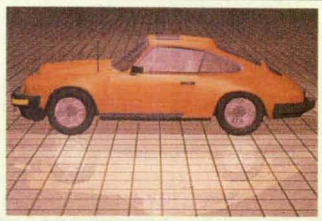
For More Information Write In No. 726

ND Industries Adhesives and Sealants Division, Royal Oak, MI, has formulated a two-part **structural adhesive** for permanent, production-line bonding of metals, plastics, ceramics, and wood. Unlike epoxies, the new ND 240015 requires no mixing—simply apply the primer to one surface, the resin to the other, and press the two surfaces together for a permanent bond within five minutes.

For More Information Write In No. 711

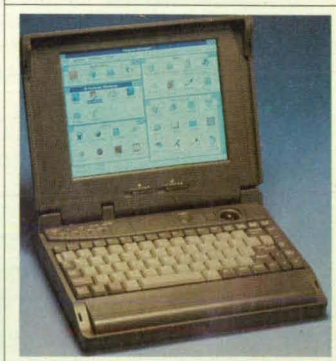
Electrascan Inc., Berkeley, CA, has developed a **digital meter** to noninvasively measure voltage, current, and power. The VIP-500 senses and integrates the electric field surrounding a wire without contacting the conductors. The unit features a 0-500 VAC voltage measurement range, a 0-200 A current measurement range, and a 0-100 kW power measurement range.

For More Information Write In No. 712



RenderPrint™ software from Insight Development Corp., San Ramon, CA, produces fast, photo-realistic 3D images on any printer at full printer resolution from any graphics application. The program will convert to and from most popular file formats, including BMP, GIF, IGES, JPEG, PCX, TIFF, TGA, and WPG. It works in ADI-protected mode within AutoCAD and other applications such as AutoVision and 3D Studio.

For More Information Write In No. 715



The DESIGNBOOK **portable computer** from TRI-STAR Computer Corp., Chandler, AZ, allows design professionals to work with high-performance software such as Quark, AutoCAD, Pagemaker, and Multimedia. DESIGNBOOK offers up to 20 MB of RAM, and incorporates a 512k Cirrus Logic VESA Local Bus Video to provide up to 1024 x 768 color resolution when connected to a external monitor.

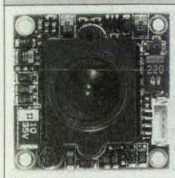
For More Information Write In No. 713

New on the Market

Tripos Associates Inc., St. Louis, MO, has announced MatchMaker, **software that predicts 3D protein models** by including interactions with neighboring residues. The program recognizes entire protein folds and families from sequences of globular proteins using a large database of known structures and is available on Silicon Graphics workstations, as a stand-alone, or as a Tripos SYBYL molecular analysis option.
For More Information Write In No. 720

Immersion Corp., Palo Alto, CA, has introduced the Immersion Personal Digitizer™, the first consumer product for digitizing 3D objects. Priced at $1575 (including software), the desktop unit traces object profiles with a pen-like stylus and stores them as a data set in standard formats. The device functions as a full-degree-of-freedom interface tool, allowing digitized objects to be manipulated in 3D space.
For More Information Write In No. 718

Design Sciences Corp., Vienna, VA, has released Artificial Neural Systems-based **software for modeling complex processes and building data-driven decision support systems**. Dubbed DS2000, the program offers an icon-oriented design that permits users to experiment with configurations of multiple network models to construct powerful classification or pattern recognition-based systems. It works with data from databases, spreadsheets, image files, expert system shells, and simulation/modeling tools.
For More Information Write In No. 709



Two ultra-compact, solid-state **CCTV cameras** have been unveiled by Chinon America Inc., Mountainside, NJ. The CX-060 micro-miniature monochrome board camera measures 1¼" x 1¼" x 1 1/16" and weighs just .59 oz.; the CX-062 color board camera weighs 2.3 oz. Both employ a 1/3 CCD type imaging chip for 250,000-pixel resolution and feature auto exposure capability and automatic gain control.
For More Information Write In No. 719

