

Over 200,000 Copies Printed

NASA Tech Briefs

Official Publication of
National Aeronautics and
Space Administration
Volume 14 Number 9

Transferring Technology to
American Industry
and Government
September 1990

21st Century
Space Explorer



Science Teacher Fred Holtzclaw Has Successfully Created Energy In A Classroom.

In the nearly 20 years that Mr. Holtzclaw has been teaching high school science in Tennessee, he's learned a lot about energy. How to impart enthusiasm, for instance. The hard work needed to overcome inertia. And most difficult of all, what to do about burn-out.

He's not alone. Every day, teachers all over the country face the same challenges.

That's why Martin Marietta is helping to underwrite a new regional Academy for Teachers of Science and Math at the University of Tennessee. It's an intensive program of study and discussion for Martin Marietta Fellows; outstanding educators in all grade levels. Through the Academy, the private sector, government and academia are all joining together to support a critical educational initiative by President Bush.

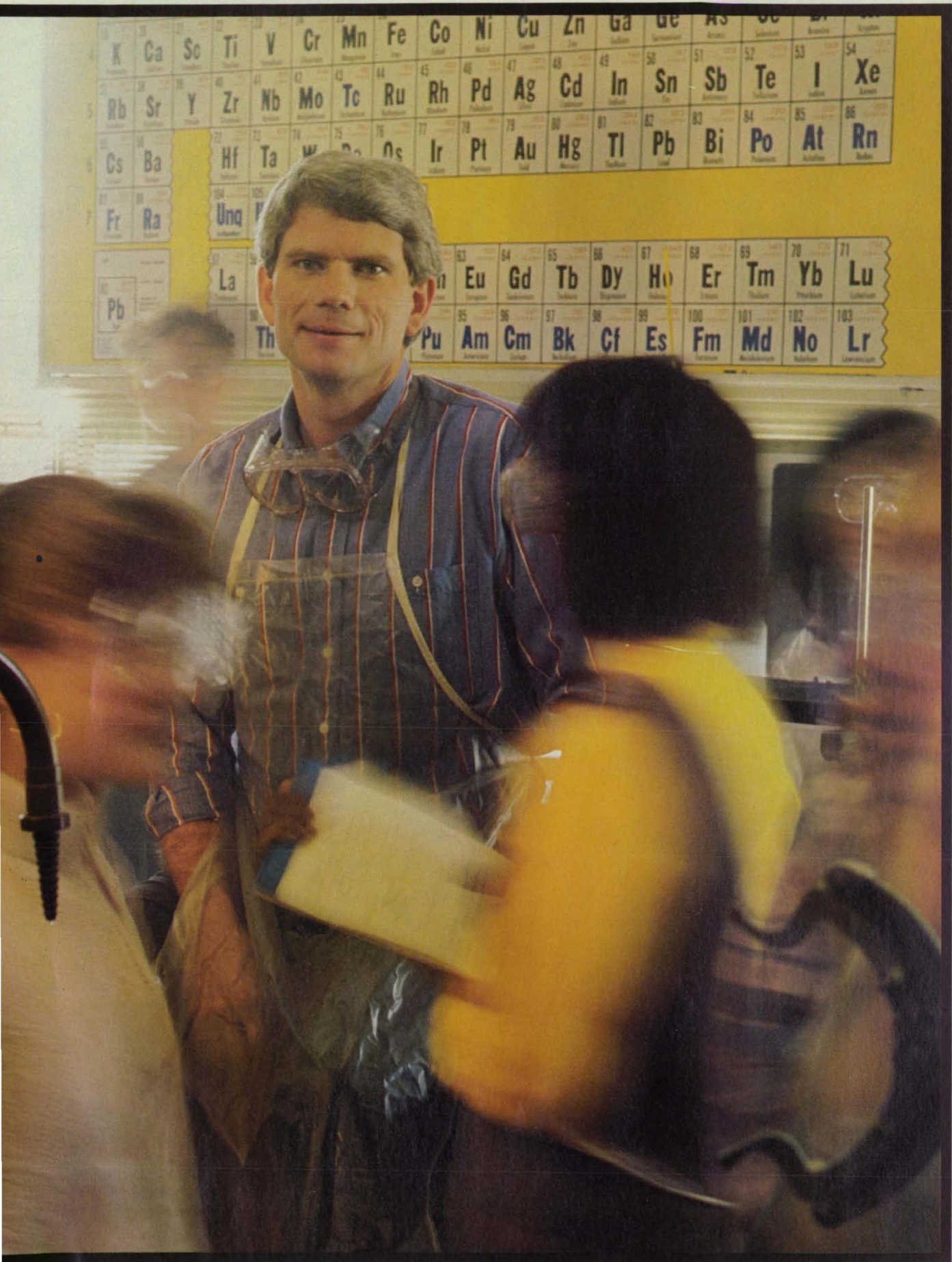
It's important to help keep things moving in the classroom, and teachers like Fred Holtzclaw are the right place to start. If we want to fire-up the masterminds of tomorrow, the best thing we can do is keep our outstanding teachers energized today.

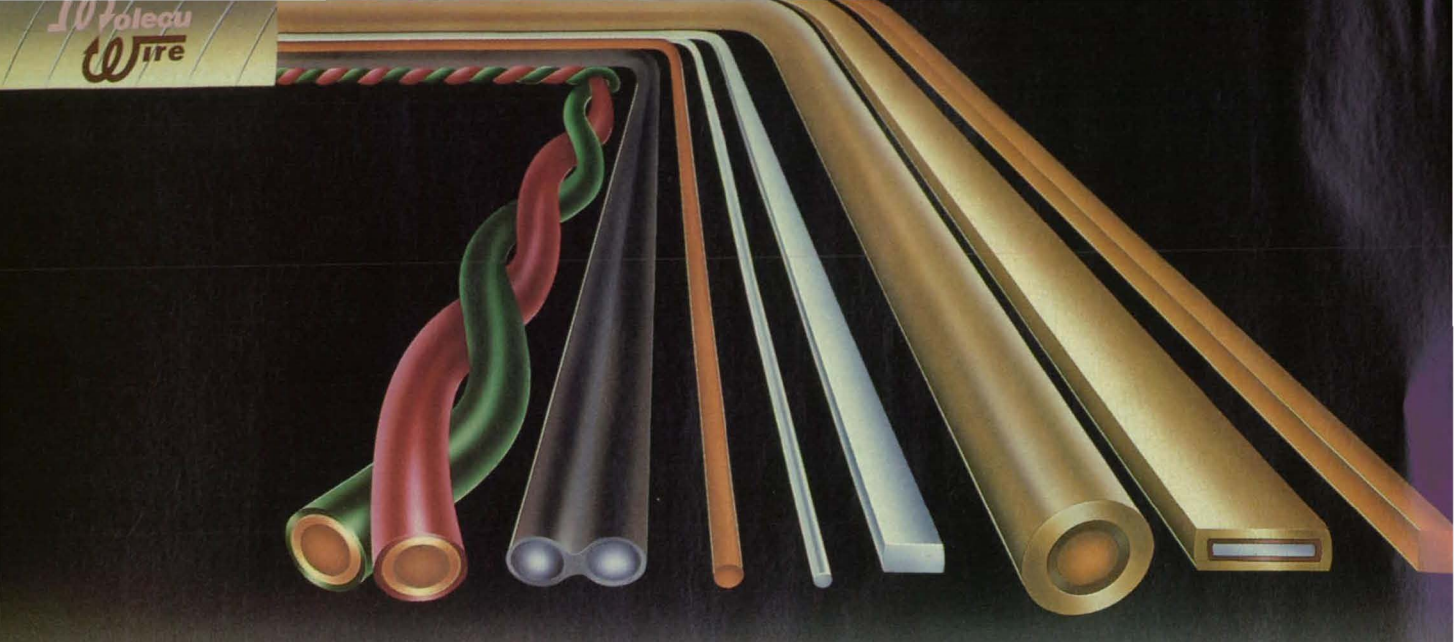
MARTIN MARIETTA

6801 ROCKLEDGE DRIVE, BETHESDA, MARYLAND 20817

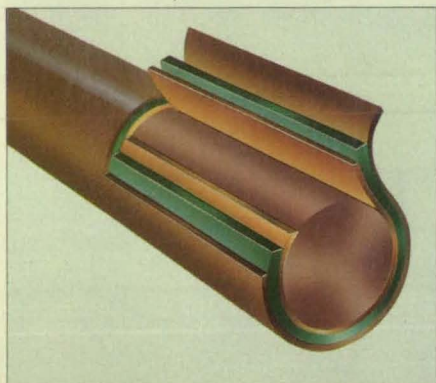
MASTERMINDING TOMORROW'S TECHNOLOGIES







Molecu Wire: Your innovative source for specialty wire and ribbon



WHEN YOUR APPLICATION calls for "impossible" wire or ribbon, turn to Molecu Wire to insure your project's success.

No matter how tough your process or product parameters—and no matter whether your field is aerospace or data processing . . . medical devices or robotics . . . consumer electronics,

telecommunications, appliances or virtually anything else—Molecu's accomplished team of experts can help make your application a reality.

To guarantee the flawless wire or ribbon you need, Molecu's full-service capabilities include metallurgical and application R&D, product engineering, prototyping, complete in-house tool and diemaking, full-scale production with rigorous quality controls including SPC, and some of the most sophisticated testing available anywhere.

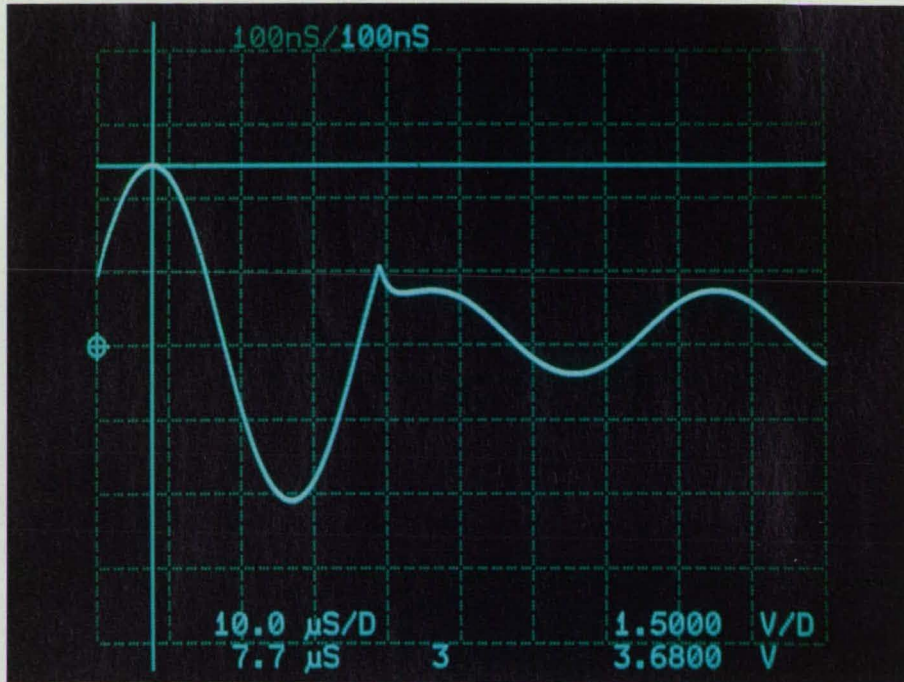
Established in 1958, Molecu is a recognized leader in custom precision wire and ribbon design, engineering and manufacturing. We work

with the world's foremost companies—from global giants to small, emerging firms—to pioneer tomorrow's products and technologies . . . today.

To learn more about how you can put Molecu's one-of-a-kind wire and ribbon technology to work for you, call us today at (201) 938-9473. Or write Molecu Wire, P. O. Box 495, Farmingdale, New Jersey 07727. Fax: (201) 938-3189.

**Molecu
Wire**

Are you missing the big picture in digital oscilloscopes?



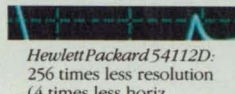
Nicolet 430E: 256K Memory/Channel, 12 bits vertical resolution.



LeCroy 9450:
80 times less resolution
(5 times less horiz.,
16 times less vert.)



Tektronix DSA602:
208 times less resolution
(13 times less horiz.,
16 times less vert.)



Hewlett Packard 54112D:
256 times less resolution
(4 times less horiz.,
64 times less vert.)



Fluke PM 3323:
256 times less resolution
(64 times less horiz.,
4 times less vert.)

There's more of everything with the Nicolet 400 Series.

Any way you look at it, competitors just can't touch the Nicolet 400 Series when you consider memory and vertical resolution.

The closest major competitor's per-channel memory is four times less. Vertical resolution—four times less again. And when memory and vertical resolution are combined, the nearest offering is 80 times less! Clearly no match.*

Now add other 400 Series advantages like the choice of two or four channels, with 64K to 256K memory in each. Single ended or differential inputs. A 3½" or 5¼" floppy drive. One to 200 MS/s digitizing rates. The unique 44 MB removable hard disk or 40 MB internal disk. Plus dual timebase, choice of 8 or 12 bit digitizing resolution (separate or combined); built in MS-DOS drive; LEARN mode for automated test sequences; FFT and averaging.

More individual features, more combined memory and vertical resolution, more of everything. Get the picture?

Call today about the Nicolet 400.

*Based upon known specifications as of 7/90.

Nicolet Test Instruments Division

5225 Verona Rd., Madison, WI 53711-4495, 608/273-5008 or 800/356-3090

Circle Reader Action No. 696

Nicolet
INSTRUMENTS OF DISCOVERY



Technology so advanced it will change the evolution of flight.

Superior Flight Speeds. For the high speed demanded of the next generation of aircraft, we now offer proprietary thermoplastic/carbon fiber prepreg systems that can withstand operating temperatures of over 300°F. These thermoplastic composite systems offer design advantages essential for aircraft that can fly higher, faster and with more fuel efficiency than ever before.

Revolutionary Toughness. These new thermoplastic prepregs, based on polyarylsulfone, polyamide-imide or polysulfone systems, are among the most damage-tolerant composites available. They provide exceptional impact resistance, stiffness and strength as well as high temperature resistance.

Processing Breakthroughs. Not only do these materials offer rapid processability, they offer the evolutionary advantages of reformability, usable scrap, fusible parts and patchable damage repair. Spot heat of 600°F can be used to make them flow or reflow as necessary. They will consolidate over a form. They are available in woven fabrics up to 60" or more, and as biaxial tapes up to 10' in width. Shelf life of these new materials is indefinite.

Historic Leadership. From the pioneering years to today's cutting edge, Amoco's R&D has been on the forefront of thermoplastic composite technology. We offer one of the broadest product lines available with operating temperature ranges from 200°F to 350°F and beyond.

Call us. Ask us questions. The earlier you involve us, the more we can help. You can reach Amoco Performance Products Customer Service at 1-800-222-2448.

We can help you take flight into the future.

THE ALL AMERICAN SOLUTION



Amoco Performance Products

Circle Reader Action No. 336

Transferring Technology to
American Industry and Government

September 1990
Volume 14 Number 9



Photo courtesy NASA

Scientists at Jet Propulsion Laboratory are field-testing a semi-autonomous navigation system on a computer-operated robotic vehicle for possible use in future planetary explorations. Turn to page 10.

SPECIAL FEATURE

NASA's Planetary Rover Project:
Building "Smart" Robots For Space
Exploration..... 10

TECHNICAL SECTION

	New Product Ideas	14
	NASA TU Services	16
	Electronic Components and Circuits	18
	Electronic Systems	34
	Physical Sciences	44
	Materials	63
	Computer Programs	65
	Mechanics	70
	Machinery	80
	Fabrication Technology	84
	Mathematics and Information Sciences	91
	Life Sciences	99
	Subject Index	107

DEPARTMENTS

On The Cover: The "Ambler," a six-legged autonomous prototype robot being developed for NASA by Carnegie Mellon University, could bring an important new dimension to solar system exploration. Because the robot literally walks, it can traverse rough terrain by stepping over crevices and large boulders. Future operational rovers based on the Ambler design could reach areas on the moon or Mars inaccessible to wheeled vehicles or too dangerous for humans. See page 10. (Original artwork by Robert Parrett, Caterpillar Inc.)

New on the Market	100
New Literature ..	103
Advertisers Index	110



Photo courtesy NASA

The design and performance of a 3D and of a 2D backscatter laser velocimeter, both used in low-speed wind tunnels, are described in a new report (page 42) along with a historical overview of laser velocimetry's development.

This document was prepared under the sponsorship of the National Aeronautics and Space Administration. Neither Associated Business Publications Co., Ltd. nor anyone acting on behalf of Associated Business Publications Co., Ltd. nor the United States Government nor any person acting on behalf of the United States Government assumes any liability resulting from the use of the information contained in this document, or warrants that such use will be free from privately owned rights. The U.S. Government does not endorse any commercial product, process, or activity identified in this publication.

Permissions: Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Associated Business Publications, provided that the flat fee of \$3.00 per copy is paid directly to the Copyright Clearance Center (21 Congress St., Salem, MA 01970). For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Service is: ISSN 0145-319X/90 \$3.00+ .00

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright © 1990 in U.S., is published monthly by Associated Business Publications Co., Ltd., 41 E. 42nd St., New York, NY 10017-5391. The copyrighted information does not include the individual tech briefs which are supplied by NASA. Editorial, sales, production and circulation offices at 41 East 42nd Street, New York, NY 10017-5391. Subscription for non-qualified subscribers in the U.S., Panama Canal Zone, and Puerto Rico, \$75.00 for 1 year; \$125.00 for 2 years; \$200.00 for 3 years. Single copies \$10.00. Remit by check, draft, postal or express orders. Other remittances at sender's risk. Address all communications for subscriptions or circulation to NASA Tech Briefs, 41 East 42nd Street, New York, NY 10017-5391. Second-class postage paid at New York, NY and additional mailing offices.

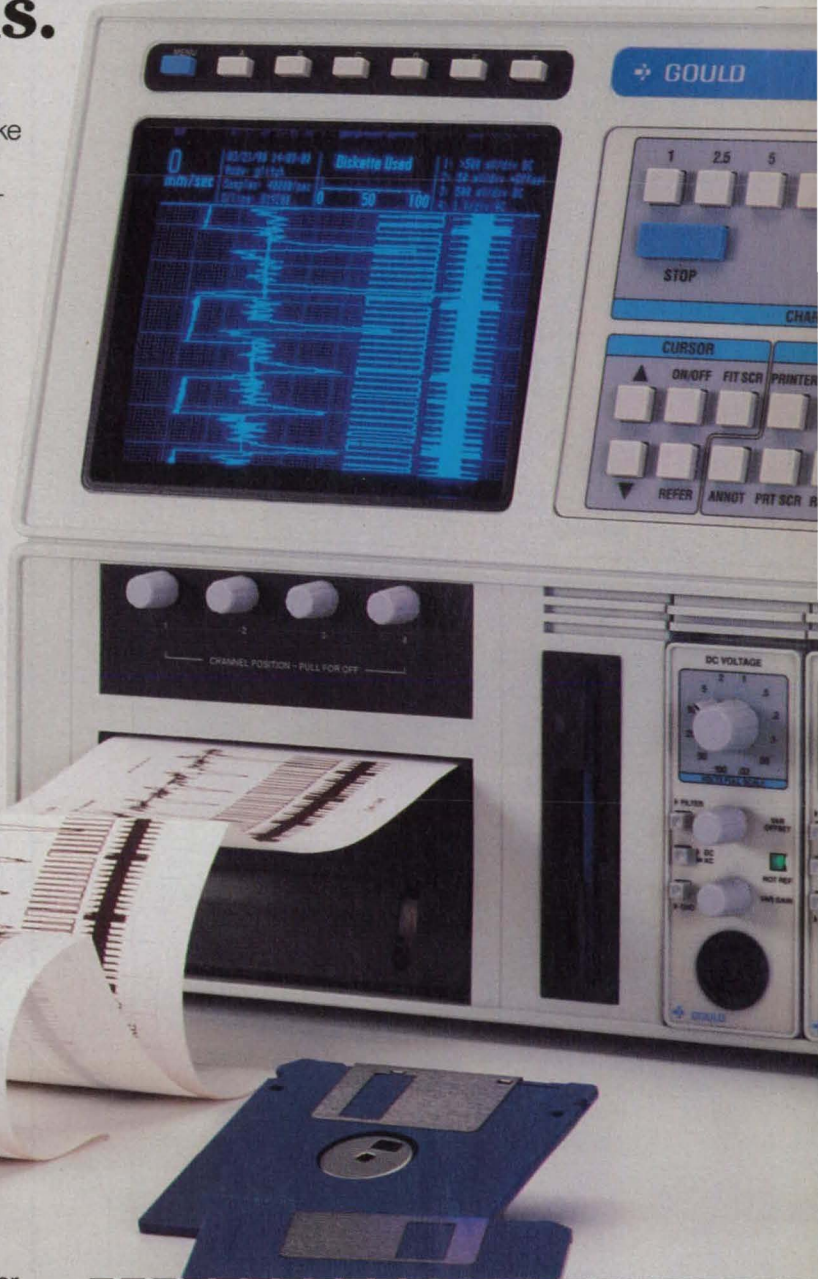
POSTMASTER: please send address changes to NASA Tech Briefs, 41 E. 42nd Street, Suite 921, New York, NY 10017-5391.

Our new recorder comes with everything but complications.

Sitting down with our new WindoGraf recorder is like sitting down with a trusted friend. WindoGraf is as easy to use as the recorders we've been making—and you've been using—for years.

Nearly everything about WindoGraf is familiar, from its recorder-style speed controls to its bench-top portability. And when it comes to signal conditioning, WindoGraf offers just what you'd expect in a Gould recorder: input-to-output isolation, DC offset (zero suppression), variable sensitivity, and a selection of signal conditioners to meet most physical test requirements. WindoGraf also features a unique CRT display that lets you monitor your signals in real-time without continuously running paper. And if you'd like to see hard copy, press a button to activate WindoGraf's 4-channel thermal array recorder, which also operates in real-time.

Press another button, and your signals are recorded on WindoGraf's built-in disk drive for future review or analysis.



WindoGraf. Just another way Gould is helping you meet your physical test and measurement needs . . . without complications.

NTB 9/90



Free demo disk!

Yes! Show me how Gould's new WindoGraf is as simple as it is advanced!

(please print)

NAME: _____ TITLE: _____

COMPANY: _____

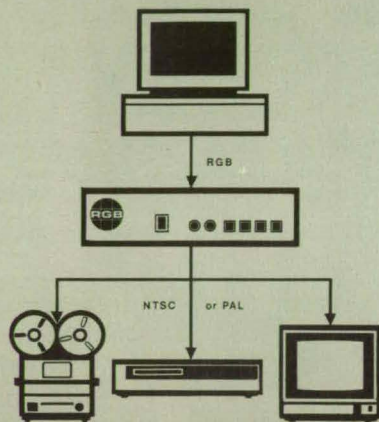
STREET: _____

CITY: _____ STATE: _____ ZIP: _____

TELEPHONE: _____

Send to: Gould, Inc., Test and Measurement Group, 8333 Rockside Road, ValleyView, Ohio 44125, or call (216) 328-7000, Fax (216) 328-7400.

Convert Computer Graphics to Video



RGB/Videolink™ Scan Converters with Autosync

The Link Between
Computer Graphics
and Television Video for
Video Taping, Video Transmission
and Video Teleconferencing

- Adjustment free auto-locking
- Full broadcast quality encoder and sync generator
- Flicker elimination
- Anti-aliasing
- Genlock
- Video overlays with linear keyer
- Full 24 bit color processing
- Composite (NTSC or PAL), S-Video, Y, R-Y, B-Y and RGB video outputs
- Made in the USA

Model 1400AX
autosyncs to workstation
displays (45–80 kHz)

Model 600AX
autosyncs to EGA, VGA, and Mac II
displays (21.5–35.0 kHz)



SPECTRUM

2550 Ninth Street, Berkeley, CA 94710
TEL: (415) 848-0180 FAX: (415) 848-0971

NASA Tech Briefs

Official Publication of
National Aeronautics and
Space Administration



NASA Tech Briefs:

Published by **Associated Business Publications**
Editor-in-Chief/Publisher **Bill Schnirring**
Associate Publisher **Frank Nothaft**
Editor **Joseph T. Pramberger**
Managing Editor **R. J. Laer**
Assistant Editor **Theresa M. Detko**
Technical Advisor **Dr. Robert E. Waterman**
Production Manager **Rita Nothaft**
Traffic Manager **James E. Cobb**
Circulation Manager **Cheryl Golden**
Telecommunications Specialist **Evelyn Mars**
Reader Service Manager **Sylvia Valentini**

Briefs & Supporting Literature:

Provided to National Aeronautics and Space Administration by **International Computers & Telecommunications, Inc.**, NY, NY with assistance from **Logical Technical Services, NY, NY**

Technical/Managing Editor **Ted Selinsky**
Art Director **Luis Martinez**
Administrator **Elizabeth Teixeira**
Chief Copy Editor **Lorne Bullen**
Staff Writers/Editors **Dr. James Boyd, Dr. Larry Grunberger,
Dr. Theron Cole, Jordan Randjelovich,
George Watson, Oden Browne**
Graphics **Vernald Gillman,
Charles Sammartano**
Editorial & Production **Bill Little, Ivonne Valdes,
Frank Ponce, Susan Finelli**

NASA:

NASA Tech Briefs are provided by the National Aeronautics and Space Administration, Technology Utilization Division, Washington, DC:
Administrator **Richard H. Truly**
Assistant Administrator for Commercial Programs **James T. Rose**
Deputy Assistant Administrator (Programs) **Henry J. Clarks**
Acting Director TU Division (Publications Manager) **Leonard A. Ault**
Manager, Technology Utilization Office, NASA Scientific and Technology Information Facility **Walter M. Heiland**

Associated Business Publications

41 East 42nd Street, Suite 921, New York, NY 10017-5391
(212) 490-3999 FAX (212) 986-7864

President **Bill Schnirring**
Executive Vice President **Frank Nothaft**
Vice President **Domenic A. Mucchetti**
Operations Manager **Rita Nothaft**
Controller **Felecia Lahey**

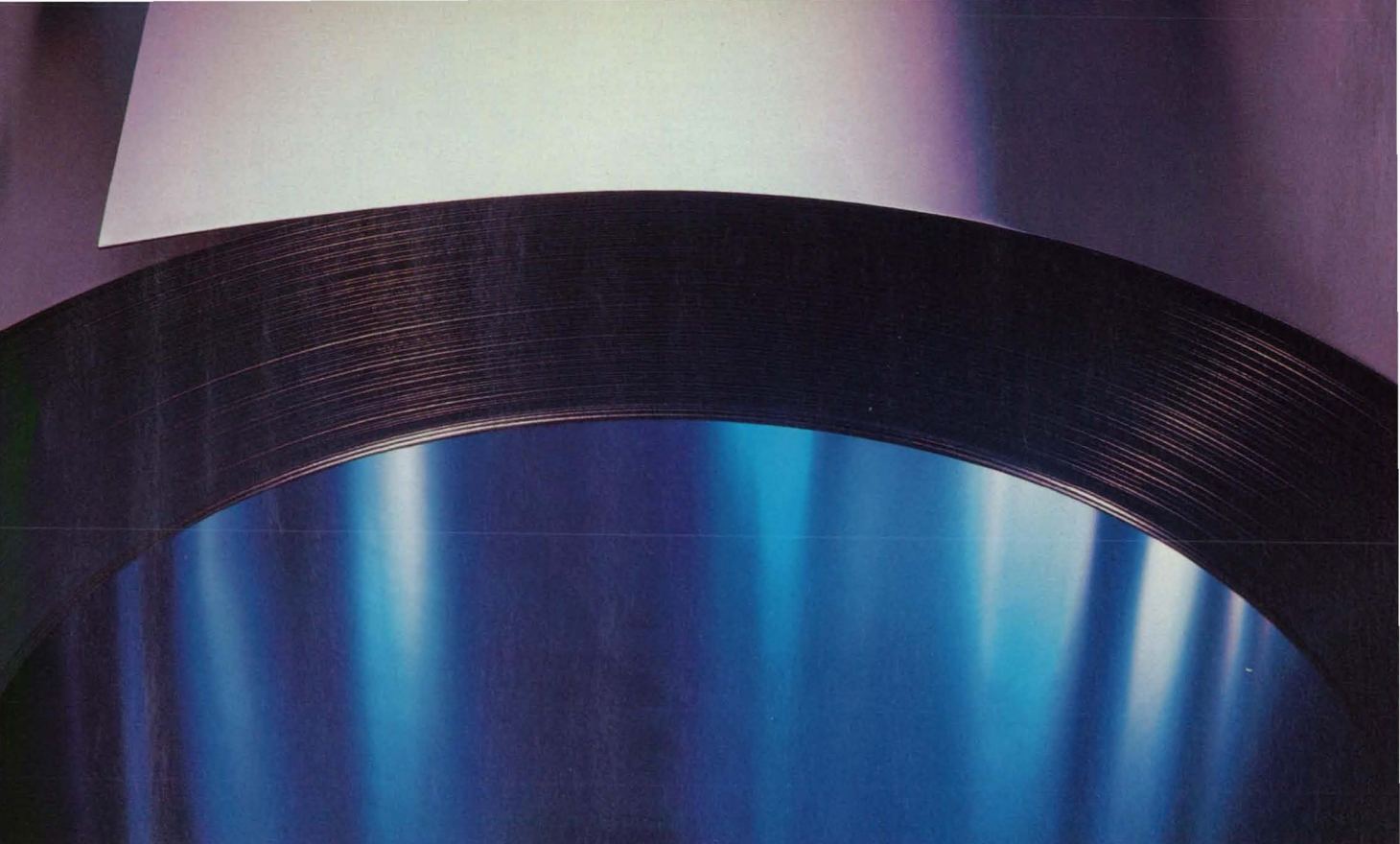
Advertising:

New York Office: (212) 490-3999 FAX (212) 986-7864

Director of Advertising Sales **Domenic A. Mucchetti**
Account Executive (NY, NJ) **Brian Clerkin**
at (201) 285-0880
Account Executive (VA, DC, MD, DE, WV) **John D. Floyd**
at (215) 399-3265
Account Executive **Debby Crane** at (201) 967-9838
Account Executive (Midwest) **Paul Leshar, CBC**
at (708) 501-4140
Account Executive (Northwest) **Bill Hague, CBC**
at (206) 858-7575
Regional Sales Manager (South-Central) **Douglas Shaller**
at (212) 490-3999
Account Executives (Eastern MA, NH, ME, RI) **Paul Gillespie**
at (508) 429-8907; **Bill Doucette** at (508) 429-9861
Account Executives (Western MA, CT, VT) **George Watts**
or **David Haggatt** at (413) 253-9881
Account Executives (Southeast) **Newton Collinson**
or **Jonathan Kiger** or **Lawrence Mischik** at (404) 939-8391
Account Executives (Calif., AZ, NV, NM)
for Area Codes 818/213/805 — **Robert D'Alexander**
for Area Codes 408/415/916/209 — **Elizabeth Cooper**
and for Area Codes 619/714 — **Karen Mock** at (213) 372-2744

NTBM-Research Center

Account Supervisor **Lourdes Del Valle**



MORE HIGH-PERFORMANCE ALLOYS IN MORE FORMS. BECAUSE YOU KEEP FINDING MORE JOBS FOR THEM.

At Inco Alloys International, you'll find the world's widest selection of high-nickel alloys in the widest range of forms and sizes. Rod, bar, plate, sheet, strip, section, pipe, tubing, wire, and companion welding products. All from one full-line manufacturer, all available through a worldwide network of sales offices and distributor warehouses.

As the pioneers of nickel alloy technology, our scientists invented the alloys whose trademarks are synonymous with quality and performance — MONEL, INCONEL, INCOLOY, INCO, NIMONIC, BRIGHTRAY, and NILO.

These alloys offer superior corrosion resistance, high-temperature strength and other special properties for your most demanding applications, prolonging equipment life and preventing costly repair, replacement and downtime.

A single source for the properties and performance you need, in the forms you need, with the quality assurance and traceability you need, delivered where and when you need them. Inco Alloys International is the only name you need to know.

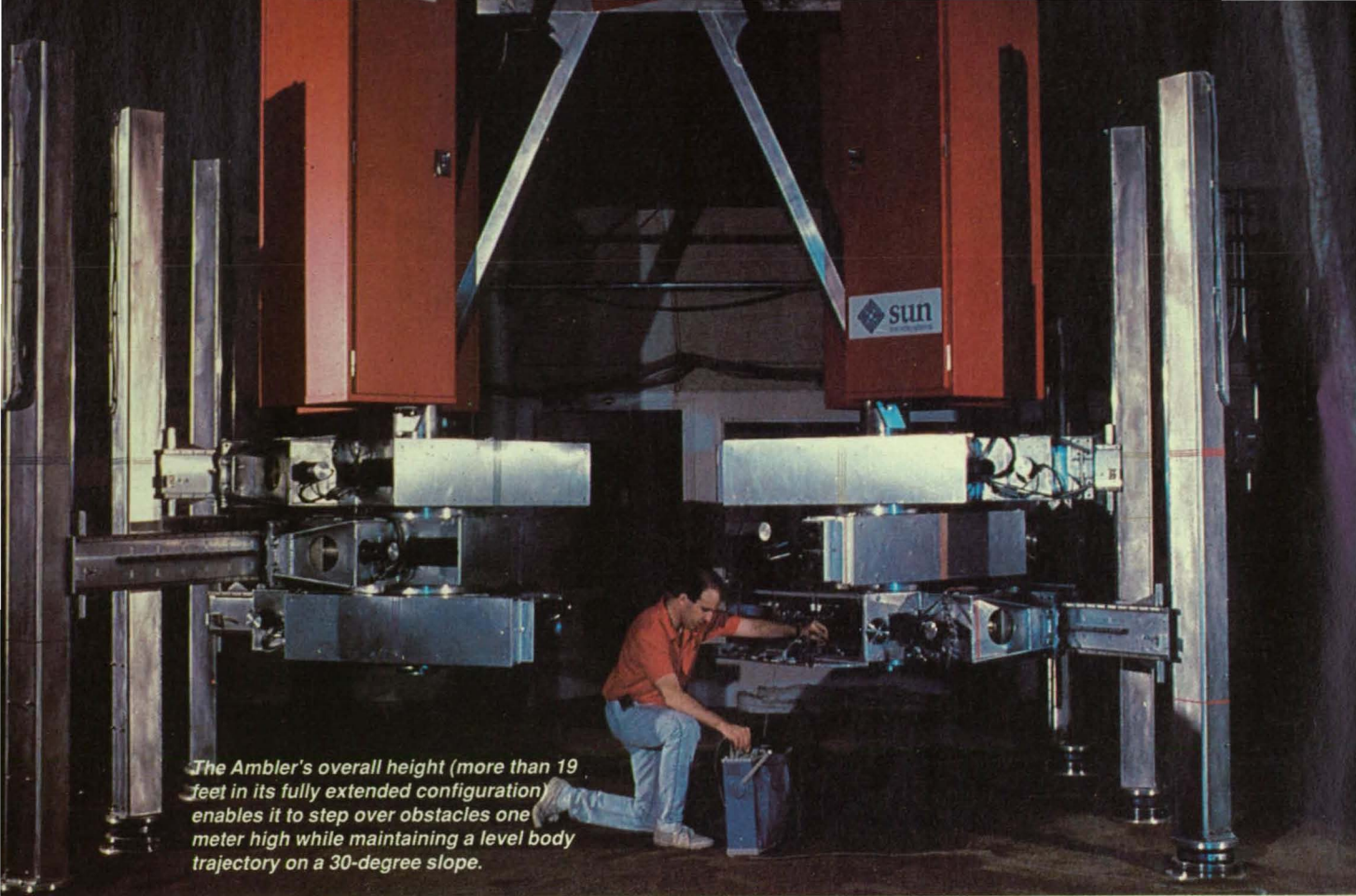
Write for a free copy of our "Quick Reference Guide." Inco Alloys International, Inc.,

Huntington, West Virginia 25720. Or, for a quicker reply, FAX us at (304) 526-5441.

MONEL, INCONEL, INCOLOY, INCO, NIMONIC, BRIGHTRAY and NILO are trademarks of the Inco family of companies.



**INCO ALLOYS
INTERNATIONAL**
Circle Reader Action No. 569



The Ambler's overall height (more than 19 feet in its fully extended configuration) enables it to step over obstacles one meter high while maintaining a level body trajectory on a 30-degree slope.

Photo courtesy Carnegie Mellon University Robotics Institute

NASA's Planetary Rover Project: Building "Smart" Robots For Space Exploration

Research teams at Carnegie Mellon University and Jet Propulsion Laboratory are creating a new breed of autonomous robots with the "brains" and motor skills to explore the rugged terrain of Mars. Experimenters are studying both legged and wheeled concepts as part of NASA's Planetary Rover Program, which looks to develop unmanned and piloted surface vehicles for future planetary exploration missions. Unmanned rovers are needed for out-post site survey and regional robotic exploration and sampling, and manned rovers for local and long-range transportation.

Unmanned rovers must be able to make autonomous decisions because of the long transmission times for commands between Earth and planetary surfaces—about 45 minutes one way to Mars. "The intent for the vehicles being designed is for them to be capable of operating on their own with just a very general set of directions," said David Lavery, manager of NASA's Planetary Rover Program.

Carnegie Mellon's Robotics Institute in Pittsburgh is developing a six-legged, 19-foot-tall prototype autonomous rover called the Ambler—for Autonomous Mobile Exploration Robot. Because the Ambler literally walks, it can traverse rough terrain by stepping over crevices and large boulders. Future operational rovers based on the Ambler design could reach areas on the moon and Mars inaccessible to wheeled vehicles or too dangerous for humans.

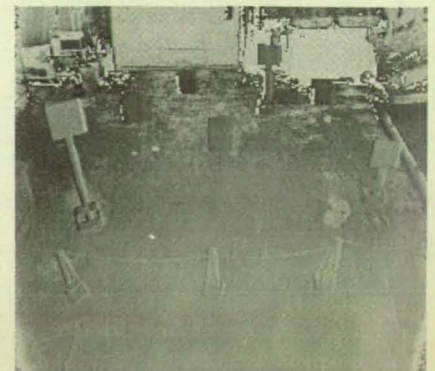
Since October 1987, Carnegie Mellon researchers have been developing the algorithms, hardware, and software required for the Ambler's locomotion, perception, and planning. The Ambler represents an integrated, self-sufficient system that will be used to give NASA mission managers the confidence that legged vehicles are a realistic alternative to wheeled rovers.