The NP-1600, a 300-dpi color and monochrome **network printer** for homogeneous or heterogeneous TCP/IP or EtherTalk-based networks, has been introduced by Codonics Inc., Middleburg Heights, OH. The NP-1600 uses dye-sublimation technology with 16.7 million simultaneously printable colors to produce continuous-tone prints.
For More Information Write In No. 716

Computer Witchcraft Inc., Louisville, KY, has introduced WinNET™ Mail and News Version 2.0, the first Windows **software to make the Internet accessible to ordinary PC users**, eliminating the need to navigate a terminal emulator, UNIX command prompts, or character-oriented menus. Distributed free of charge, the software offers instant account registration, automated news subscriptions, and a multi-document interface.
For More Information Write In No. 707

Z-World Engineering, Davis, CA, has unveiled the Little Star™ C **programmable controller for manufacturing automation and OEM control** applications. Measuring 4" x 5" and priced at $295, the unit features an operator interface, an enclosure with a built-in LCD, and a 12-key keypad. Users can scan multiple menus and change system parameters using just five keys.
For More Information Write In No. 727

ERDAS Inc., Atlanta, GA, has released IMAGE RESTORATION™, a **resampling module** that sharpens images by compensating for each sensor's inherent distortions and restoring brightness values present when the image was captured. Available as an add-on to ERDAS IMAGINE®, RESTORATION recreates original scene radiometry for the Landsat and MSS, SPOT Panchromatic and XS, and AVHRR sensors.
For More Information Write In No. 717

New on the Market

High-efficiency **ball screw actuators** are available in volume from Thomson Saginaw Ball Screw Company Inc., Saginaw, MI. Measuring 0.375" diameter x 0.125" lead, the ball screw is suitable for push-pull mechanisms in consumer products as well as manufacturing and processing equipment. The basic ball nuts can be fitted with a variety of housings or adapters, including internal trunnions, end flanges, and V-thread (inch or metric).
For More Information Write In No. 724

Innovative **multiprocessor programming software** from Dynetics Inc., Huntsville, AL, allows users to program by building block diagrams. Called DataFlo MP, it is the first complete graphical programming environment for both embedded and desktop multiprocessor systems. Its basic library provides more than 250 signal processing and data processing icons.
For More Information Write In No. 722

A line of microprocessor-based **programmable voice products** from Logical Products Inc., Gurnee, IL, can record and play back up to 300 words, phrases, or sounds in their natural analog form. Prompted by input from clocks, calendars, timers, counters, data registers, or sensors, the units speak clearly and naturally, offering customized, sequential instructions, information, or warnings. Two of the units include bright message displays.
For More Information Write In No. 721

Interactive Products Inc., Eugene, OR, has released VoiceMouse™ **speech recognition software** for Windows. The speaker-independent program provides control via voice commands for all popular software applications and features an unlimited vocabulary. Compatible with all 8- and 16-bit sound cards, VoiceMouse is available for $79.95.
For More Information Write In No. 725

The Sig32C-8 from Signalogic, Dallas, TX, combines the AT&T DSP32C 32-bit **floating point digital signal processor** with eight channels of analog I/O on a 7.5" PC plug-in board. Each channel contains 16-bit sigma-delta A/D and D/A converters and programmable input gain, output attenuation, and sampling rate. Sigma-delta technology gives each channel automatic anti-aliasing and reconstruction filters.
For More Information Write In No. 723

The DKC-5000 CatsEye™ **digital camera system** from Sony Electronics, Montvale, NJ, incorporates three 440,000-pixel CCD chips, new spatial pixel offset technology, and 10-bit analog-to-digital conversion to provide high-resolution images with excellent color fidelity in real time. Priced at $15,000, the system offers up to ten frame memories and can transfer images to a computer in 10-20 seconds.
For More Information Write In No. 714

PowerPro, the industry's first high-accuracy **oscilloscope** for power applications, has been announced by Nicolet Instrument Corp., Madison, WI. Even in hostile electrical fields of 100 kV/m and 1000 A/m, the unit offers ±0.5% accuracy. Its 25 MHz bandwidth is optimized to capture the fastest power transients but reject high-frequency RF interference while ultra-low-noise 75 MS/s, ten-bit digitizers insure accurate signal capture.
For More Information Write In No. 710

POSITIONS WANTED

20 years in hybrid microelectronics; designing, developing, and transferring new products into manufacturing. Developed reliable military power modules, sensors for cameras and hybrids for pacemakers. Also started up facilities to manufacture these high-reliability systems. By linking hybrid materials knowledge and sculptured LTCC multilayer structure technology, new microelectronics packaging options can be developed. BS in physics.
Box number 20C

BS, MBA/finance, seeking sales/marketing position for instrumentation market. 10 years in development of sales channels for both domestic and Pacific Rim territories. Excellent communication and negotiation skills utilizing strong analytical, financial and budgeting techniques. Let me help you increase your market share for new or existing products.
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Box number 22C

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Box number 24C

BSChE, PE in seven states. 20 years in engineering, design, construction, management, marketing, sales, startup. Have worked extensively in a variety of industries as a process and industry and controls engineer. Good verbal and communication skills. Looking for permanent, temporary, or project assignments. Tel: 404-998-9485.
Box number 25C

Biomedical engineering Ph.D and MS, EE/CS/Sciences BS, business school graduate in management of technology. 7 years in developing electrophysical instrumentation all the way from basic research through production. Excellent publication record. Young innovator with strong management & interpersonal skills. Seeking R&D position in the biomedical industry.
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MBA, BA, certified professional contract manager, with more than 14 years experience in all aspects of contract administration and management. Solid understanding of FAR/DFARs. Seeking position as contract manager, contract/subcontract administrator. Will relocate anywhere USA.
Box number 27C

Creative thinking mechanical aeronautical engineer, MSME. Background in structural/aerodynamic design & analysis using composite materials. Math modeling and simulation software development with C, C++, FORTRAN. Hands-on experience with: FEM, composite manufacturing techniques, structural & wind tunnel testing and data acquisition. Motivated, available—call now! Gary Cohen: 415-292-2428.
Box number 28C

Departing federal government's senior executive service. Over 25 years working for NASA, commerce, and DOD. Experience with technology development, transfer, dual use, and export licensing. Available for temporary/permanent as manufacturers representative and for liaison with federal agencies and Congressional committees. BSEE, MEA, BSBMGT, PE, FCC License. Fax: 703-684-6371.
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Box number 30C

R&D position; Ph.D, ME ('88 Cornell). Strong background in computer modeling in thermo-fluids and tomographic image processing. 5 years consulting and R&D experience in modeling turbulent mixing flows, reacting flows, heat transfer. CFD, kinetics codes: FIDAP PHOENICS, CHEMKIN. 10 years programming experience: FORTRAN, PASCAL, UNIX. Good publication record.
Box number 31C

Civil (structural) engineer, PE computer-assisted design and drafting (frame analysis and AutoCAD), human factors, and computer programming. BS: civil engineering (12/93). BS: psychology, BS: science, BS: social science, BS: general studies; AS: liberal arts, and AS: computer science.
Box number 32C

BSEE with 8 years in the defense industry as a technician in the RF, microwave, and analog fields. Proficient in C, Assembly, Pascal, AutoCAD, and have studied neural networks. Seeking entry-level position in any area of electrical engineering that utilizes technical skills and provides new learning opportunities.
Box number 33C

Open-minded new grad seeks challenging position in ME design and manufacturing. Very committed and hard working. Recently completed BS at UC Santa Barbara. Has small business design and management experience. Talents include CAD, composite structures, negotiations and communications with other engineers, customers, and vendors. Happy to travel or relocate.
Box number 34C

Extensive experience in system design and implementation, FAA overhaul documentation, aircraft engine overhaul/workscoping--worldwide contacts. Configuration management and control, Quality, SQA. TQM and SPC trained. BS mgt/math, MBA. Seeking a technical/maintenance position as airline customer rep, maintenance facility, or manufacturer. Direct or contract. W. Valentine: 316-442-3600, ext. 656.
Box number 35C