The aluminum robot has two sets of stacked legs, with three legs per stack. These legs separately lift, advance, and circulate to their original positions, much like an egg beater. "The body is pro-

pelled in a motion similar to cross-country skiing," said Dr. William "Red" Whitaker, director of Carnegie Mellon's Field Robotics Center. "A single leg reaches out in front of the others, places itself firmly on the ground like a ski pole, and then pulls the machine forward." In the event of an accident or failure, any functional leg can reposition itself to substitute for any failed leg. Thus, the Ambler retains its ability to walk even if it loses mobility in two legs.

Its two stacks are connected to an *A laser intensity image generated by the Ambler's vision system shows a set of traffic cones and vertical targets on a flat floor.*

Photo courtesy Carnegie Mellon University Robotics Institute



arched body structure that includes enclosures for power generation, electronics, computing, and scientific equipment. Because the drive motors that support the Ambler's body are separate from those that propel it, the robot remains level whether it's walking on flat or rugged ground. The design provides a stable platform for sensors, scientific instruments, and sample acquisition tools.

The legged machine is energy-efficient, an important feature for long-duration planetary missions. A Mars Rover Sample Return mission could last two years, during which the Ambler might travel hundreds of kilometers collecting rocks and soil samples. Weighing more than two tons, and with power restricted to a fraction of a kilowatt, the Ambler would navigate the uneven terrain at an approximate rate of one kilometer per day.

The robot "sees" where it's walking by bouncing laser beams off objects in its path. Using a scanning laser range-finder, it creates three-dimensional maps of the surrounding topography and objects it might be interested in sampling. After studying the maps, it decides in which direction to move and where to place its feet. Future versions deployed on Mars could combine the current laser sensing system with video and thermal imaging cameras, sonar, and other sensors to provide the full spectrum of information needed for navigation and sampling. "These machines will have to contend with rugged and soft terrain, low temperatures, high winds, dust, and equipment failure," said Takeo Kanade, co-director of the Robotics Institute. "A good vision system is critical for autonomous operation under such conditions."

Planning Safe Steps

A unique software control system, called Task Control Architecture (TCA), enables the Ambler to plan for the selection of stable and safe steps. The system addresses three major issues: integration of different planners, each potentially using different algorithms; flexibility in handling contingencies, plan failures, and unexpected situations; and self-awareness of the robot's own capabilities and limitations. "The rover must be able to reason about the uncertainty in its models of the environment and the reliability of its effectors in planning a course of action that is within an acceptable level of risk," Dr. Whittaker explained. "It must take its physical and computational resources into consideration when scheduling tasks. And,

ultimately, it must know when it does not have enough knowledge and needs help from Earth.

"A major advantage (of the TCA) is that it enables us to experiment easily with different control schemes," said Whittaker, who plans to apply the software technology to mine navigation machines. "The open architecture offers a variety of tools that facilitate the construction of robots to work in dynamic and uncertain environments."

Carnegie Mellon is presently using a Sun processor as Ambler's brains. It processes about two million instructions per second (MIPS), consumes 500 watts, and weighs approximately 25 pounds. With rapid advances in computer technology, it should be possible in two years to have a 50 MIPS processor that uses only 50 watts and is one-fourth the size and one-fifth the weight, Dr. Whittaker said.

The Ambler recently took its first steps in a university laboratory while tethered to its power supply and computer. Researchers are working to incorporate these components on board the robot, which soon could be ambling outside in simulated Martian terrain, according to David Pahnos, assistant director of the Field Robotics Center.

Robby Put To The Test

Meanwhile, experimenters at Jet Propulsion Laboratory in Pasadena, CA,

are field-testing a semi-autonomous navigation system on a prototype wheeled rover, dubbed Robby. The testing program is being carried out mainly in the Pasadena Arroyo, a dry river bed adjacent to JPL.

While legged rovers are a new and virtually untested technology, NASA's experience with wheeled rovers dates back to the Apollo program. The piloted Lunar Rover Vehicle (LRV), first used in Apollo 15, enabled astronauts to transport scientific equipment and television cameras over significant distances. During Apollo 17, the last Apollo mission, astronauts used an LRV to traverse more than 35 kilometers. "Robby represents the next step—an unmanned wheeled rover that could be used on Mars as well as the moon," said Brian Wilcox, supervisor of JPL's Robotic Sensing and Perception Group.

The six-wheeled, three-body rover offers greater mobility than conventional four-wheeled, single-body models. It is approximately 13 feet long, 5 feet wide, 6.5 feet high, and weighs 2500 pounds. Its 35-inch-diameter wheels and articulated body enable it to climb over obstacles a meter high. A commercial robot arm, for grasping soil and rock samples, is mounted on the front body. The middle section contains an electronics rack to house the onboard processors and other electronics, while serving as a mounting

Robby picks its way through a dry river bed near Jet Propulsion Laboratory in Pasadena, CA.

Photo courtesy NASA



pedestal for the rover's stereo camera navigation sensors. The rear body houses a generator that provides 3500 watts of power.

The robot features two computer systems, one for perception and planning and the other for control of the actuators in the wheel drive and robot arm. The arm has six links and six degrees of freedom, with a pivot axis and gripper providing two additional degrees of freedom.

In May, Robby made its first continuous semi-autonomous navigation traverse over rough natural terrain. JPL researchers planned a general route for the vehicle, and the rover used input from its stereo cameras and stored database to maneuver around local obstacles. During the remainder of 1990, a computer-aided remote driving (CARD) capability will be integrated onto the testbed. With CARD, stereo pictures from the rover are transmitted to a control station, where they are viewed by a human operator who designates a safe path for the vehicle to follow as far ahead as can be seen. The plan is sent to the robot, which executes the path by dead reckoning navigation aided by surface property determination sensing, autonomous hazard detection and

avoidance, and expectation generation and monitoring. A new pair of pictures are taken from each new position and the process repeats itself.

While CARD allows a greater degree of human control over the robot's operation, it is a much slower process than semi-autonomous navigation. CARD navigation of a wheeled rover offers about a 7 kilometer daily traverse capability on the moon and about 400 meters on Mars. By comparison, semi-autonomous navigation would provide a 24 km daily traverse capability on the moon and about 23 km on Mars.

Smarter Robots For Industry

Other components of NASA's Planetary Rover Program include the development of mission operations, mobility, and power research at JPL; mission operations research at Ames Research Center in Moffett Field, CA; and piloted rover technology at the Marshall Space Flight Center in Huntsville, AL. The project has implications for Earth-bound activities such as hazardous waste removal, construction, and mining, according to Mr. Lavery. "It could lead to a new generation of intelligent robots to work in natural terrains," he said.

Though much progress has been made to date, researchers caution that a flight-ready autonomous robot is still many years away. "Some people think that once you build the hardware you're finished," commented Mr. Kanade. "But the reality is that the hardware is just the beginning; you then have to build intelligence into the machine and get it to reliably perform tasks on its own. We still have a long way to go." □

Editor's note: Carnegie Mellon University's Robotics Institute will be displaying a model of the Ambler and discussing the robot's capabilities at Technology 2000, November 27-28, Washington, DC Hilton Hotel.

For further information about the technologies described in this article, contact:

Christopher Locke
Director, Industrial Relations
The Robotics Institute
Carnegie Mellon University
Pittsburgh, PA 15213

Arif Husain
Technology Utilization Officer
Jet Propulsion Laboratory
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109

Where do you need to measure temperature?

Tell YSI. We'll analyze your application, then design and build probes that work. These are some of the applications we've handled for others.


- Chicken incubators & hatcheries • Food transport containers
- Natural gas pipelines • Hydroelectric plant effluent
- Liquid-cooled mainframe computers • Heart-lung machines
- Thermal vents 3,000 meters under the sea • The Voyager satellite

In fact, since 1955 we've designed over 4,000 different temperature probes. So call us with your application at 800 343-4357. In Ohio, call 513 767-7241.



YSI Incorporated
Yellow Springs, Ohio 45387 USA





We know solar dynamic power
will work up here,
because it's being proven down there.




Space Station Freedom's orbit 240 miles above the Earth, is the perfect place for a power system designed for 30 years of uninterrupted operation.

Prove it? NASA's Lewis Research Center is doing just that in numerous test environments. One power conversion unit has run successfully for over 38,000 continuous hours; its only moving part in perfect condition, since it spins on a "cushion" of air.

Add this proven long life to greater power efficiency and life cycle cost savings, and Solar Dynamic becomes what America needs for Space Station Freedom, and missions beyond: a system that can be built now, on-time and on-budget.

Who on earth can do that?

Garrett Fluid Systems Division, a member of the NASA-LeRC/Rocketdyne Power System Team. 1300 West Warner Road, Tempe, AZ 85284. (602) 893-4421.

 **Allied
Signal Aerospace**

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 appro-

prate 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 16). NASA's patent-licensing program to encourage commercial development is described on page 16.

Making Self-Lubricating Parts by Powder Metallurgy

Composition and parameters of powder-metallurgical fabrication processes have been determined for a new class of low-friction, low-wear, self-lubricating materials.

These materials can be used in oxidizing or reducing atmospheres in bearings and seals at temperatures from below 25 °C to as high as 900 °C. (See page 63)

Switching Matrix for Optical Signals

A proposed matrix of electronically controlled shutters would switch signals in optical fibers between multiple input and output channels. The device would serve as a building block for small, low-power, broadband television- and data-signal-switching systems. (See page 22)

Planar Microstrip Yagi Antennas

A new class of Yagi microstrip antennas features the microstrip elements designed to exploit mutual coupling in a way that shapes the radiation pattern to advantage. Possible applications include antennas on land vehicles, television receiving antennas, and conformal antennas on aircraft. (See page 18)

Dual-Head Robotic Welder

A robotic welder uses two welding heads simultaneously. Welding proceeds continuously on both joints on opposite sides of the workpiece, resulting in little or no distortion of the parts. (See page 87)

Emulsions Containing Perfluorocarbon Support Cell Cultures

An additive reduces mechanical damage to mammalian cells, promoting denser growth. A volume fraction of 11.49 percent of perfluorocarbon added to the aqueous medium increases the density enough to prevent the cells from settling. Densities as high as $2.5 \times 10^6 \text{ mL}^{-1}$ have been reached. (See page 99)

Catalytic Destruction of Toxic Organic Compounds

A proposed process would dispose of toxic organic compounds in contaminated soil or carbon beds safely and efficiently. The process would oxidize the toxic materials without producing such other contaminants as nitrogen oxides. (See page 46)



With **X11/AT**
you get...

- ...simultaneous X Windows capability within Microsoft® Windows,
- ...system responsiveness approaching expensive workstations,
- ...graphic communications between MS-DOS and UNIX computers,
- ...the freedom to switch displays to suit your application, and
- ...full X11 Release 3 functionality while retaining the use of your desktop 286® or 386® PC.

Priced at \$395
To Order your copy,
CALL (714) 978-6201
FAX (714) 939-0746

 **Integrated
Inference
Machines**

IS YOUR CAR DYING OF NATURAL CAUSES?

Now you can stop that deadly friction that tears away at your engine

USE **Tufoil**[®]
AND YOUR ENGINE
WILL LAST... AND
LAST...AND LAST!

"INVENTOR OF THE YEAR" AWARD
AND INDUCTION INTO
"N.J. INVENTORS HALL OF FAME"
GOES TO INVENTOR OF TUFOIL

You've seen the price of new cars...they go up every year! Cars get flimsier...prices get higher...it never seems to end. There are lots of reasons to keep that nice car of yours on the road as long as possible.

Car sales are down and Tufoil sales are up. People are smart...they're taking the economical way out and what could be easier than Tufoil. Just add 8 oz. to the crankcase the first time and 4 oz. each time after that. You don't have to shake the container or add an engine flush. Just pour it in and drive away!

Your throttle will get silky smooth...acceleration will improve. One customer said his car "takes off like a scared rabbit!"

Tufoil works wonders for all known engine oils. It's actually slipperier than Teflon (according to a famous U.S. Government laboratory).

You'll get astonishingly fast starts on cold mornings with both diesels and gas engines. The Canadian government tested Tufoil at it's cold regions lab. They showed faster cranking and significant fuel savings with Tufoil.

What about additives that claim to be a one-time treatment that will last the life of an engine? Well, I've been following the scientific literature on lubrication for a very long time. As far as I know, there isn't a shred of scientific evidence for such a claim. So don't believe it!



TREAT YOUR CAR
TO ONE 8 OZ. BOTTLE OF
TUFOIL FOR ONE OIL CHANGE

You'll notice quieter, smoother operation, quicker starting, snappy acceleration! If you don't, just send us proof of purchase and we'll refund the price of an 8 ounce container.

Send for Tufoil today and prove to yourself the amazing increase in your car's performance. Fill in the coupon today or call TOLL-FREE any time, 24 hours a day.

1-800-922-0075.



Stay in tune with your car!

Engines last longer with Tufoil. Our 1976 476 T-Bird is now at 190,000 miles and purring.

A bunch of customers' cars have now passed 250,000 miles.

Several months ago, a nice man I'd never seen before walked into my office, big smile on his face, sat down and said, "Would you believe 340,000 miles on a Tufoil engine?" He went on to rave about how well his engine has been running all these years. I couldn't get a word in edgewise.

Recently, a truck driver called in with over 1,000,000 miles on a diesel using Tufoil - WOW!

A customer from Vermont added 10% Tufoil to his sticky mechanical transmission, called in and said he couldn't believe it... "Shifting is like slicing butter now!" he said.

SAAB owners are writing letters praising Tufoil in their "NINES" magazine. They report spectacular improvements in their engines and transmissions!

Don't forget! Tufoil is the result of over 15 years of research and development. The U.S. government has awarded us 6 patents so far...so have Germany, England, France and Canada.

No other lubricant even comes close.

FREE... Products based on TUFOIL technology. Check one with each order of 2 bottles or a quart. Check 2 for each gallon order. Values range from \$3.98 to \$9.95.

- TUFOIL Gun-Coat — Super rust inhibited, smooth action
- TUFOIL Compu-Lube — Low viscosity for computer mechanisms
- TUFOIL Lightning Grease — Easily sheared grease for instruments
- TUFOIL Lubit-8 — General purpose, household use lubricant

FREE brochures...

- 30 Questions/Answers about TUFOIL

FLUON[®] is reg. T.M. of ICI Americas Inc.
TEFLON[®] is reg. T.M. of DuPont[®]
TUFOIL[®] is reg. T.M. of Fluoramics
U.S. Patent No. 4,284,518
U.S. Patent No. 4,224,173
U.S. Patent No. 3,933,656
Other U.S. Patents issued and pending.

When
POPULAR MECHANICS
tested TUFOIL, it reported
"TUFOIL is absolutely
spectacular!"

YES

rush my TUFOIL order:

- ONE 8 oz. bottle... treat one car for \$14.25 (plus \$3.50 shipping and handling). See money back guarantee.
- TWO 8 oz. bottles... treat two cars for \$25.00 (plus \$4.00 shipping and handling) **SAVE \$6.00**
- ONE Quart bottle... treat 4 cars for \$34.95 (plus \$4.00 shipping and handling)
- ONE GALLON... treat 16 cars for \$125.00 (plus \$6.00 shipping and handling.)

We ship within days!

MONEY BACK GUARANTEE ON 8-OZ.'S

Fluoramics, Inc. NTB-990

18 Industrial Avenue
Mahwah, NJ 07430

My check or money order for \$ _____ is enclosed.

Charge my credit card:

Am. Express Master Card Visa

Card No. _____

Exp. Date _____

Phone No. _____

Name _____

Address UPS Shipping Address _____

City _____

State _____ Zip _____

(N.J. residents please add 7% sales tax.)

Canadian Distributor: 1-800-363-7753



HOW YOU CAN BENEFIT FROM NASA'S TECHNOLOGY UTILIZATION SERVICES

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

We've outlined below NASA's TU 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 by NASA's Technology Utilization Network.

How You Can Utilize **NASA's Industrial Applications Centers**—A nationwide network offering a broad range of technical services, including computerized access to over 100 million documents worldwide.

You can contact NASA's network of Industrial Applications Centers (IACs) for assistance in solving a specific technical problem or meeting your information needs. The "user friendly" IACs are staffed by technology transfer experts who provide computerized information retrieval from one of the world's largest banks of technical data. Nearly 500 computerized data bases, ranging from NASA's own data base to Chemical Abstracts and INSPEC, are accessible through the ten IACs located throughout the nation. The IACs also offer technical consultation services and/or linkage with other experts in the field. You can obtain more information about these services by calling or writing the nearest IAC. User fees are charged for IAC information services.

Aerospace Research Applications Center (ARAC)

Indianapolis Center for Advanced Research
611 N. Capitol Avenue
Indianapolis, IN 46204

Dr. F. Timothy Janis, Director
(317) 262-5036

Central Industrial Applications Center/NASA (CIAC)

Rural Enterprises, Inc.
P.O. Box 1335
Durant, OK 74702

Dr. Dickie Deal, Director
(405) 924-5094
(800) 658-2823 (toll-free US)

Science and Technology Research Center (STRC)

Post Office Box 12235

Research Triangle Park,
NC 27709-2235
H.L. (Lynn) Reese, Director
(919) 549-0671

NASA Industrial Applications Center, 823 William Pitt Union
University of Pittsburgh
Pittsburgh, PA 15260
Robert G. Konecny, Acting Director
(412) 648-7000

Southern Technology Applications Center (STAC)
Box 24
Progress Ctr., One Progress Blvd.
Alachua, FL 32615
J. Ronald Thornton, Director
(904) 462-3913
(800) 354-4832 (FL only)
(800) 225-0308 (toll-free US)

NASA/UK Technology Applications Program
University of Kentucky
109 Kinkead Hall
Lexington, KY 40506-0057
William R. Strong, Director
(606) 257-6322

NERAC, Inc.
One Technology Drive
Tolland, CT 06084
Dr. Daniel U. Wilde, President
(203) 872-7000

Technology Application Center (TAC)
University of New Mexico
Albuquerque, NM 87131
Dr. Stanley A. Morain, Director
(505) 277-3622

NASA Industrial Applications Center
University of Southern California
Research Annex
3716 South Hope Street
Los Angeles, CA 90007-4344
Robert Stark, Director
(213) 743-6132
(800) 642-2872 (CA only)
(800) 872-7477 (toll-free US)

NASA/SU Industrial Applications Center
Southern University Department of Computer Science
P.O. Box 9737
Baton Rouge, LA 70813-9737
Dr. John Hubbell, Director
(504) 771-6272
(504) 771-4950

If you represent a public sector organization with a particular need, you can contact NASA's Application Team for technology matching and problem solving assistance. Staffed by professional engineers from a variety of disciplines, the Application Team works with public sector organizations to identify and solve critical problems with existing NASA technology. **Technology Application Team, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709. Dr. Doris Rouse, Director, (919) 541-6980**

How You Can Access Technology Transfer Services At NASA Field Centers: **Technology Utilization Officers & Patent Counsels**—Each NASA Field Center has a Technology Utilization Officer (TUO) and a Patent Counsel to facilitate technology transfer between NASA and the private sector.