Magnetic device R&D specialist. Applications areas include transformers and inductors for communications, and low wattage power supplies. MSEE with more than 20 years in magnetic devices and materials, and holder of 5 patents. Available now for contract, consulting, or permanent employee position.
Box number 36C

Ph.D in computer science seeks R&D position in software engineering. Thesis in software complexity metrics. Research interests include software quality, software testing, fault-tolerant computing, and computer graphics. Several years experience developing software in C in C++. Familiar with UNIX, VMS, X Windows, Ada, FORTRAN, 8088 assembly, GL, PostScript, and TCP/IP. Knowledge of FEA, CAD tools, and 3D visualization. Willing to relocate.
Box number 37C

Technology applications analysis, systems engineering, and high level new project/program feasibility studies & management. Expert in financial competitiveness and valuation analysis. BS & MS mechanical engineering (PE), MBA finance. Seeks position with corporate/government financial/engineering group, management consulting, investment banking/venture capital firm. Tel: 310-498-8768.
Box number 38C

Motivated staff electrical engineer, BSEE, MSM, PE experienced in hardware, software, and system design, development, integration, and test. Also management of proposals, engineering projects, and R&D contracts. Application areas include inertial guidance systems, simulators and trainers, display systems, air traffic control, communications, digital computers. Skilled in communications, customer relations, and contract negotiations.
Box number 39C

BSEE diversified engineer for responsible design, professional review, management and technical assistance, energy reviews, maintenance, power and controls, hazardous areas and billing analysis for a variety of industries. Hazardous waste, environmental, industrial, chemical, steel, munitions, and projectiles. Familiar with PLC/DCS, codes, standards, specifications and PC programs. Tel: 713-952-2561.
Box number 40C

Senior engineering executive with record of success in project management, development, and marketing of telecommunications products. Strong technical background and bottom-line orientation. Experienced in product development life cycle, manufacturing operations, and total quality improvement methods. MBA Program/MSEE/BSEE. Full-time or consultant in product development, project/program management, process reengineering, or total quality management. George A. Vincent, Tel: 817-281-7940.
Box number 41C

To Request Resumes:

To obtain resumes corresponding to the above ads, fill out this form and mail to: Gregg McQueen, *NASA Tech Briefs*, 41 East 42nd St., New York, NY 10017; or call 1-800-944-NASA and ask for Gregg McQueen.

Send resumes for the following box numbers (limit 5):

Box_____ Box_____ Box_____

Box_____ Box_____

Name: _____

Company Name: _____

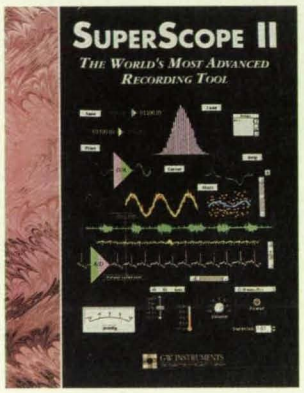
Street Address: _____

City/State/Zip: _____

New Literature

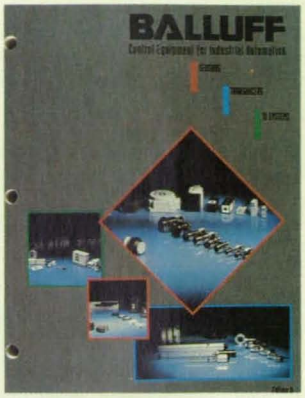
A 20-page catalog from Eastern Air Devices Inc., Dover, NH, highlights **brushless DC motors** in frame sizes from 1" to 4.38", including two new sizes, 3.38" and 4.38". As a result of magnetic design improvements, longer stack lengths, higher speeds, and higher torque ratings are available for all of the company's motors.
For More Information Write In No. 730

A brochure from GW Instruments, Somerville, MA, showcases Superscope II, Macintosh-based **software that can digitize, analyze, calculate, graph, and create databases for waveforms** in real-time with the help of the company's data acquisition hardware. The program includes a strip chart recorder, oscilloscope, spectrum analyzer, and XY recorder. It can digitize long continuous waveforms, spool them to disk, plot and analyze every point, allow on-line annotation, and support post-acquisition viewing.
For More Information Write In No. 732



A handbook on **self-clinching fasteners** has been published by Penn Engineering and Manufacturing Corp., Danboro, PA. The 12-page guide offers an overview of the self-clinching process, types of fasteners, and installation procedures. Included are answers to commonly asked questions and a glossary of technical terms.
For More Information Write In No. 728

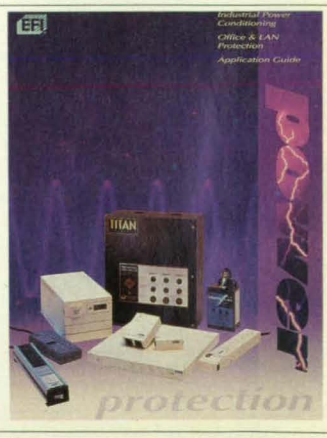
Power conditioning products and loss prevention programs and services are highlighted in a catalog from EFI Electronics Corp., Salt Lake City, UT. The company offers facility-wide solutions to power and data line protection from transient voltages and other problems found in commercial, industrial, and medical facilities. The catalog addresses power quality specifications, network power management software, and power and data line protection products for PCs, workstations, copiers, fax machines, laser printers, and laptop computers.
For More Information Write In No. 734



Balluff Inc., Florence, KY, has published a 650-page catalog of **industrial automation control equipment**. The company offers a wide range of switches—including proximity, optoelectronic, mechanical limit, rotary positioning, linear position, and programmable limit—as well as electronic identification systems, and motion control devices.
For More Information Write In No. 733

Miles Polymer Division, Pittsburgh, PA, has released a 32-page design guide detailing numerous **joining techniques for a variety of engineering resins**. *Plastics Joining Techniques* covers mechanical fastening, ultrasonic assembly, metal inserts, snap and press fits, heat welding and sealing, and solvent and adhesive bonding.
For More Information Write In No. 729

An 800-page update of the *Numerical Control Software Buyer's Guide* from CIMdata Inc., Ann Arbor, MI, describes products from 32 vendors for mainframe, workstation, PC, and Macintosh systems. New products include CAM-POST from ICAM Technologies, Generative Machining from SDRC, PAMS from Pathtrace, Personal Machinist from Computervision, Prelude Manufacturing from MATRA Datavision, and Virtual Gibbs from Gibbs and Associates.
For More Information Write In No. 731

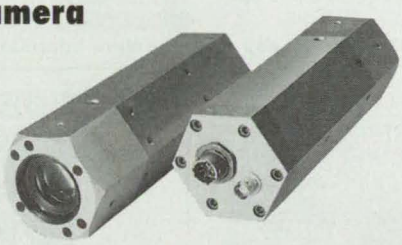


HIGH-TECH PRODUCT NEWS

QuickStart™ Software Cuts Development Time

QuickStart™ software from Berkley Process Control eliminates development costs associated with machine control system start-up and configuration, motor tuning, and hardware diagnostics by providing these standard functions on powerup. Designed for the multi-axis Bam™ Series-64 Machine Controller, QuickStart's facilities can provide intuitive touch screen operation for a wide range of industries. **Write In No. 567**

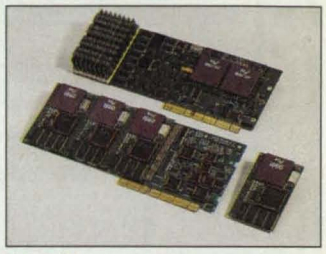
LE-900 Space Camera



The LE-900 series of video cameras is designed for use in extremely high altitude or for orbiting spacecraft applications. They have proven to operate and withstand the rigors of the high shock and vibration, temperature extremes, and the vacuum conditions found in space. The cameras have also found use inside vacuum chambers to monitor internal events and testing. The camera includes an integrated lens with field-of-view choices from wide angle to telephoto. The LE-900 is vacuum operation prepared with no out-gassing materials used. Full automatic exposure/shutter control camera functions can be switched and remote controlled via RS-422 or TTL/CMOS levels. Video output is RS-170 or differential. Imager is 1/2" interline transfer 768H x 493V CCD. Options include color, image intensifier, and digital video output. Each camera is certified by vibration and thermal-vacuum testing before delivery. The LH-900 is a flight proven imaging system. For more information call Rick Clifford at Lido Engineering, (714) 645-2935. **Write In No. 568**