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

Ames Research Ctr.
Technology Utilization Officer: Laurance Milov
Mail Code 223-3
Moffett Field, CA 94035
(415) 604-4044
Patent Counsel: Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 604-5104

Lewis Research Center
Technology Utilization Officer: Anthony F. Ratajczak
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-2225
Patent Counsel: Gene E. Shook
Mail Code LE-LAW
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5753

John C. Stennis Space Center
Technology Utilization Officer: Richard A. Galle (acting)
Code HA-32
Stennis Space Center,
MS 39529
(601) 688-1929
John F. Kennedy Space Center
Technology Utilization Officer: Thomas M. Hammond
Mail Stop PT-PMO-A
Kennedy Space Center, FL 32899
(407) 867-3017
Patent Counsel: James O. Harrell
Mail Code PT-PAT
Kennedy Space Center, FL 32899
(407) 867-2544

Langley Research Ctr.
Technology Utilization Officer: John Samos
Mail Stop 139A
Hampton, VA 23665
(804) 864-2484
Patent Counsel: George F. Helfrich
Mail Code 279
Hampton, VA 23665
(804) 864-3523
Goddard Space Flight Center
Technology Utilization Officer: Donald S. Friedman
Mail Code 702.1
Greenbelt, MD 20771
(301) 286-6242
Patent Counsel: R. Dennis Marchant
Mail Code 204
Greenbelt, MD 20771
(301) 286-7351

Jet Propulsion Lab.
NASA Resident Office
Technology Utilization Officer: Arif Husain
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4862
Patent Counsel: Tom Jones
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-5179
Technology Utilization Mgr. for JPL: Dr. Norman L. Chalfin
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

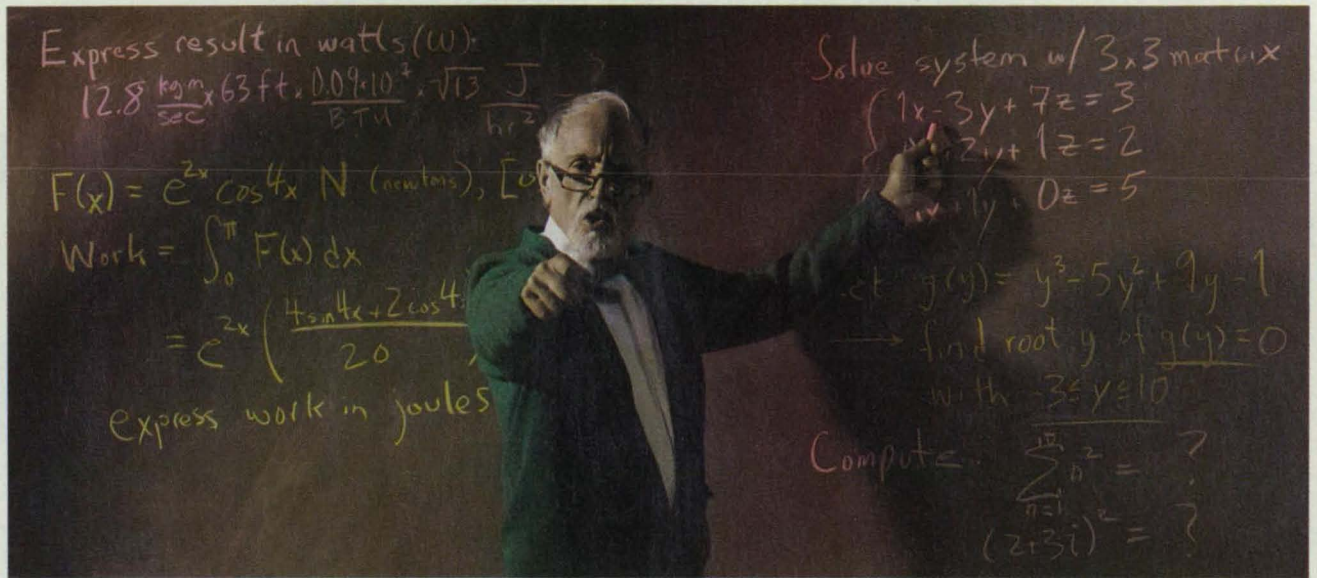
George C. Marshall Space Flight Center
Technology Utilization Officer: Ismail Akbay
Code AT01
Marshall Space Flight Center,
AL 35812
(205) 544-2223
Fax (205) 544-3151
Patent Counsel: Bill Sheehan
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0021

Lyndon B. Johnson Space Center
Technology Utilization Officer: Dean C. Glenn
Mail Code IC-4
Houston, TX 77058
(713) 483-3809
Patent Counsel: Edward K. Fein
Mail Code AL3
Houston, TX 77058
(713) 483-4871
NASA Headquarters
Technology Utilization Officer: Leonard A. Ault
Code CU
Washington, DC 20546
(703) 557-5598
Assistant General Counsel for Patent Matters: Robert F. Kempf, Code GP
Washington, DC 20546
(202) 453-2424

A Shortcut To Software: COSMIC®—For software developed with NASA funding, contact COSMIC, NASA's Computer Software Management and Information Center. New and updated programs are announced in the Computer Programs section. COSMIC publishes an annual software catalog. For more information call or write: **COSMIC®** 382 East Broad Street, Athens, GA 30602 *John A. Gibson, Dir., (404) 542-3265*

If You Have a Question . . . NASA Scientific & Technical Information Facility can answer questions about NASA's Technology Utilization Network and its services and documents. The STI staff supplies documents and provides referrals. Call, write or use the feedback card in this issue to contact: **NASA Scientific and Technical Information Facility**, Technology Utilization Office, P.O. Box 8757, Baltimore, MD 21240-0757. *Walter M. Heiland, Manager, (301) 859-5300, Ext. 242, 243*

In college, you would have killed for MathCAD. So why aren't you calculating with it now?



100,000 engineers and scientists already let MathCAD do their calculations for them.

Now that college is far behind you, perhaps it's time you graduated from spreadsheets, calculators and programming.

Because in today's working world of engineering and science, there's no time for anything less than MathCAD. The software that lets you perform engineering and scientific calculations in a way that's faster, more natural, and less error-prone than any calculator, spreadsheet, or program you could

write yourself.

Thanks to MathCAD's live document interface™, you can enter equations anywhere on the screen, add text to support your work, and graph the results.



March 14, 1989 issue. Best of '88 Best of '87

It also comes complete with over 120 commonly used functions built right in. Perfect for creating complex equations and

formulas, as well as exponentials, differentials, cubic splines, FFTs and matrices.

You get three-dimensional plotting, vivid graphing, and the ability to import HPGL files from most popular CAD programs, including AutoCAD®.

Done calculating? MathCAD prints *all* your analyses in presentation-quality documents, even on PostScript® compatible printers.

All of which has made MathCAD far and away the best-selling math software in the world. In fact, it's used by over 100,000 engineers and scientists — just like you.

There's MathCAD for the PC. MathCAD for the Mac, written to

take full advantage of the Macintosh® interface. And a Unix® version that utilizes the speed and unlimited memory of your Unix workstation.

We also have Applications Packs for Advanced Math, Statistics, Mechanical, Chemical, and Electrical Engineering. Each is a collection of adaptable mathematical models, designed to let you start solving your real world problems right away.



For a free MathCAD demo disk, or upgrade information, dial 1-800-MATHCAD (in MA, 617-577-1017). Or see your software dealer.

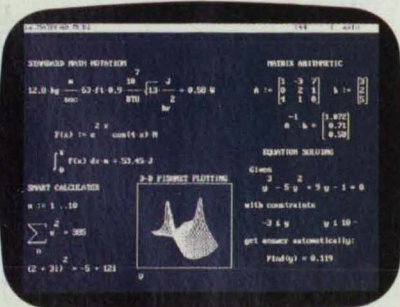
Available for IBM® compatibles, Macintosh computers, and Unix workstations.

TM and ® signify manufacturer's trademark or registered trademark, respectively.

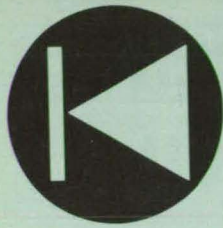
1-800-MATHCAD

MathCAD®

MathSoft, Inc., 201 Broadway, Cambridge, MA 02139



MathCAD 2.5 includes 3-D plotting, HPGL sketch import, and PostScript output.



Electronic Components and Circuits

Hardware, Techniques,

and Processes

- 18 Viewing Integrated-Circuit Interconnections by SEM
- 18 Planar Microstrip Yagi Antennas
- 22 Switching Matrix for Optical Signals
- 24 Dielectric-Filled Paraboloidal Front Ends
- 26 MCT/MOSFET Switch
- 28 Millimeter-Wave Quantum-Well Frequency Multipliers
- 30 High-Efficiency Klystron for Television Transmitters

Book and Reports

- 32 Effects of Dose Rates on Radiation Damage in CMOS Parts
- 33 More About Lens Antenna for Mobile/Satellite Communication
- 33 Directional Couplers for Detecting Circular Waveguide Modes
- Computer Programs**
- 65 Computing Scattering Matrices for Circular Waveguides
- 66 Diffraction Analysis of Distorted Reflector Antennas

Viewing Integrated-Circuit Interconnections by SEM

Back-scattering of energetic electrons reveals hidden metal layers.

NASA's Jet Propulsion Laboratory, Pasadena, California

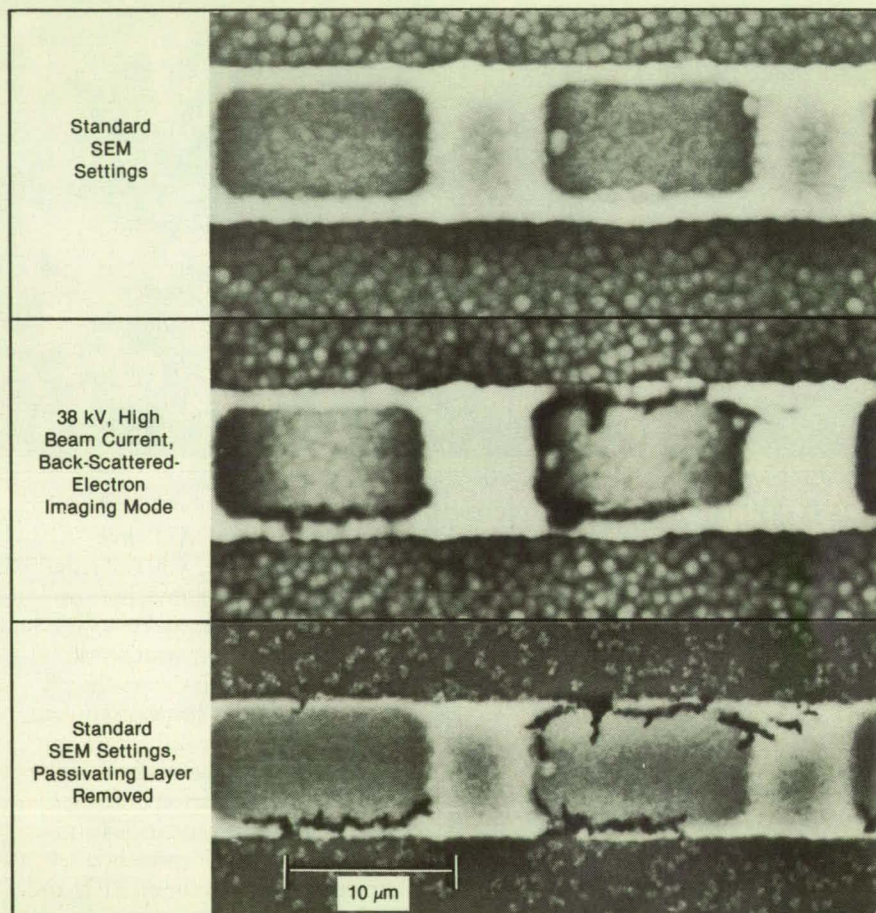
An experiment has shown that with suitable operating adjustments, scanning electron microscopy (SEM) can be used to look for defects in aluminum interconnections in an integrated circuit. Unlike in previous uses of SEM for this purpose, it is no longer necessary to etch away the passivating surface layer of silicon dioxide that covers the aluminum. One advantage of the modified SEM technique is that it enables the monitoring, in situ, of changes in the defects caused by changes in temperature. Another advantage is that it gives a truer picture of the defects, inasmuch as etching can change the stress field of the metal-and-passivation pattern, causing changes in the defects.

In the modified SEM technique, the electrons are accelerated to unusually high kinetic energy (accelerating potential > 35 kV), a high electron-beam current is used, and the instrument is operated in the back-scattered-electron imaging mode. Under these conditions, the metal, defects, and voids can be viewed directly through the passivating layer.

The upper part of the figure is a secondary electron micrograph, taken with standard SEM techniques and settings, with the passivating layer in place. This image shows a strip of aluminum with contact windows indicated by darker areas, but no defects or voids are visible.

The middle part of the figure is a back-scattered electron image obtained with an accelerating potential of 38 kV and a high beam current, again with the passivating layer in place. This image also shows the aluminum through the passivating layer; in this case, however, voids in the aluminum are clearly visible.

The lower part of the figure is a micrograph taken to verify the middle part. The passivating layer was etched away with



These **Scanning Electron Micrographs** show that with appropriate operating conditions, defects and voids in metal interconnections of integrated circuits can be viewed directly through surface layers of silicon dioxide.

hydrogen fluoride, and a layer of AuPd 50 Å thick was sputtered onto the specimen to enhance contrast. The image was formed at standard SEM settings. The appearance of the voids is similar to that of the middle part of the figure; this suggests that the voids were there before and were not gen-

erated by the etch.

This work was done by Russel A. Lawton, Robert E. Gauldin, and Ronald P. Ruiz of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 96 on the TSP Request Card. NPO-17635

Planar Microstrip Yagi Antennas

Mutual coupling between microstrip elements, ordinarily considered a nuisance, is used to advantage.

NASA's Jet Propulsion Laboratory, Pasadena, California

A developmental class of antennas is based on the combination of the microstrip-

patch and Yagi-array concepts. Heretofore, mutual coupling between microstrip

antenna elements has usually been considered a disadvantage because in many

versatile multi-channel
digital waveform acquisition and complex analysis.

Made simple.

Sometimes the most complicated problems are best handled by the simplest of solutions. Like the Nicolet System 500.

This is the most advanced instrument we've ever designed for complex multi-channel waveform acquisition and analysis. Yet with the System 500's unique operating software, it's incredibly easy to use. Software so simple that the System 500 is ready to roll minutes after you lift it out of the box. No pouring over thick manuals. No tedious programming. Just hook it up and turn it on.

And if the software doesn't already fit you like a glove, we've included a

Nicolet Test Instruments Division

225 Verona Rd.,
Madison, WI 53711-4495
800/273-5008 or 800/356-3090



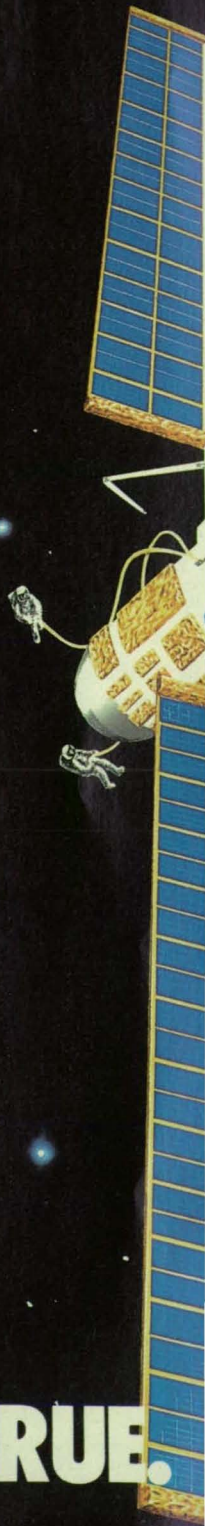
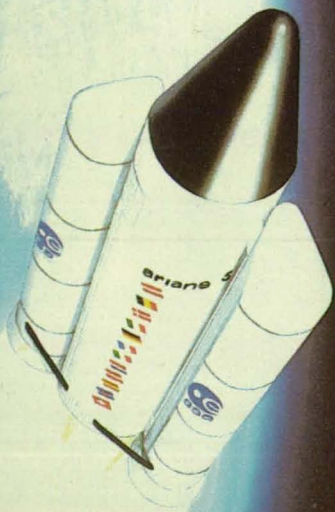
handy IEEE-488.2 command set so you can write your own or have Nicolet do it for you.

With intuitive pull-down menus, mouse and keyboard shortcuts, and easily understood displays, the 500 handles complex procedures with ease. With surprising quickness, you'll process incoming data through hundreds of independent input channels at 12 bit resolution, compile the longest data records (up to one Megaword), and turn even the most detailed acquisitions and analyses into mere child's play.

Need more information? We've made that simple, too. Just give us a call at 1-800-356-3090.

Nicolet
INSTRUMENTS OF DISCOVERY

Circle Reader Action No. 697



**SOME ARE DREAMERS.
WE MAKE DREAMS COME TRUE.**



TECHNOLOGY GETS YOU THERE



aerospatiale

AEROSPATIALE, the European leader of space transport system technology, is going forward once again, to 1995, 1998, 2015 and even beyond.

The Ariane 5 Space Transport System will be launched in 1995. For this new, more powerful rocket, AEROSPATIALE is systems integrator and stage contractor. Ariane 5 will carry satellites and even parts of future European space stations into orbit.

In 1998, Ariane 5 will lift off with Europe's Spaceplane, Hermes, built by an AEROSPATIALE-led team. Hermes is designed to taxi three astronauts and their material to and from space stations.

AEROSPATIALE space infrastructure expertise should keep Europe in the forefront in the year 2015. Designs for post Ariane 5 launchers, transfer and escape vehicles and an independent European station, are already in AEROSPATIALE's computers.

After Diamant and Ariane 1, 2, and 3, we're developing the Ariane 5 Space Transport System for the European Space Agency. We're used to making Europe's dreams come true.

AEROSPATIALE SPACE AND STRATEGIC SYSTEMS
BP 96 - 78133 LES MUREAUX CEDEX FRANCE
TEL. 33 (1) 34 92 12 34 TELEX. AIRSPA 698850F

Circle Reader Action No. 339

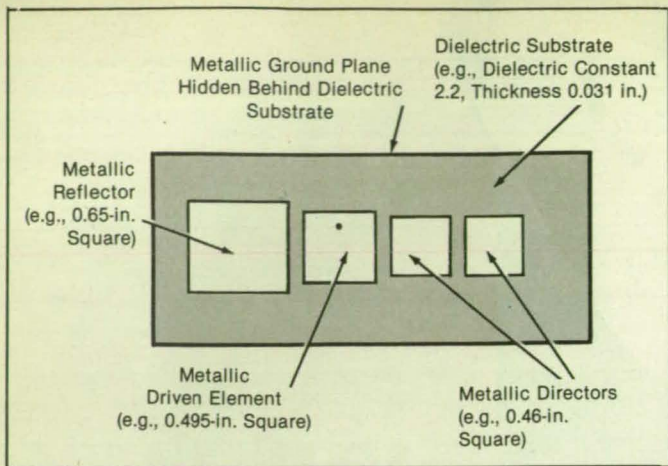


Figure 1. A **Microstrip Yagi Antenna**, like a conventional rod-dipole Yagi antenna, includes a driven radiating element and parasitic (reflecting and directing) radiating elements. The numerical specifications shown for example are those of an experimental antenna designed for operation at a frequency of 6.9 GHz.