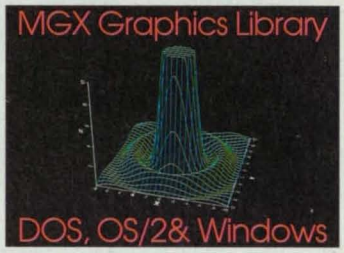
Advanced Composite Construction Brochure Literature Review

HEMCO Corporation is pleased to offer their brochure "Advanced Composite Construction." Featuring the largest selection of advanced composite fume hoods in the industry, HEMCO has long been at the forefront of advanced composite technology. This brochure details the construction features of the HEMCO advanced composite fume hood and present the advantages of advanced composite technology: light weight, high strength, and resistance to heat, chemicals, and corrosion. For more information on HEMCO products, call (816) 796-2900; Fax: (816) 796-3333, or write: HEMCO Corporation, 111 North Powell, Independence, MO 64056. **Write In No. 569**



DSP/Array Processors Plus Graphics

Microway, Kingston MA, is pleased to announce two new products. An 860XP/EISA DSP or array processing card that combines a 400 MB/Sec memory system with the XP's 100 megaflop speed, plus a Graphics/Plotting package for our NDP family of 32-bit 386/486/Pentium Compilers. These products join our 200 megaflop QuadPuters-860 and can be used to build systems which have up to a gigaflop of throughput. Call 508-746-7341 or fax 508-746-4678 for information. **Write In No. 570**



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THE TECHNOLOGY CONNECTION

Call For Nominations

NASA SOFTWARE OF THE YEAR AWARD

NASA's Office of Safety and Mission Assurance (OSMA), Washington, D.C., in conjunction with NASA's Inventions and Contributions Board (ICB), has announced the Software of the Year Award to recognize software or software technology used by NASA. The award, which will include a plaque and a monetary award of up to $100,000, will be presented to the author or authors of software programs or technologies promoted, adopted, sponsored, and deemed significant in the performance of NASA space and aeronautics activities. For information on the award criteria, contact Don Sova, Manager of Software Engineering, NASA Headquarters, Tel: 202-358-0534. Entries must be submitted no later than June 1, 1994.

Technology Transfer

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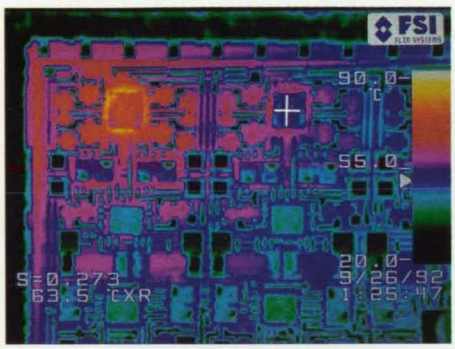
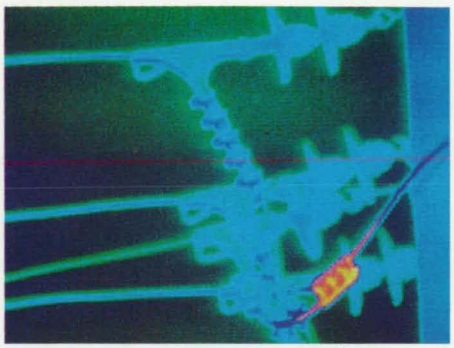
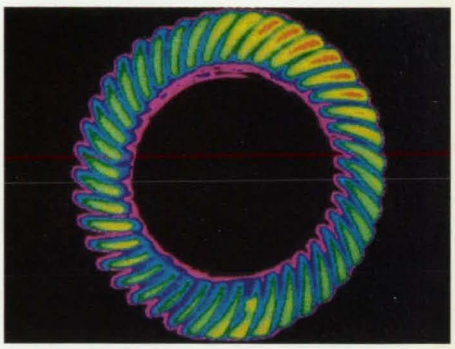
BEFORE WE CAN TELL YOU WHAT'S WRONG, WE'LL HAVE TO TAKE YOUR TEMPERATURE.