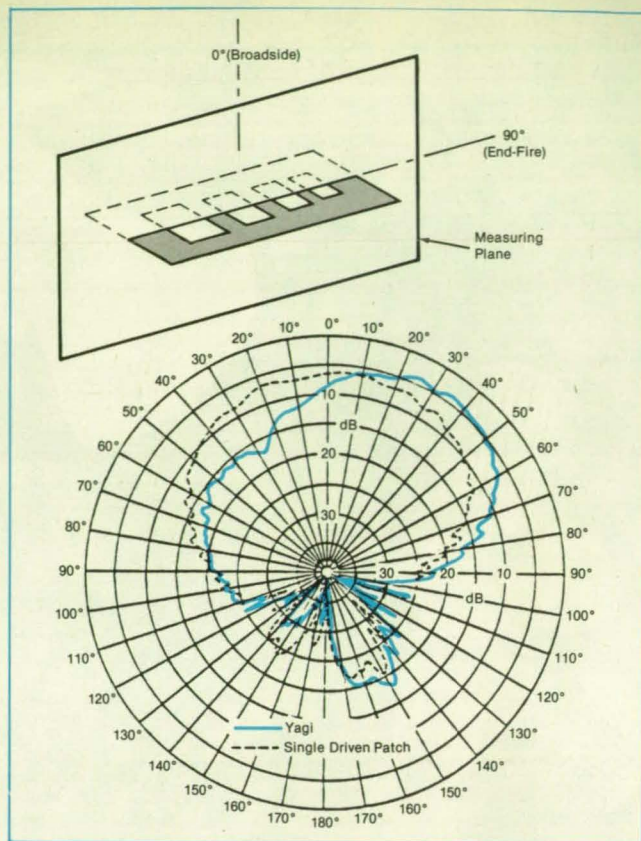


Figure 2. The **Radiation Pattern** of the experimental 6.9-GHz, linearly polarized microstrip Yagi antenna described in Figure 1 is compared with that of a similar antenna that includes only the driven element. On the circular chart, 0° denotes the broadside direction in the measuring plane.

cases it has reduced gains while increasing side lobes of radiation patterns. In the new Yagi microstrip antennas, as in Yagi's original linear arrays of rod elements, the microstrip elements are designed to exploit mutual coupling in a way that shapes the radiation pattern to advantage. Potential applications include antennas on land vehicles, television receiving antennas, and conformal antennas on aircraft.

The microstrip Yagi concept is applicable to both linearly and circularly polarized antennas. Figure 1 illustrates the general configuration of a four-element microstrip Yagi antenna with one driven element, one reflecting element, and two directing elements. Such an antenna could also serve as part of an array. Although such an antenna or array tends to be larger than is a conventional microstrip antenna or array, its use of fewer driven elements results in less complexity and reduced loss of power

in the associated transmission lines and other coupling and power-distributing circuitry.

Figure 2 illustrates the kind of improvement that can be obtained by adding Yagi parasitic elements to a microstrip array to change a radiation pattern. When the reflector and directors are added, the direction of peak gain is tilted away from broadside, toward the end-fire direction (the direction along the centerline of the patches in the microstrip plane).

The dimensions of the Yagi microstrip elements and the distances between them can be optimized for a particular purpose by trial and error or chosen on the basis of principles similar to those used to design conventional rod-dipole Yagi antennas. However, some aspects of the design problem are unique to microstrips. In particular, the dielectric constant should not be less than about 1.5 or greater than about

5. If it is too low, the microstrip patches have to be made so large that the required separations between the centers of patches cannot be maintained; if it is too high, the patches have to be made so small that the gaps between them become large enough to substantially reduce mutual coupling. In general, the separations between the centers and the sizes of parasitic patches govern phases, while gaps between parasitic patches govern amplitudes.

This work was done by John Huang of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 26 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 16]. Refer to NPO-17873.

Switching Matrix for Optical Signals

Size, weight, and power consumption would be reduced.
John F. Kennedy Space Center, Florida

A proposed matrix of electronically controlled shutters would switch signals in optical fibers between multiple input and output channels. The device would serve as a building block for small, low-power, broadband television- and data-signal-switching systems that provide high isolation between nominally disconnected channels. In principle, any degree of isolation between input and output channels could be

achieved by stacking a sufficient number of such devices back-to-back in a package.

Present switching devices incorporate mechanical coaxial or reed relays or semiconductor matrices of moderate to large size, weight, and power consumption. The proposed device offers the advantages of microscopic integrated-circuit design, power consumption in the range of microwatts to milliwatts, bandwidth as high as 30

GHz, and separation of input and output power sources. The switching speed is limited only by the characteristics of the liquid crystal, electro-optical cell, or other type of electronic shutter.

The figure shows a representative device of four input and four output channels. The input and output paths would be etched into quartz wafers, which would be fused to a quartz wafer that contains the

POWERFUL PERFORMANCE

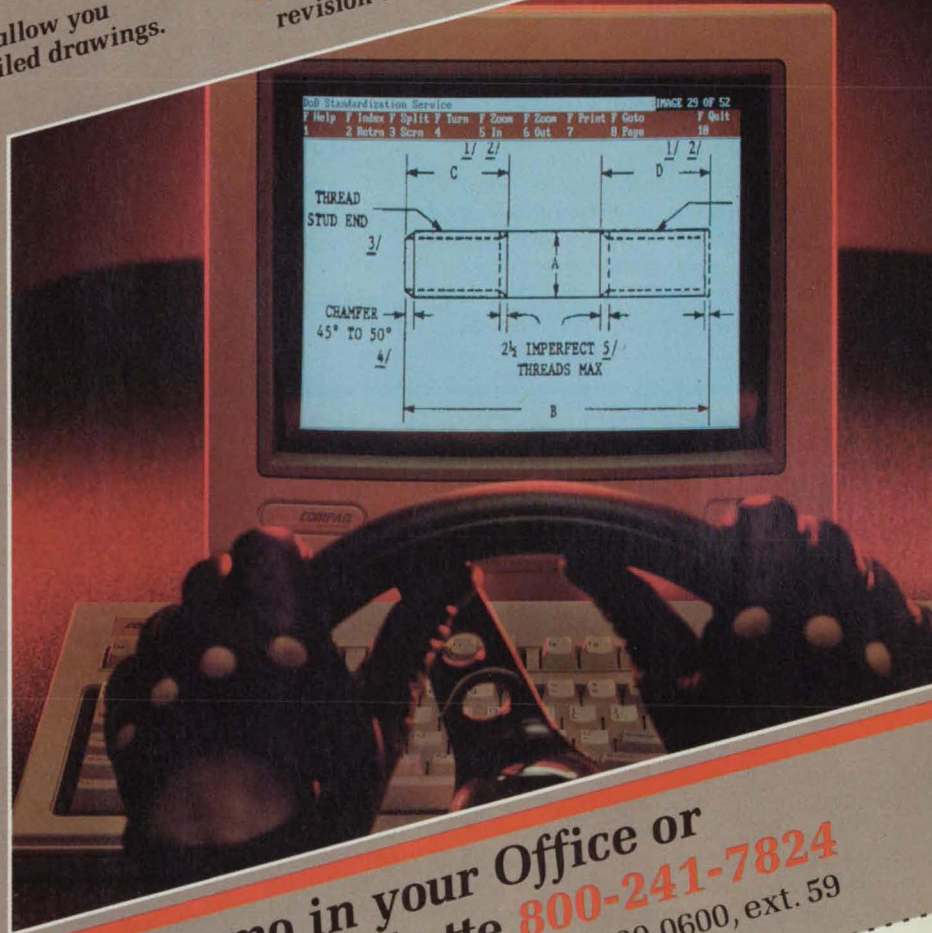
- Zero in on exact paragraphs, sub-paragraphs, tables and figures by scanning our exclusive document outlines.
- Multiple zoom and print features allow you to easily read small type and detailed drawings.

- Search by keyword, phrases, document number, FSC or Locator Code.
- Automatically link to applicable, referenced or superseded documents.
- Amended paragraphs and documents under revision are flagged.

DoD Standardization Service on CD-ROM



Speed your research with access to U.S. Military and Federal Specifications, Standards and related documents on your own personal computer. **Complete, full-text documents**—exact images of the paper originals—may be viewed on your PC monitor or printed with CALS-compliant 300 dots per inch clarity.



**FREE Demo in your Office or
FREE Demo Diskette 800-241-7824**
In Colorado or outside the U.S. call 303-790-0600, ext. 59

**Yes, I'd like to take the
DoD Standardization Service
for a test drive!**

- I'd like a FREE on-site demonstration. Please send me a FREE Demo Diskette.

Name _____

Title/Department _____

Organization _____

Address _____

City _____ State _____ Zip _____

Phone _____

Information Handling Services®

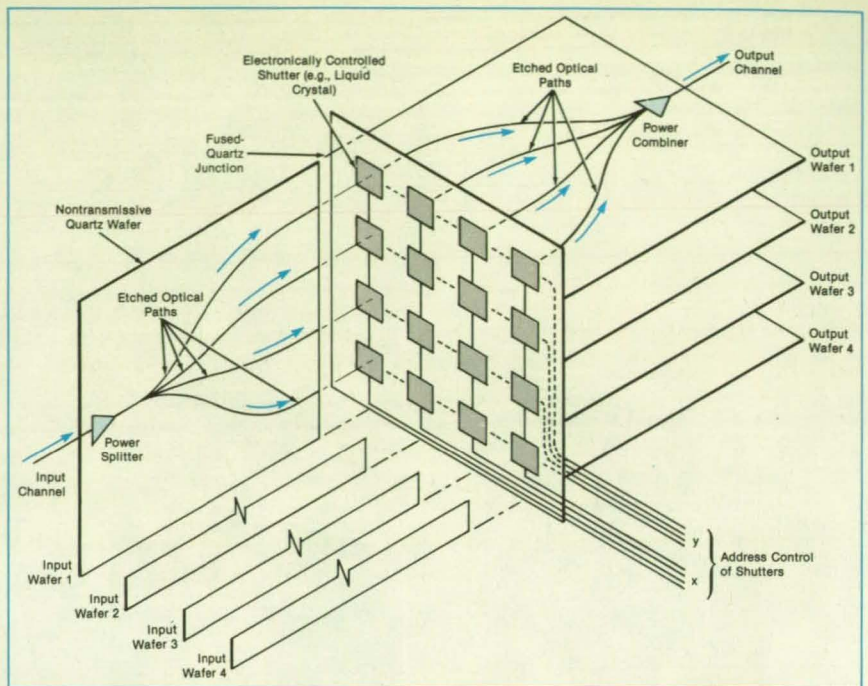
15 Inverness Way East
Englewood, CO 80150
Outside the U.S. fax 303-799-4097
or telex 4322083 IHS UI.
Circle Reader Action No. 478

shutters. Each shutter would be opened or closed by a signal addressed to it according to its row and column (standard "x-y" address control).

Each input channel would lead to a unique column of the shutters. The power in each input channel would be split optically, with automatic gain control, for distribution among the four input paths leading to the four shutters in its column. By use of a similar configuration, signals would be led to each output channel from a row of shutters. The signals from the shutters in each row would be combined with automatic gain control at the junction of the paths from the shutters, then launched into the output channel.

This work was done by Charles H. Grove of Kennedy Space Center. For further information, Circle 155 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, Kennedy Space Center [see page 16]. Refer to KSC-11392.



An **Electronically Controlled Matrix of Shutters** would switch signals from input channels on quartz wafers to output channels on other quartz wafers stacked perpendicularly.

Dielectric-Filled Paraboloidal Front Ends

Planar antennas with receiving and/or transmitting circuits are integrated at the focal point.

NASA's Jet Propulsion Laboratory, Pasadena, California

Reflectors formed from shaped dielectric material with a metallized parabolic surface can serve as the basis for a wide variety of planar, integrated receiver and transmitter circuits operating at millimeter and submillimeter wavelengths.

At short wavelengths, it is desirable to be able to integrate a receiver or transmitter circuit with a planar antenna and beam-shaping optics to produce an easily fabricated, compact and robust structure to serve as the front end of a much larger radio-frequency (RF) telescope system. At microwave and millimeter-wave frequencies, a waveguide generally has been the medium of choice for coupling energy into or out of the receiver or transmitter element, and a feed horn has usually been used to match efficiently onto the main collecting surface. At higher frequencies (above 350 GHz), waveguide devices are very difficult to fabricate, and suitable alternatives have been sought for some years.

The dielectric-filled parabola takes advantage of the fact that an antenna on a dielectric half-space radiates preferentially into the dielectric. It combines an input feed (planar antenna), transmitting or receiving element (integrated detector, mixer, or oscillator diode), bias and/or intermediate-frequency lines and beam-forming optics into a single robust structure. The main component is a planoconvex dielectric lens with the convex surface shaped into a parabola having an f/D (focal-length-

to-diameter) ratio of 0.25. The parabolic face is metallized, and a planar antenna and receiver (or transmitter) element are integrated onto the center of the flat surface of the dielectric lens, the focal point of the parabola.

A heterodyne array receiver front end using a dielectric-filled parabola is shown in the figure. Radiation is incident on the flat surface of the dielectric, presumably but not necessarily from some larger collecting-area dish or telescope. The incoming beam passes through the dielectric, reflects off of the metallized parabolic face, and is focused onto the antenna array on the planar surface of the lens. The antenna elements couple the RF radiation directly to the detectors or downconverting devices located at the terminals. Intermediate frequency removal and direct-current (DC) biasing are accomplished using coplanar lines (other transmission-line media are of course possible), which are integrated on the dielectric surface at the same time as the antenna elements. These include low-pass filter elements to remove the detection or mixing products without affecting the RF antenna characteristics. Connections to external circuitry are made at the edge of the dielectric lens through bond wires attached to pads at the ends of the coplanar line. For heterodyne operation, the local-oscillator signal can be injected through a hole left for this purpose at the center of the metallized surface of the lens.

For a dielectric with a high index of refrac-

tion, a quarter-wavelength-thick matching layer is added on the flat surface of the lens.

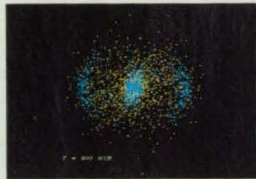
The f/D ratio of the input or output beam can be adjusted by forming the planar surface of the lens slightly inside or outside the nominal focal point.

Since off-axis rays entering the dielectric come to a focus on the flat surface of the lens but laterally displaced from the focal point, the dielectric-filled parabola can be used with a planar array. In fact, due to the refraction, which occurs at the dielectric/air interface, beam steering to greater angles off axis is possible than with an equivalent air-filled paraboloidal system.

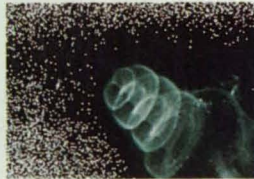
The dielectric-filled parabola can be used over a wide range of frequencies and in a variety of modes: as a receiver or transmitter, in a heterodyne or direct-detection mode, with a single element, or with an array. It combines the high directivity of a parabolic reflector with the convenience of a large substrate lens on which both planar antenna elements and receiving or transmitting devices can be integrated. It allows some control over the output beam and can match very broad-beamed radiators to systems that have reasonable f/D ratios. The design is inherently robust, is easy to fabricate, can be scaled to very high frequencies, and is cryogenically coolable.

Although intended for use in the millimeter- and submillimeter-wavelength bands, operation at lower frequencies is possible

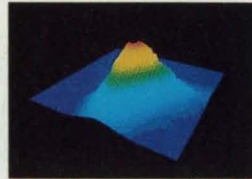
Last Year, This Is How They Won The IBM Supercomputing Competition.



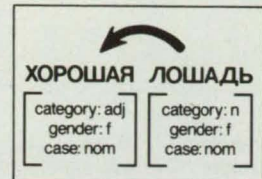
1st Place: Gas dynamics and star formation in merging galaxies.
Kevin M. Olson,
University of Massachusetts.



1st Place: 3-D reconstruction of cochlea structure.
Carl S. Brown and
Alan C. Nelson,
University of Washington.



1st Place: Stretching and bending of material surfaces in turbulence.
Stephen B. Pope and
Sharath Girimaji,
Cornell University;
Pui-Kuen Yeung,
Pennsylvania State University.



1st Place: A dependency parser for variable word order languages.
Michael A. Covington,
University of Georgia.

This Year, This Is How You Can.

For information and an entry form, write to:

Supercomputing Competition Administrator
IBM Corporation
36 Mill Plain Road, Suite 404
Danbury, CT 06811

Name _____

Affiliation _____

Address _____

City _____ State _____ Zip _____

Phone _____ FAX _____

NTB

Call For Papers

Last year, the response was overwhelming. So this year, the IBM Supercomputing Competition, with a new division, returns.

Created to discover, acknowledge and reward gifted American and Canadian scientists and engineers, this prestigious competition honors those whose papers describe innovative approaches to large-scale analysis and modeling.

Each paper must describe work using an IBM 3090™ Supercomputer and/or the paper must describe distributed or cooperative processing in which IBM technical workstations are linked to IBM mainframes.

The papers will be judged in five divisions: Physical Sciences and Mathematics; Engineering; Life and Health Sciences; Social Sciences, Humanities and the Arts; and Computer Sci-

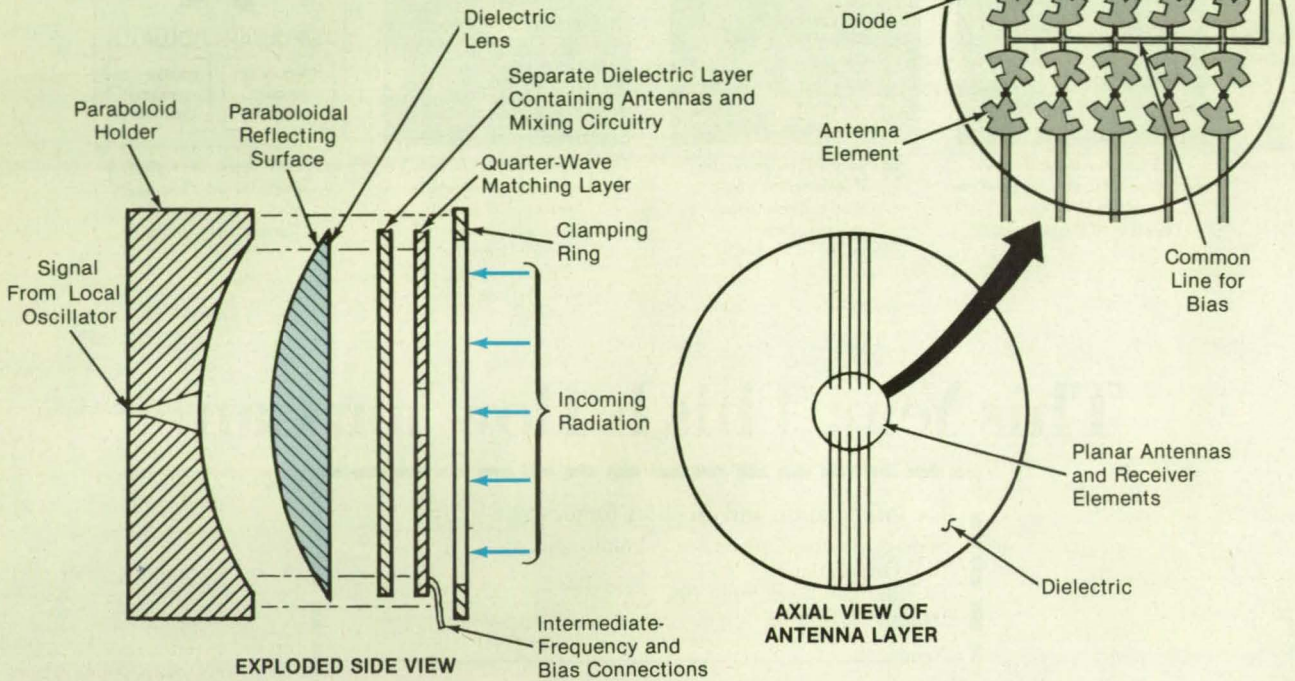
ences—Distributed and Cooperative Processing (new division). Each division will receive a first, second and third prize of \$25,000, \$15,000 and \$10,000, respectively. Also, a "PROCEEDINGS" of selected papers will be published.

Contestants must register an abstract of their paper by October 16, 1990. Those who have registered their abstracts must forward their papers by January 15, 1991.

To select winners, IBM will retain a panel of independent authorities in each division. Winners will be announced by March 30, 1991.

For more information, contact your IBM marketing representative or call the IBM Supercomputing Competition Administrator at (203) 794-1355, FAX: (203) 792-7507 in the U.S.; (416) 758-4136 in Canada.

A 10-Element Heterodyne-Array Receiver Front End incorporates a dielectric-filled parabola. The dielectric filling serves as a coupling medium and nonobstructing mount for the integrated antenna and mixing circuitry at the focal point of the parabola. Log-periodic antenna elements are shown, but other types may be used. The local-oscillator signal is injected via a conical horn incorporated into the metallic housing and a hole at the center of the metallized face of the dielectric-filled parabola.



and, for example, at X-band (8 to 12 GHz), an acceptably large parabola would be 8 in. (20 cm) in diameter and 2 in. (5 cm) thick.

This work was done by Peter H. Siegel of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle

14 on the TSP Request Card. NPO-17802

MCT/MOSFET Switch

A hybrid of two different switching transistors has large safe operating area and high speed.

NASA's Jet Propulsion Laboratory, Pasadena, California

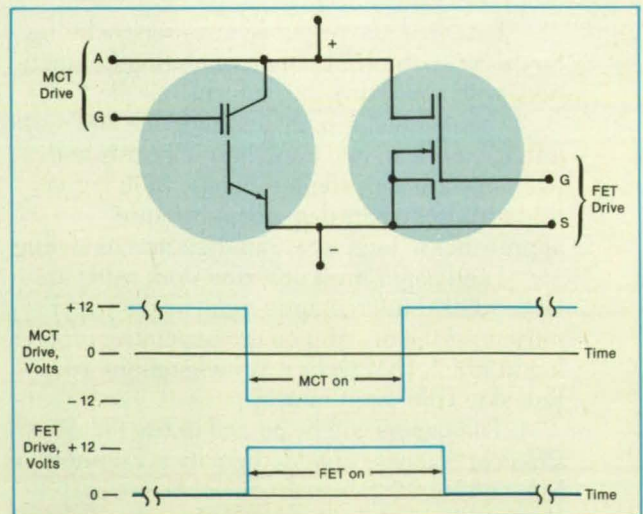
A metal-oxide/semiconductor-controlled thyristor (MCT) and a metal-oxide/semiconductor field-effect transistor (MOSFET) have been connected in a switching circuit to obtain better performance than is possible with either device alone. In comparison with previous semiconductor switching devices and circuits, this combination offers (1) high utilization of silicon (that is, high current per unit total area of silicon), (2) low forward voltage drop during the "on" period of the operating cycle, (3) fast turn-on and turnoff, and (4) large turnoff safe operating area (a safe operating area on a plot of operating voltage vs. current vs. time, characterized by a high current density and the ability to turn off at high voltage).

The advantages of MCT's include high utilization of silicon, the ability to operate at high temperatures, high static blocking voltage, and ease of drive. However, these devices have two major disadvantages:

The **Parallel Combination of an MCT and a MOSFET** in a switching circuit combines the advantages of both devices. The MCT dominates the operation during the on-period; the MOSFET dominates during the turnoff transient.

turnoff times are long (of the order of 1 μ s), and the maximum voltage that a typical MCT can block during turnoff without the use of a snubber (a resistor-and-capacitor

dampener) is only half the static blocking voltage. The latter disadvantage necessitates some form of turnoff snubbing; this, in turn, entails additional mass, volume, cost, and



STACK ATTACK.

Is there a band saw blade mean enough to cut through this stack of hard, abrasive materials smoothly and easily?



Fiberglass Piping,
Honeycomb, Fabric-
Reinforced Plastic,
Foam Glass, FRP,
Graphite-Reinforced
Composite,
Pearlite,
Hardened Tool Steel,
Friction Material, Aircraft Tire,
Case Hardened Steel

We're talking mean. These are some of the most difficult-to-cut materials commonly used today. Materials which have revolutionized the aerospace and reinforced plastics industries have also played havoc in manufacturing lines. In the past, manufacturers chose between high priced diamond blades and inefficient conventional blades. Today, they're choosing "Grit-Edge" band saw blades.

RemGrit® provides the answer to twentieth century cutting problems with its unique "Grit-Edge" technology: thousands of crushed tungsten carbide particles permanently, metallurgically bonded to tough alloy steel. These reversible blades won't strip or snag, have no teeth to dull, and last much longer than conventional blades.

Is there a band saw blade mean enough to attack this stack? You bet there is. It's mean. It's "Grit-Edge".

Ask about our complete line of "Grit-Edge" saw blades.

RemGrit

939 Barnum Avenue • Bridgeport, Connecticut 06608
Telephone: (203) 336-2525 • FAX: (203) 576-6769 • TELEX: 240327
"RemGrit" and "Grit-Edge" are registered trademarks of The RemGrit Corporation.

A MEMBER OF
The
InterTech
Group

**"GRIT
EDGE"**

loss of power.

In the hybrid switching circuit, the MOSFET is connected in parallel with the MCT. Both the MCT and the MOSFET are driven on at the same time, but the on-state MOSFET drive is continued for a short time after the MCT drive is switched to the off state (see figure). By this scheme, the MCT is made to dominate the behavior of the switch during the on period, whereas the MOSFET is made to dominate the switching action during the turnoff transient.

The total silicon area required in a switching device or combination of devices to keep the forward voltage drop below a given value is considerably less in the MCT/

MOSFET combination than in a MOSFET acting alone; that is, much of the high utilization of silicon that characterizes the MCT is preserved. The turnoff switching loss of the combination is only slightly greater than that of a MOSFET acting alone. The turnoff safe operating area of the combination includes both the static-breakdown voltage and the peak allowed current of the MCT; that is, no voltage derating is required to accommodate the dynamics of the MCT.

The optimal ratio between the silicon areas of the MOSFET and the MCT is about 1. The optimal extension of the MOSFET on period is of the order of 3

times the decay time constant of the MCT current. Tests indicate that turnoff switching speed can be increased to about 10 times that of an MCT acting alone, while the utilization of silicon can be increased to about 5 times that of a MOSFET acting alone.

This work was done by Wally E. Rippel of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 100 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 16]. Refer to NPO-18001.

Millimeter-Wave Quantum-Well Frequency Multipliers

A double-barrier quantum-well GaAs diode produced 0.25 mW output at the third harmonic, 191 GHz.

NASA's Jet Propulsion Laboratory, Pasadena, California

A double-barrier quantum-well GaAs diode achieved 0.61 percent efficiency as a frequency tripler when operated at an input frequency of 63.7 GHz, nearly one-tenth the cutoff frequency of the diode. Efficiency increased with drive level up to the maximum input power available, 40 mW. Inasmuch as this performance is comparable to that of a GaAs varactor diode of the same cutoff frequency, these initial results are considered quite promising.

The diodes are being studied for use in local-oscillator chains in microwave radiometers. Other potential applications include spectrometers and radar.

The various semiconductor devices that could be used as frequency multipliers have different efficiency limitations. There are two types of semiconductor devices with monotonically increasing current-vs.-voltage (I-V) curves: resistive devices (varistors), which have a maximum efficiency of $1/n^2$ for harmonic n , and reactive devices (varactors), which are limited in efficiency by parasitics.

The layered structure of a quantum-well diode is shown in Figure 1. For testing, a diode chip was mounted in a waveguide assembly that had been constructed for testing a varactor frequency tripler. Each 0.1-mm square diode chip has a 10×10 array of the individual $4\text{-}\mu\text{m}$ diameter diodes. A low-pass filter of suspended stripline on a quartz substrate connected the input waveguide to the quantum-well diode. This structure prevented harmonics from leaking back into the input circuit. The diode chip was indium-soldered to the last low-impedance section of the filter and protruded 0.1 mm into the output waveguide, where a pointed metal whisker $6\text{-}\mu\text{m}$ in diameter made contact with one of the diodes in the array. The whisker acted as an electric-field probe to couple the output to the waveguide.

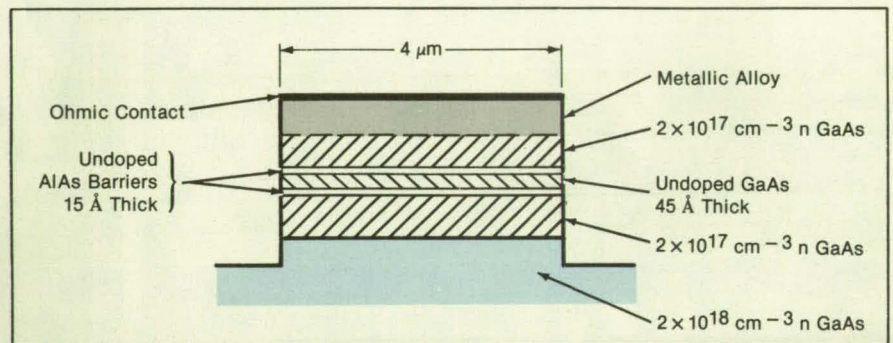


Figure 1. Quantum-Well Double-Barrier Diodes were fabricated on a GaAs chip. Each diode was a mesa-shaped structure $4\text{-}\mu\text{m}$ in diameter. The electrical parameters of each diodes were series resistance = $15\ \Omega$, capacitance = $15\ \text{fF}$, and cutoff frequency = $730\ \text{GHz}$.

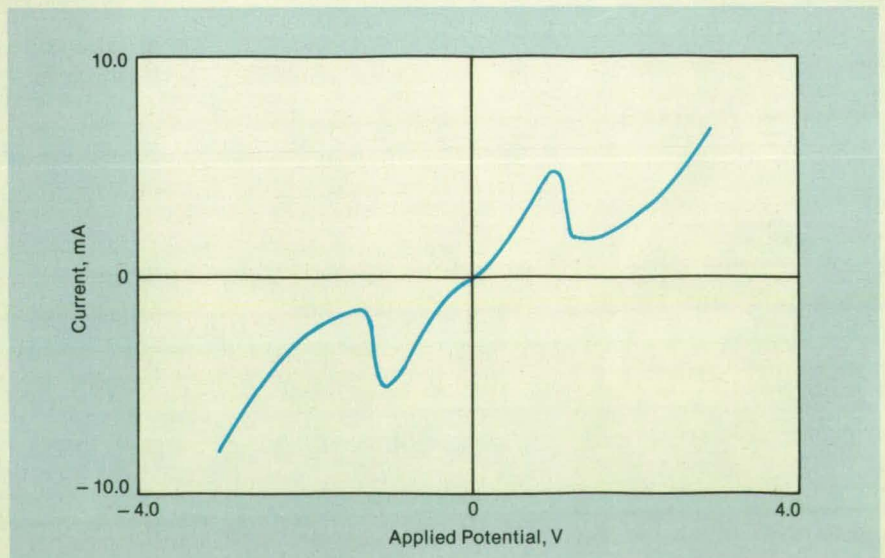


Figure 2. The I-V Curve of the quantum-well diode is essentially symmetric about the origin and has two negative-resistance regions.

A double-barrier quantum-well device has two polarity-symmetric negative-resistance regions (see Figure 2). Critical to the achievement of the negative-resistance regions is the structure formed by the thin undoped barriers. These partially transparent reflectors form a Fabry-Perot et-

alon. This results in a current singularity as the magnitude of the applied voltage increases, followed by a decrease in current above electron-energy resonance. The resulting negative-slope portions of the I-V curve are the negative-resistance regions. Because this curve is not a monotonically

AT&T's DSP₃ Parallel Processor: every cubic foot, a gigaflop.



Give the AT&T DSP₃* Parallel Processor your toughest tasks—image processing and object recognition,

25 megaflop processing engine, the DSP₃ can handle multi-gigaflop computational loads in a network configuration of over 100 processors. The DSP₃ also gives you extreme flexibility: it can be populated with one to

powerful processing with the density you need, look to the AT&T DSP₃. It can cut your algorithm problems down to size. For more information,

With 1 gigaflop per cubic foot, it delivers the enormous power and density you need to implement your algorithms in a variety of tactical hardware.

beamforming, neural networking, speech recognition, synthetic aperture radar—and it'll handle the problem with speed and ease.

The DSP₃ delivers 1 gigaflop per cubic foot of active area (up to 3.2 gigaflops in a single array). With an advanced package that gives you 800 megaflops in only 9 cubic inches.

Speed? 40 megabytes/second on each of four channels for an aggregate bandwidth of up to 160 megabytes/second.

Capacity is also maximized. Using a

eight boards, each with 16 processing nodes, providing 400 megaflops of power and four megabytes of memory.

AT&T's DSP₃ gives you access to high-level language software such as a C compiler and a wide library of signal processing subroutines. And it leads the industry in price per megaflop. Plus, of course, you get the unparalleled support and service of AT&T Bell Laboratories and AT&T Field Applications Engineers.

So, for realtime parallel processing,

**We've got solutions
down to a science.**

call your
AT&T
Federal
Systems
Account
Execu-

tive, or 1800 553-8805. (N.C. residents, call collect: 919 697-9580.)

*Developed in part under a DARPA sponsored contract.



AT&T

The right choice.

Circle Reader Action No. 665

increasing function, the $1/n^2$ efficiency limit of varistors does not apply. Because of the symmetry of the response function, only odd harmonics are generated when such a diode is driven by a sinusoidal voltage. This

allows the embedding circuit to be substantially less complex than those necessary for previous semiconductors.

This work was done by Paul D. Batelaan and Margaret A. Frerking of Caltech for

NASA's Jet Propulsion Laboratory. For further information, Circle 32 on the TSP Request Card. NPO-17584

High-Efficiency Klystron for Television Transmitters

A multistage depressed collector recycles energy from spent electrons.


Lewis Research Center, Cleveland, Ohio

An improved klystron is designed for use as the final amplifier in an ultrahigh-frequency (UHF) television transmitter. The new device incorporates a multistage depressed collector (MSDC) of advanced design to increase efficiency by recovering, from the spent electron beam, some of the


residual kinetic energy that would otherwise be dissipated as heat. Originally developed by NASA to increase the efficiencies of spaceborne transmitters, the MSDC technology can halve the power consumed by a typical UHF television transmitter. The MSDC-klystron concept could

also be applied to increase the efficiencies of microwave communication, equipment, radar systems, and particle-beam accelerators.

The experimental version of the MSDC klystron was made by modifying a com-



SAIC
Science Applications
International Corporation
An Employee-Owned Company



Delta II


Floating Point Processor


WE'VE TAKEN THE MYSTERY OUT
OF NEURAL NETWORKS

Over 2000 Satisfied Customers Worldwide

Single Source Solutions

- Hardware and Software Tools
- Customer Support
- Applications Development
- Customer Education/Training
- Embedded Systems
- Commercialization of Research Projects
- Fuzzy Logic Solutions
- VAX Program
- Third Party Software
- Worldwide Representation and Distribution





SAIC Science Applications
International Corporation
An Employee-Owned Company

Artificial Neural Systems Division
10260 Campus Point Drive, MS 71, San Diego, CA 92121
Tel (619) 546-6148 FAX (619) 546-6706

Circle Reader Action No. 692

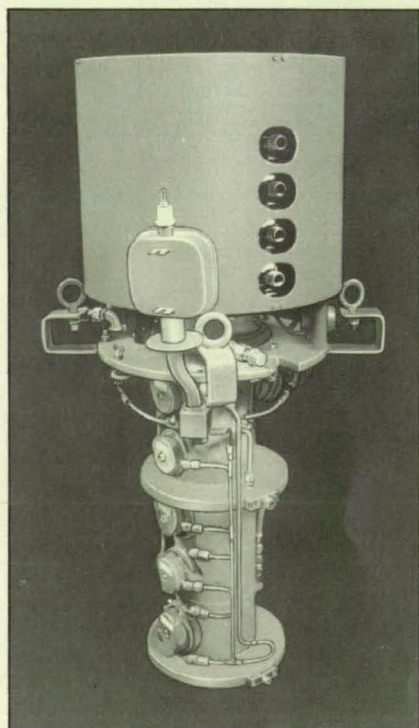


Figure 1. The **Multistage Depressed Collector** at the top of the klystron is shown with its metal shield.

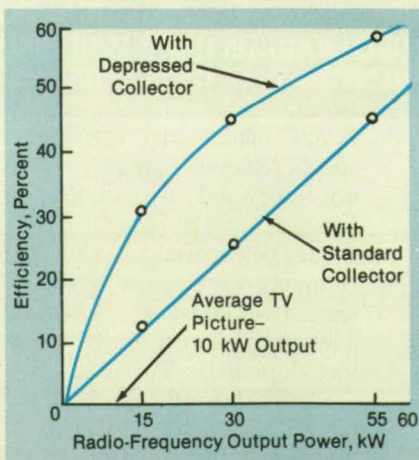
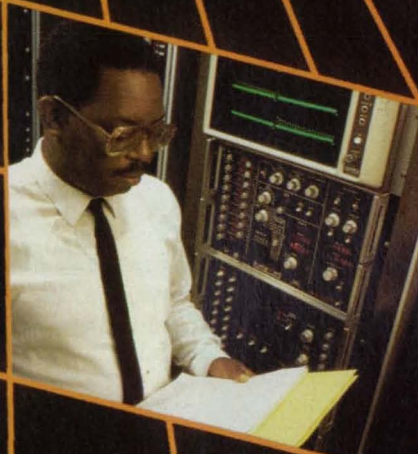


Figure 2. The **Overall Efficiency** of the MSDC klystron is compared with that of the conventional version of the same klystron.



NUSC Engineers Go Places.



A career that starts at the cutting edge of technology is a career that's going places.

At the Naval Underwater Systems Center (NUSC), that's where our work begins, and that's the advantage our engineers have. Their work starts at the point others' has ended and takes them forward to new technologies, out of the labs and into real-world situations, and closer to their full potential.

As the Navy's primary research and development laboratory for submarine systems, NUSC provides vital technology that allows the U.S. to maintain its defensive posture worldwide. Doing so requires our civilian engineers to constantly break new ground in the areas of communications, artificial intelligence, electromagnetics/electro-optics, acoustics, fluid dynamics, and structural analysis.