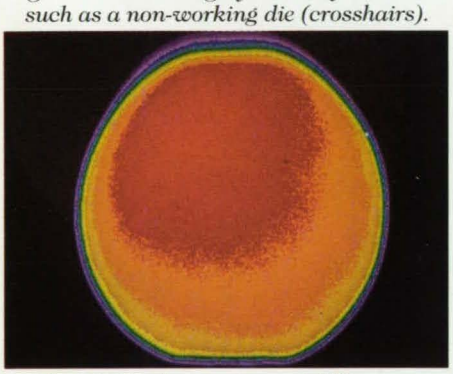
Even on the smallest hybrids, the IQ 325's high resolution imagery unveils fine details such as a non-working die (crosshairs).



Inspect power equipment from a moving vehicle with the IQ 325's real-time imaging capability.



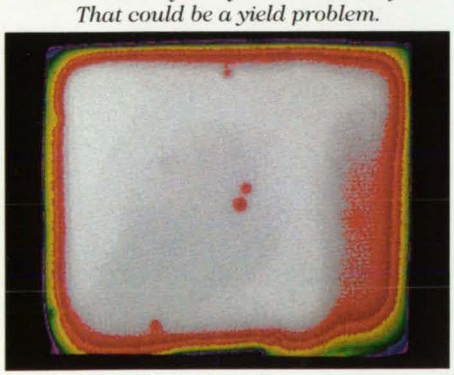
The rugged IQ Series can monitor on-line processes—such as inductive heating of components—in factory environments.



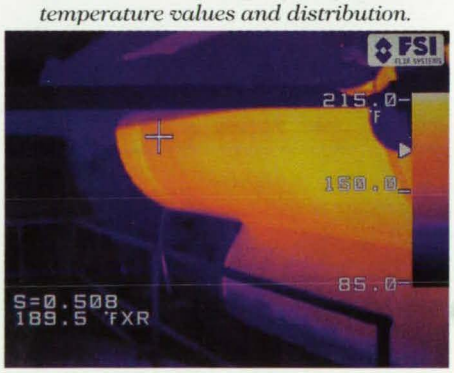
The IQ 812 detects thermal differences across the surface of this silicon wafer. That could be a yield problem.

At break-out, real-time imaging can check a metal casting's quality via its temperature values and distribution.

A thermal video system can show you a hot component and, with hard-disk image storage and retrieval, allow on-the-spot trend analysis.



The IQ 812 displays the most minute temperature deviations to inspect composites for defects that may lead to catastrophic failure.



Despite a hot, humid environment, the IQ 812 system confirms uniform moisture content in this high-speed paper production process.

The IQ Series Model 325 detects short wave infrared radiation, while the Model 812 detects long wave infrared.

With their excellent image quality and built-in processing power, FLIR Systems' thermal video systems can give you a new perspective for your industrial applications. And our handheld systems let you take thermal imaging wherever you need it.

For a copy of case studies describing the above thermograms, or a demonstration of FLIR Systems' thermal imaging products, call 1-800-322-3731, or fax 1-503-684-5452.