These efforts often extend beyond the main NUSC laboratories in Newport, Rhode Island, and New London, Connecticut. Our engineers' work has taken them to locations as diverse as the ocean floor for at-sea testing of the systems they developed; high-powered program offices in Washington, D.C., for critical project planning and review; and unexplored regions of the Arctic for under-ice research.

And at NUSC, we know that to remain ahead, our workforce has

to be the finest. We ensure this through encouragement and financial support of continuing education, offering a dual-career ladder with technical and managerial opportunities, and providing assignments to challenge even the highest levels of interest, skills, and abilities.

New professionals and experienced electronics, electrical, and computer engineers with plans to go places in their careers should think about NUSC.

It's a great place to work. For more information or to apply, contact:

NAVAL UNDERWATER SYSTEMS CENTER

Placement Officer, Code 083 (NTB)
Personnel Staffing Division
Newport, RI 02841-5047

Or call: (401) 841-4404



U.S. Citizenship Required
An Equal Opportunity Employer

Circle Reader Action No. 324

mercial klystron that has five internal cavities and provides 60 kW of power at frequencies from 700 to 850 MHz (see Figure 1). The collector is enclosed in a metal shield to minimize radio-frequency interference. It is composed of five elements mounted between electrically insulating ceramic rings. Each electrode contains a passage for cooling water. A refocusing electromagnet inserted between the klystron and the collector adjusts the electron beam as it enters the collector.

The experimental klystron was tested in a pulsed mode at 60 pulses per second,

each pulse lasting 16.7 μ s. Its performance was measured over a wide range of operating conditions to obtain a complete characterization. From the measurements, the efficiency was calculated and plotted as a function of radio-frequency output power (see Figure 2). More, recently, another type of UHF television klystron that has four external cavities was modified to an MSDC design. Two such tubes were tested and found to perform similarly to the experimental klystron. In addition one of the tubes performed satisfactorily in a continuous-wave mode under simulated television conditions.

In comparison with a typical klystron now in use in UHF television stations, the new klystron can save as much as 400,000 kWh per year. In terms of typical prices for electricity in 1989, this amounts to an annual saving of about \$30,000.

This work was done by Peter Ramins and James Dayton of Lewis Research Center, and Earl McCune, Sr., of Varian Associates, Inc., and Henry Kosmahl of Analex for Lewis Research Center. For further information, Circle 154 on the TSP Request Card.
LEW-14926

Books and Reports

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

Effects of Dose Rates on Radiation Damage in CMOS Parts

Damage is more severe at lower dose rates.

A report describes measurements of the effects of ionizing-radiation dose rate on the consequent damage to complementary metal oxide/semiconductor

(CMOS) electronic devices. This topic is important to the semiconductor industry because the effects of varying dose rates on damage and/or annealing (gradual post-irradiation changes) may have to be taken into account when analyzing test results on device radiation-damage sensitivity. Depending on irradiation time and degree of annealing, the survivability of devices in outer space, or after explosion of nuclear weapons, may be enhanced. However, annealing that involves recovery beyond the pre-irradiation conditions (rebound) may be detrimental.

The test devices were commercial versions of the 4011 quad two-input NAND

gate and the 4013 dual "D" flip-flop. These devices were exposed to radiation from Co^{60} and Cs^{137} sources, at various rates from 0.02 to 200 rad (Si)/s. Each exposure was continued until the device was deemed to fail by virtue of changes in quiescent currents beyond manufacturers' specified limits, incorrect outputs, or threshold potentials in excess of 0.45 V.

Experiments were also conducted to study the effects on devices following irradiation, while maintaining the devices under bias. Data were acquired during post-irradiation periods up to 2,231 hours. The annealing responses at increased temperatures (accelerated annealing) of some devices were also measured, to determine whether this was a viable way to shorten the time required to measure post-irradiation effects and reduce testing costs.

Test results led to the discovery that more damage is done at low dose rates than at high, contrary to the previously accepted assumption. One practical implication is that CMOS devices rated by extrapolation of tests at high dose rates, but used in low-radiation environments, may fail two to six times as fast as anticipated. Other conclusions drawn from the tests include the following:

- Rebound occurs in devices exposed at higher rates of dosage but not in those exposed at lower rates.
- The mechanisms of damage at high and low dose rates appear to be different.
- Accelerated annealing is acceptable for the study of postirradiation effects.

This work was done by Charles A. Goben, James R. Coss, and William E. Price of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Dose Rate Dependence of Failure Levels and Post Irradiation Effects (PIE) of Commercial CMOS 4000 Series Parts," Circle 15 on the TSP Request Card.
NPO-17344

Two DSP Tools ONE POWERFUL DSP SOLUTION



Start with the blazing speed of our DSP32C-based ZPB34 DSP processor board, then add the versatility of our upgraded DSPlay XL™ code development software. The unique combination forms one of the most powerful integrated DSP platforms available on an IBM® PC or compatible. Simple, painless, and powerful.

The ZPB34 features AT&T's 50MHz DSP32C floating point processor and is available in four standard memory configurations from 64KB to 576KB. It's ideal for applications requiring large FFTs, execution of complex real-time algorithms, and image processing. High-speed buffered serial ports are included for interconnections of processing boards or connection to our ever-expanding line of high-performance analog I/O systems.

Add power to speed with our improved DSPlay XL DSP code generation software. It features a menu-driven diagram approach to algorithm development and generates standard executable code for both AT&T's DSP32 and DSP32C. New version 3.15 includes over 100 DSP functions, an assembler for user-defined blocks, FIR and IIR digital filter design routines, and I/O control.

Put the power of our DSP solutions to work for you. For information on our entire line, call 1-800-548-6132, or write Burr-Brown Corp., P.O. Box 11400, Tucson, AZ 85734.

DSPlay XL™, Burr-Brown Corp.
WE®, AT&T Corp.
IBM®, IBM Corp.



More About Lens Antenna for Mobile/Satellite Communication

Details of a flat phased-array design are presented.

A report presents additional details of the design of the proposed phased-array antenna described in "Lens Antenna for Mobile/Satellite Communication" (NPO-16948), *NASA Tech Briefs*, Vol. 12, No. 10 (November, 1988), page 24. The antenna is intended to be compact and to lie flat on top of a vehicle on the ground. The antenna would transmit and receive circularly polarized radiation in the frequency ranges of 821 to 825 MHz and 860 to 870 MHz, respectively (or at other frequencies by suitable scaling of its dimensions). The transmitting and receiving beams would be electronically steerable to any of 48 evenly spaced directions to provide complete azimuth coverage, and would be fixed, but wide, in elevation, to provide coverage at elevation angles from 20° to 60°.

The report tells how the design evolved, motivated by the need for an electronically steerable vehicle antenna of relatively low cost. The design was simplified (and, consequently, the cost was reduced) somewhat by incorporating the fixed-elevation feature. In a standard approach to the design of an electronically steerable antenna, a phase shifter is required for each radiating element. To reduce the number of phase shifters and, thereby, the cost, another feeding technique must be used. The report discusses feeding networks that consist of various combinations of more or fewer phase shifters, hybrid couplers, interconnecting cables, striplines, and dielectric lenses. It discusses the design features of each as they pertain to the intended mobile/satellite application, showing why each prior feeding arrangement was rejected in favor of the R-KR-lens-fed array that was ultimately selected for the proposed design.

As described in the noted previous article in *NASA Tech Briefs*, an R-KR lens is a stripline disk of radius KR ($K < 1$), through which radiating elements, evenly spaced on a circle of radius R , are fed. The lens is fed from the point on its periphery that is opposite that of the intended beam azimuth. The lens eliminates the need for a phase shifter for each radiating element by providing all the necessary phase shifting between the feed point and the radiating elements.

To obtain complete illumination of the aperture, the design of the specific lens calls for two pairs of stripline lens layers (lens A and lens B), a central radiating element plus two concentric rings of radiating elements, and power-dividing and -switching networks. By use of three different schemes for ap-

portioning the power fed to the ports of lenses A and B, and by switching among the 24 azimuthally spaced ports, the beam would be steered to the desired one of the 48 azimuthal headings.

The report describes computer simulations of the far-field radiation pattern of the antenna. The results of the simulation were used to assess the performance and were fed back into the design to obtain dimensions that would optimize coverage. Diffraction from the edges of the roof of the vehicle was also considered, inasmuch as it could affect communication with a satellite near the horizon. Also investigated were the projected ability of the antenna to separate signals to or from two satellites located at different longitudes, and considerations involved in the design of an acquisition-and-tracking system that would include the antenna.

This work was done by Y. Rahmat-Samii of Caltech and D. G. Bodnar and B. K. Rainer of Georgia Institute of Technology for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "A Novel Array Antenna for MSAT Applications," Circle 159 on the TSP Request Card. NPO-17680

Directional Couplers for Detecting Circular Waveguide Modes

Samples of TE_{11} and TE_{12} modes are coupled selectively out of a circular waveguide.

A report presents additional details of the theory, construction, and measured operating characteristics of the directional couplers described briefly in "Microwave Transmitter With Multimode Output Section" (NPO-16826), *NASA Tech Briefs*, Vol. 12, No. 5 (May 1988), page 22. To recapitulate from the noted article: The directional couplers consist of tapered rectangular-cross-section waveguides fastened lengthwise to the outside of a circular waveguide, with uniformly-lengthwise-spaced round coupling holes between each rectangular waveguide and the circular waveguide. The directional couplers are used to take small samples of the power propagating in the TE_{11} and TE_{12} modes in the circular waveguide from a proposed 400-kW, 34.5-GHz gyrokystron amplifier. The samples of forward- and reverse-propagating powers in these modes are used to diagnose the performance of the amplifier and the associated waveguide components.

The design of the couplers is based on S. E. Miller's theory of loose coupling, which was published in 1954. The sample powers are coupled through the holes via the lon-

gitudinal magnetic field in the circular and rectangular waveguides. The sizes of the holes determine the amount of coupling. Each coupler waveguide is attached to the circular waveguide on the short side of its rectangular cross section to prevent the coupling of any transverse magnetic (TM) power out of the circular waveguide.

The coupling to a particular mode in the circular waveguide is maximized by choosing the long side of the rectangular cross section so that the phase velocity of the dominant mode in the rectangular waveguide matches that of the circular-waveguide mode of interest. The holes are spaced lengthwise one-fourth the wavelength of this mode to assure high directivity. Away from the portion of its length that contains the coupling holes, the rectangular waveguide tapers down to a standard size for connection to a detector.

This coupling scheme rejects power propagating in modes other than the mode for which the coupler is designed as well as power propagating in the reverse direction in all modes. The degree of rejection is called the "selectivity." The selectivity for specified modes can be optimized by using a large number of coupling holes and tapering the sizes of the holes as a function of the longitudinal position. A simple computer program takes all of these effects into account, adding the contribution from each coupling hole to yield a figure for the total coupling for each circular-waveguide mode of interest.

The report describes the designs of the TE_{11} and TE_{12} couplers and measurements of their performances. With few exceptions, the measured coupling ratios and selectivities agreed well with those predicted for the designs.

This work was done by Daniel J. Hoppe of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Directional Couplers for Detecting the TE_{11} and TE_{12} Circular Waveguide Modes," Circle 21 on the TSP Request Card. NPO-17175

September 1990— Another Milestone for NASA Tech Briefs

With this issue *NASA Tech Briefs* enters a new era. Over 200,000 copies of *NASA Tech Briefs* were printed achieving a goal of expanding distribution of technical information and new ideas to engineers and scientists who design tomorrow's products.



Electronic Systems

Hardware, Techniques, and Processes

- 34 Bus-Programmable Slave Card
- 36 Differential Radar Interferometry Maps Changes in Elevation

- 36 Robust, High-Performance Control for Robotic Manipulators
- 38 Active Limiters for Photodetectors
- 40 Real-Time Digital Compression of Television Image Data

- 41 Checking Automated-Welder Programs by Computer

Books and Reports

- 42 Laser Velocimetry in Low-Speed Wind Tunnels

Bus-Programmable Slave Card

A specialized microprocessor development system is not necessary.

Lyndon B. Johnson Space Center, Houston, Texas

A slave microprocessor in a multimicroprocessor computing system contains modified circuit cards that can be programmed via the bus that connects the master processor with the slave microprocessors. Although slave cards in multimicroprocessor systems of recent design are programmable via the master/slave buses, those of a slightly older generation of equipment are not. Heretofore, it has been necessary to use specialized microprocessor development equipment to program the older cards. The modified cards eliminate the need for this equipment and increase the flexibility of operation.

The bus-programmable slave card is made possible by the recent introduction of tristate, high-density circuitry and 5-V electrically-erasable, programmable, read-only memories (EEPROM's), which were not available when most of the slave systems now on the market were designed. It includes 64 Kbytes of EEPROM, a real-time clock, a four-channel analog-to-digital converter, eight channels of high-power relay-type devices, and a slave-card central processing unit, which incorporates the capability for programming via the bus and

controls the bidirectional communication between the master and slave. One of the following three optional features can also be installed on the card: an additional four-channel analog-to-digital converter, a circuit to enable communication via a standard RS232 bus, or a digital-to-analog output (see Figure 1).

The bus-programmable slave card offers two modes of operation. The first is the general-run mode, which characterizes the logic state of the card during most operations. The second is the programming mode, in which the card is programmed from the bus.

In the general-run mode, the slave card acts as a single-loop slave processor to the master central processing unit. As a slave, it never gets on the bus. The card is totally self sufficient and is capable of running its own input and output as well as transferring data to and from the bus. As shown in Figure 2, all data and status information is latched in by tristate buffers. In addition, the master can reset the slave card at will. If the slave is reset, then it idles, waiting for a "start program" execution command from the master card. The slave card does

not require any modification of the operating system and gives the user 63K of programming space, which can be configured as either electrically-programmable or random-access memory in 8K blocks by a simple selection of jumpers, without exchanging circuit chips or using outside voltage sources.

In the programming mode, the user flips a switch, sending the slave into tristate suspension while its memory is imaged to the bus. At this stage, the user loads the application program into the memory of the master by using DDT, an error-correcting computer program for the CP/M operating system. Once the program is loaded, the switch is closed and the slave is released. The master central processing unit is free to leave DDT and continue other activities. The slave card can be programmed with a 16 K ".COM" file in less than 4 seconds, compared to more than 13 minutes when serial loading methods are used. Once loaded, the program can then be treated as residing in either random-access or read-only memory, depending on the selection of jumpers. At this point, the slave monitors the status port for a command to

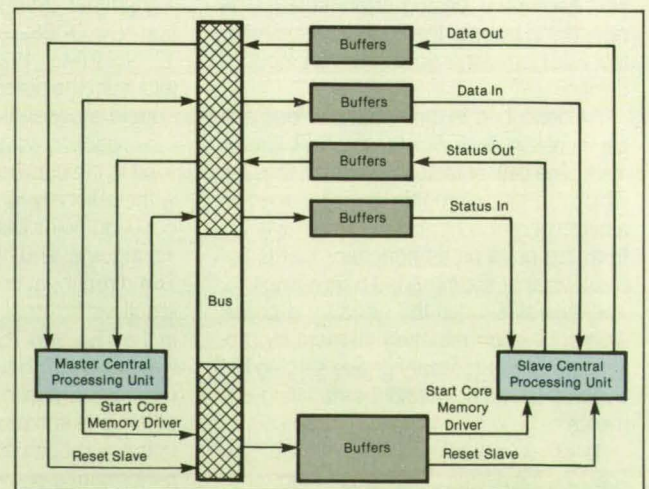
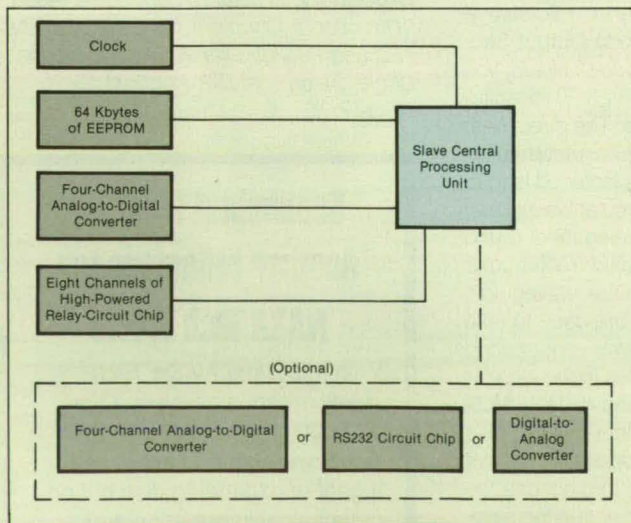


Figure 1. The **Bus-Programmable Slave Card** enables interactive, microprocessor-based, single-loop control. It confers the ability to load and run a program from the master/slave bus, without the need for a microprocessor development station.

Figure 2. **Tristate Buffers** latch all data and information on status. The slave central processing unit is never connected directly to the bus.

The best way to appreciate our new thermal array?



Inch by inch.

A fifteen-inch trace. That's probably the first thing you'll notice about our new TA4000. But at Gould, we know that trace width alone isn't enough to make a superior thermal array recorder. In fact, we've included so many new and advanced features on the TA4000, they're best appreciated one by one.

First, consider the single printhead, a feature you won't find on any other high-speed, wide-format recorder. With it, you'll get continuous, high-resolution tracing across the entire fifteen-inch chart width. No gaps. No blank spots.

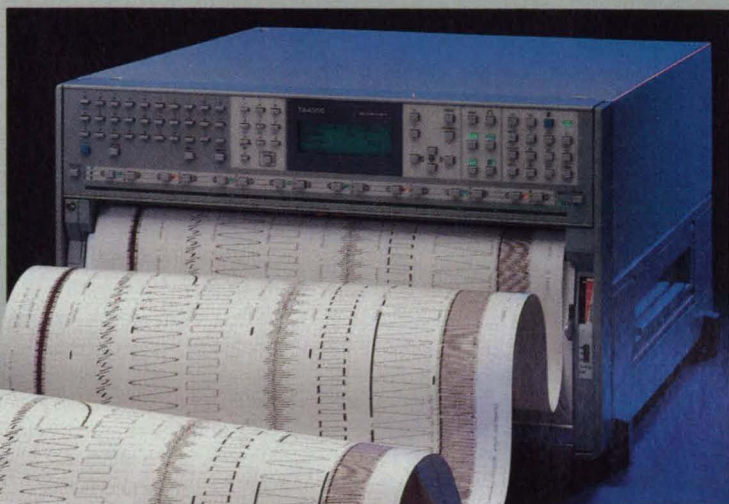
Then have a look at the TA4000's full programmability. In addition to the standard control capabilities, our new recorder will actually calibrate your complete system set-up—all by itself. Which means you'll be able to run an entire test without ever having to touch or readjust the instrument.

And if multiple measurements are what you're after, the TA4000 has up to 24 channels, each able to handle either analog signals or digitized data. What's more, our new recorder will simultaneously record analog and digitized inputs, giving you maximum measurement flexibility.

Of course, the TA4000 is push-button simple. It's designed for maintenance efficiency. And it features Micropulsing™, a new technology that extends thermal array head life and increases contrast quality.

But why measure the TA4000 by words alone?