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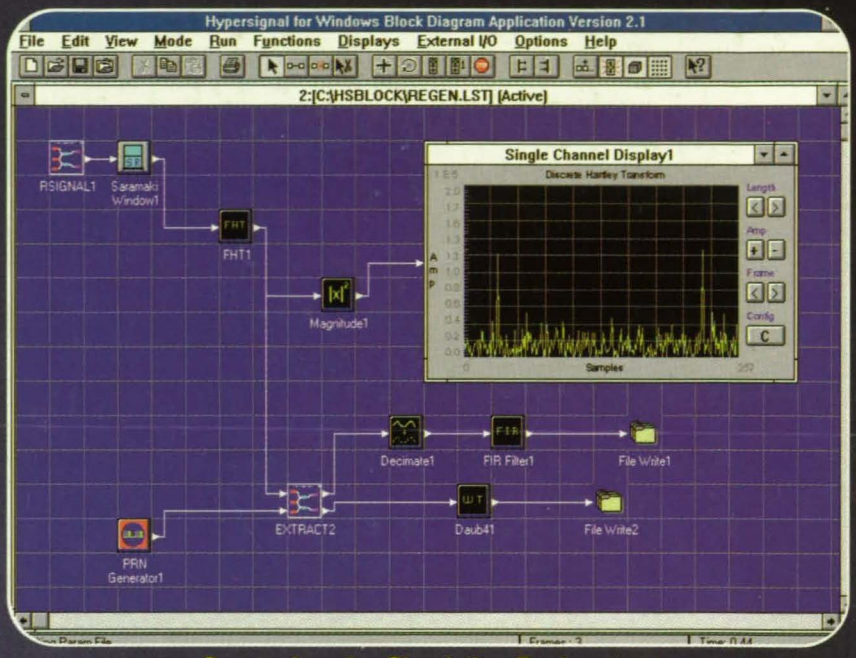
Hypersignal® for Windows™

Comprehensive Visual Design Environment

Features

- Open software architecture
- **Hierarchical** Design
- Simulation at executable (not interpretive) speed
- **Industry Standard** Real-time DSP Board Support
- User Controls for custom dials, knobs, meters, etc.
- **C source code** generation
- Support for many different DSP chips (fixed and floating point)
- Automated block generation for user developed blocks
- Run-time support for user-developed applications
- New Advanced Transmission library for specialized communications projects
- Many new functions and transforms, including **Wavelets**

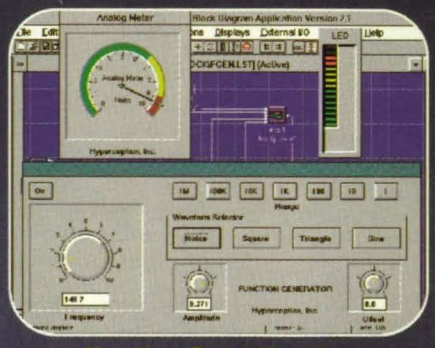


Comprehensive Simulation Environment

Hypersignal's open software architecture allows virtually limitless simulation/modeling to be performed for proof of concept designs, saving valuable engineering mantime.

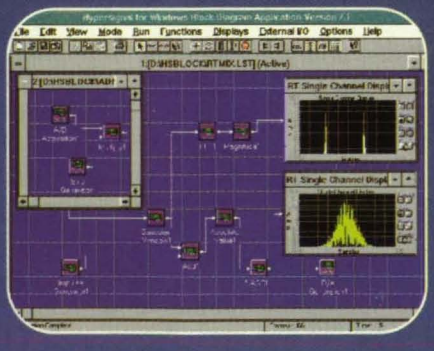
Applications

- **Visually Programmed** DSP Algorithm Development
- Rapid **Prototyping** of products and systems
- Virtual Instrumentation and Data Acquisition projects
- Many types of **Simulation** and **Systems Modeling**
- **Real-time DSP** and related Engineering Efforts
- Many other Research and Development projects



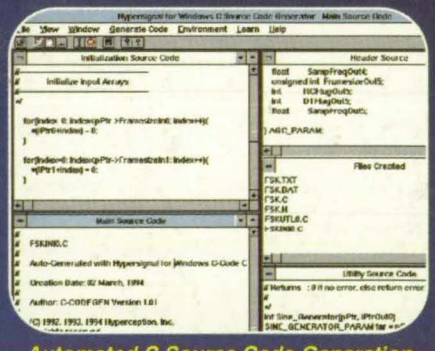
New User Control Interface

New User Controls allow for a greater variety of custom interface for both simulations and real-time projects.



Real-time DSP Board Support

Real-time DSP support using device independent DSP Board Drivers under Windows. This real-time graphical software language allows quick development of projects.



Automated C Source Code Generation

ANSI C source code generation from visually designed algorithms reduces design time for real-time projects through DSP C cross compilers, and allows portability to other c native platforms.

*For additional information, new **free** VideoTape Demo and DSP Sourcebook, contact:*

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