Call your Gould representative today to schedule your own demonstration. They'll answer any questions you may have. They'll provide you with product specifications. And together, you'll cover all the benefits of the TA4000. Inch by inch.



GOULD
Electronics

Yes!

I want to see how Gould measures up! Please send me more information about the TA4000. (please print)

NTB 9/90

NAME: _____

TITLE: _____

COMPANY: _____

STREET: _____

CITY: _____ STATE: _____ ZIP: _____

TELEPHONE: () _____

Send to: Gould, Inc., Test and Measurement Group, 8333 Rockside Road, Valley View, Ohio 44125 or call (216) 328-7000, Fax: (216) 328-7400

start executing the program. It loops endlessly until it receives the command.

This work was done by William A. Hall of Krug International for Johnson Space Center. For further information, Circle 148

on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development

should be addressed to the Patent Counsel, Johnson Space Center [see page 16]. Refer to MSC-21387.

Differential Radar Interferometry Maps Changes in Elevation

Vertical earthquake motions as small as 1 cm are detectable.

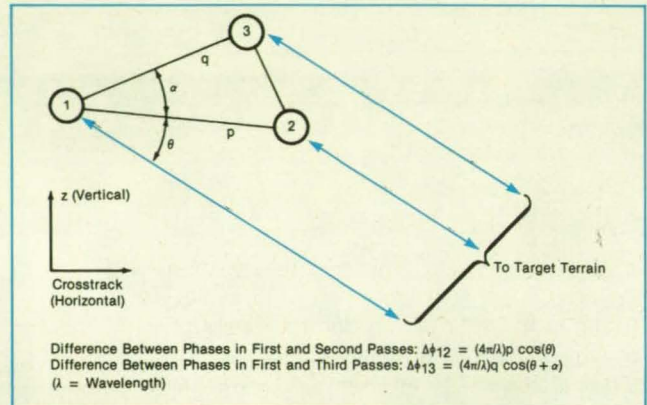
NASA's Jet Propulsion Laboratory, Pasadena, California

Differential radar interferometry can measure changes as small as 1 cm in the elevation of terrain across a swath as wide as 50 km, with a typical horizontal resolution of 10 m. This technique could be used to make extensive, accurate maps of such geophysical phenomena as heaving and buckling in fault zones, motions of tectonic plates, residual displacements from earthquakes, motions from prevolcanic swelling, motions of glaciers, tides, and even thermal expansion of mountains from diurnal heating.

Differential radar interferometry uses data from synthetic-aperture radar (SAR). Typically, three or more SAR images are formed by making passes at different times along three or more tracks that are usually separated slightly (see figure). The separate images are resampled to make them register with each other accurately. For each picture element in one of the SAR images, the differences are taken between the phase of the radar return signal and the phase of the return signal in the corresponding picture elements of the other two images. This yields two interferograms (phase maps) in which information on changes in elevation is scrambled with other topographical information.

After some further processing, the differences between the phase differences expressed in corresponding picture elements of the two interferograms are computed to produce a third, "double-difference" interferogram. The double-differencing oper-

Three Passes of synthetic aperture radar yield three amplitude-and-phase images, from which two interferograms (phase-difference images) are made. The two interferograms are used to make a third, "double-difference" interferogram that indicates vertical motion of the terrain between passes.



ation removes the components of phase due to the underlying topography, leaving nonzero phases only in areas where the surface of the Earth has moved between the times of the observations. These phases can be used to deduce the amount of motion that has occurred. (The phase images also include noiselike local components due to such activities as excavation and building between observation times, but where the phase of many adjacent picture elements include a component common to all, that component indicates a shift in the terrain.)

The technique was tested in the Imperial Valley of California — an agricultural area where the surface is frequently disturbed by plowing, resulting in noiselike phase characteristics. The double-difference interferogram showed that between

observations, phases changed in a coherent manner across entire fields. The changes are attributed to swelling of the ground when it is irrigated and shrinking when the water evaporates. The changes were found to be consistent with those expected on the basis of irrigation records for 48 out of 52 sites in the SAR images.

This work was done by Andrew K. Gabriel, Richard M. Goldstein, and Howard A. Zebker of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 116 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 16]. Refer to NPO-17831.

Robust, High-Performance Control for Robotic Manipulators

Model-based and performance-based control techniques are combined.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved control scheme for robotic manipulators results from an alternative approach to the use of both model-based and performance-based control techniques. This is a robust, high-performance adaptive control scheme that combines the advantages and overcomes the disadvantages of both types of techniques.

Model-based control techniques like the Computed-Torque method are based on the cancellation, by the controller, of nonlinear terms in the mathematical model of the dynamics of the manipulator. Such techniques require that the model be ac-

curate, that all the parameters of the model be known accurately, and that the model be computed in real time at the servo control sampling rate. These requirements are often not met in practice. Performance-based (adaptive) techniques like the direct-adaptive-control method attempt to overcome the failure to satisfy these requirements by adjustment of the controller gains in real time on the basis of the tracking performance of the manipulator. This eliminates the need for the model and for the computation of its parameters. Thus, a fast adaptation can be achieved. However,

adaptive controllers do not take advantage of any known part of the dynamics. Furthermore, rates of adaptation that are set high enough for rapid response to variations in the manipulator dynamics or payload can cause instabilities through the excitation of unmodeled dynamics.

The new control system includes a feedforward controller and a separate feedback controller. The feedforward controller is model-based and contains any known part of the dynamics of the manipulator that can be used to produce a nominal control signal. The feedback controller is perform-



**The final
step is
clean room
packaging.**

**ACLAR® Packaging for all
the ins and outs of clean rooms.**

Makers of advanced electronics, aerospace and medical technology demand that components arrive as clean as they left your clean room. Good reason to pack in ACLAR® fluoro-polymer film.

ACLAR® can be cleaned, is physically and chemically stable and biochemically inert. It meets NASA's requirements for compatibility with LOX and other hypergols, plus their low outgassing requirements for deep space use. ACLAR® won't support combustion and can be made static dissipative for sensitive electronic and satellite applications.

Take the final step in protection, pack in ACLAR® film. For more information, and our latest literature, contact Allied-Signal Engineered Plastics, P.O. Box 2332R, Morristown, NJ 07960. Phone (201) 455-5010 or FAX (201) 455-3507.

ACLAR®. A confidence level above the rest.

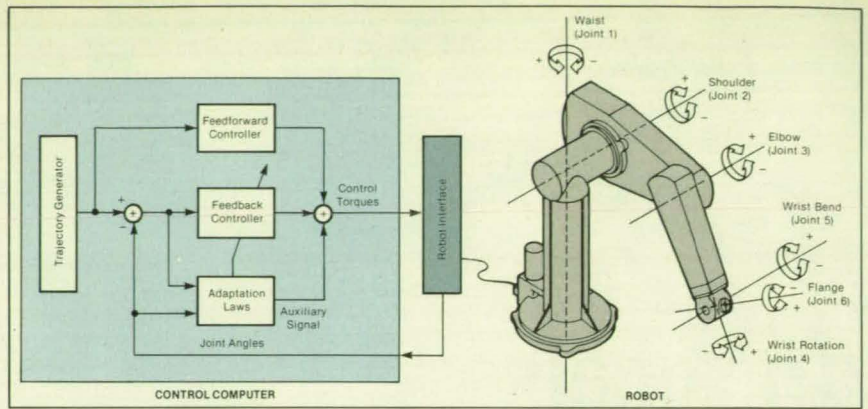
Engineered Plastics

Circle Reader Action No. 606

 **Allied
Signal**

ance-based; it compensates for any unknown dynamics and uncertainties or variations in the parameters of the manipulator and/or the payload. The feedback controller is a simple adaptive proportional/integral/derivative controller that generates an adaptive control signal to complement the nominal feedforward signal. The feedback laws are simple, enabling fast implementation of the servo control loop. To counteract potential instabilities and assure robustness in the presence of unmodeled dynamics and disturbances, decay terms are included in the integral adaptation laws.

A version of the new control scheme was tested by using it in the control computer of a commercial robot (see figure). The robot was found to track the commanded trajectory closely, even when the mathematical model of the dynamics was not used and the feedforward controller was eliminated. The results also showed that the control scheme is not sensitive to the configuration of the robot arm, torque



An **Experimental Control System** tracked the commanded trajectory closely, demonstrating the soundness of the new approach to the combination of model-based and performance-based control.

disturbances, or the desired trajectory.

This work was done by Homayoun Seraji of Caltech for **NASA's Jet Propulsion Laboratory**. For further information, Circle 120 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 16]. Refer to NPO-17785.

Active Limiters for Photodetectors

Intense radiation would trigger protective electro-optical shutters. NASA's Jet Propulsion Laboratory, Pasadena, California

Active or "smart" electro-optical shutters have been proposed for the protection of photodetectors, imaging devices, and other sensitive optical or optoelectronic elements. Such a shutter would respond rapidly and automatically to an increase in illumination above a prescribed level.

To illustrate the principle of operation, Figure 1 shows one version of a shutter that would protect a sensor against intense laser light. A beam splitter would divert a small portion of the incoming laser beam to a crude spectrometer consisting of a grating and a linear array of relatively insensitive photodetectors that are rugged enough to withstand the maximum irradiance likely to be encountered in the laser beam. The major part of the incoming laser beam would pass through the beam splitter and an electro-optical switch on the way to the protected sensor.

Processing electronics would monitor the output of the spectrometer along with control input signals. If the total irradiance or the spectral radiance at the wavelength of interest, as measured by the spectrometer, were to rise above the threshold prescribed as the maximum safe level for the protected sensor, the processing electronics would activate an amplifier, which would apply a high voltage (typically of the order of 1 kV) to the electro-optical switch to turn it opaque.

The spectrometer (as opposed to a simple photodetector) would be needed because the voltage V_{π} required to turn an

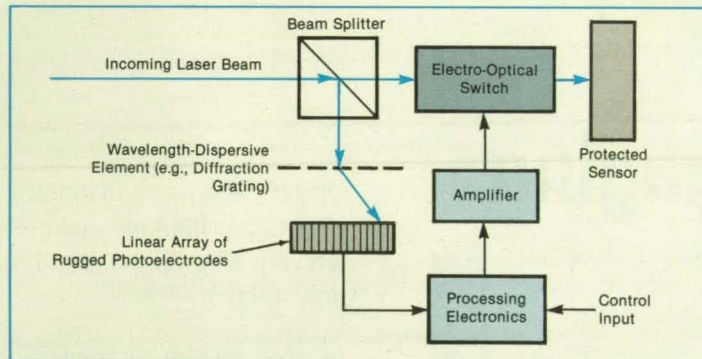


Figure 1. This "Smart" Limiter would be an active electro-optical shutter that would protect a sensor against an excessively bright laser beam. Because the shutter would include a spectrometer, it would not be necessary to know the wavelength of the laser light in advance.

electro-optical switch opaque depends on the wavelength, λ :

$$V_{\pi} = \lambda/2n^3r$$

where n represents the index of refraction in the electro-optical crystal in the switch and r represents the electro-optical coefficient of this crystal. The processing electronics and the amplifier would generate V_{π} according to this equation, using λ as meas-

ured by the spectrometer.

A more complicated shutter (see Figure 2) could be built to protect selected portions of an imaging sensor. This shutter would include another beam splitter to divert a small portion of the incoming light to a two-dimensional array of rugged photodetectors. In this system, the electro-optical switch would include a two-di-

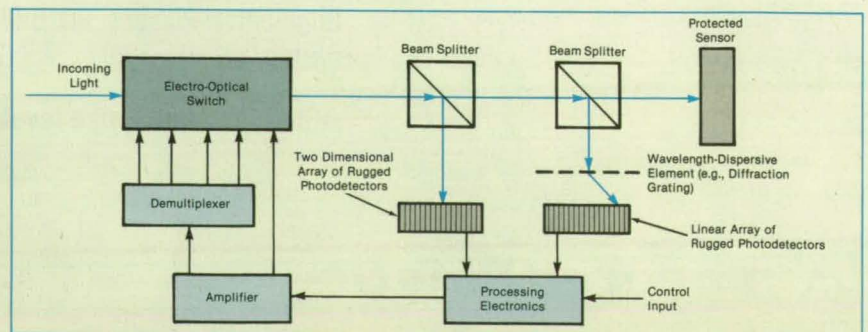


Figure 2. **Spatial Discrimination** would be added to spectral discrimination in this "smart" limiter. Selected portions of the cross-section incoming beam of light could be blocked to prevent damage to the corresponding portions of the protected sensor.

SOLID STATE RELAY

Our FB Series military solid-state relay features high speed and low off-state leakage.

#3
IN A SERIES



ACTUAL SIZE

Here's what you get:

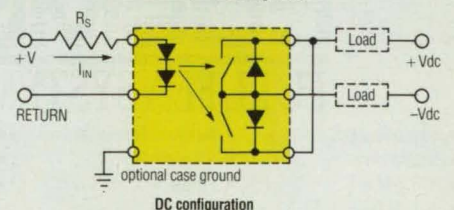
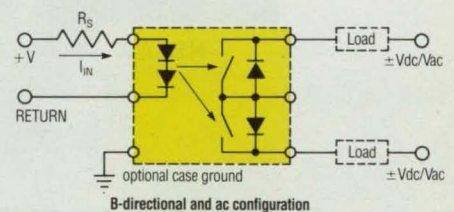
- Availability to pending DESC drawing 89116 with screening to "W" and "Y" levels of MIL-R-28750.
- High-voltage output
- Very-low leakage current (200 nA)
- DC or bi-directional power FET output (see wiring diagrams)
- Ideal for ATE applications
- Optical isolation
- Fast switching speed
- Adjustable turn-on times
- Low profile 6-pin mini-DIP
- Cost efficiency

Review the electrical characteristics below and call us for immediate application assistance.*

INPUT ELECTRICAL CHARACTERISTICS (-55° to +105° unless otherwise noted)			
	Min	Max	Units
Continuous Input Current (I_{IN})	10	50	mA_{DC}
Input Current (Guaranteed On)	10		mA_{DC}
Input Current (Guaranteed Off)		100	μA_{DC}
Input Voltage Drop at (I_{IN}) = 25mA		3.25	V_{DC}

OUTPUT ELECTRICAL CHARACTERISTICS (-55° to +105° unless otherwise noted)				
Part Number	FB00CD	FB00FC	FB00KB	Units
Bidirectional Load Current (I_{LOAD})	± 1.0	± 0.50	± 0.25	$\text{A}_{DC}/\text{A}_{PK}$
DC Load Current (I_{LOAD})	2.0	1.0	0.5	A_{DC}
Bidirectional Load Voltage (V_{LOAD})	± 80	± 180	± 350	V_{DC}/V_{PK}
DC Load Voltage (V_{LOAD})	80	180	350	V_{DC}
ON-Resistance (R_{ON}) at (I_{LOAD}) max.	0.72	1.8	12.9	Ohms
Turn-On Time (T_{ON})	800	800	500	μs
Turn-Off Time (T_{OFF})	300	600	500	μs

Notes: 1. A series resistor is required to limit continuous input current to 50mA (peak current can be higher).
 2. Rated input current is 25mA for all tests.
 3. Loads may be connected to any output terminal.
 4. ON resistance shown is for the bidirectional configuration. The DC ON resistance is 1/4 of these values.



"CREATING THE STANDARD OF THE FUTURE"

TELEDYNE SOLID STATE
A Division of Teledyne Relays

*For immediate application assistance call 1-800-284-7007.

Teledyne Solid State, 12525 Daphne Avenue, Hawthorne, California 90250.

mensional array of pairs of switching electrodes corresponding to the array of rugged photodetectors. If the light falling on such a detector were to rise above the threshold, V_{π} would be applied to the corresponding pair of electrodes to prevent the light from reaching the corresponding portion of the protected sensor.

To provide effective protection, the active limiter would have to respond before the irradiance reached a harmful level. Using currently available equipment, it is now possible to attain response times of the order of nanoseconds. If even this short a response time is still too long, a delay line — perhaps a bundle of optical fi-

bers — could be inserted between the protected sensor and the last stage of the limiter.

This work was done by Joseph Katz and Li-Jen Cheng of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 94 on the TSP Request Card. NPO-17654

Real-Time Digital Compression of Television Image Data

Broadcast-quality images can be transmitted at low data rates.

Lewis Research Center, Cleveland, Ohio

A digital encoding/decoding system compresses color television image data in real time for transmission at lower data

rates and, consequently, lower bandwidths. The reconstructed images are of broadcast quality — indistinguishable from those pro-

duced by the video source signal. A prototype of the system has been built from transistor/transistor logic digital devices, first-in/first-out memories, programmable read-only memories, and random-access memories.

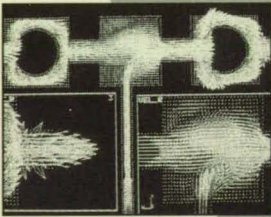
The system implements a predictive coding process, in which each picture element (pixel) is predicted from the values of prior neighboring pixels, and the coded transmission expresses the difference between the actual and predicted current values. The system combines a differential pulse-code modulation process with a nonlinear, nonadaptive predictor, a nonuniform quantizer, and a multilevel Huffman encoder. (Huffman coding assigns shorter code words to the quantized levels that have greater probability of occurrence: the result is an overall reduction in the required rate of transmission.)

Digital encoding and decoding of video images has historically involved engineering compromises among the quality of the reconstructed images, data-compression performance, and complexity of equipment. The new system achieves better performance (better quality of image at comparable rates of transmission) than do prior transform or interframe coding systems, yet the equipment is less complicated.

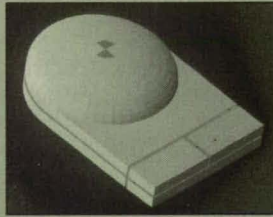
The incorporation of the nonadaptive predictor and the multileveled Huffman coder sets this system apart from older predictive systems. The nonadaptive predictor improves the reconstructed image by providing more rapid convergence at transition points in the image, thereby improving edge-detection performance. The use of the multilevel (as distinguished from single-level) Huffman codes further reduces the number of bits per pixel by enabling nearly all pixels to be represented by short code words. A separate Huffman code set is generated for each quantization level on the basis of previously determined statistical properties of "typical" pictures. These statistics indicate a trend for neighboring pixels to fall into the same or nearly the same quantization levels. The multilevel Huffman code takes advantage of this trend to obtain additional compression of data.

The multilevel Huffman coding scheme improves digital encoding/decoding system

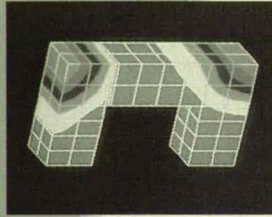
Mainframe performance at a lower price on your PC, Mac II or workstation.



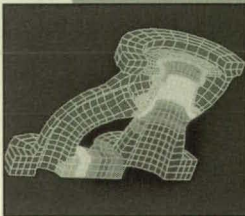
FLOWSTAR
Fluid Flow Analysis



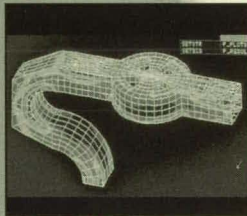
Shaded Plot



ESTAR
Electromagnetic Analysis



HSTAR*
Temperature Distribution in
Cryogenic Turboexpander Housing



GEOSTAR
Pre- and Postprocessing

COSMOS/M FULL FEA SYSTEMS FROM \$995.

- Statics/Dynamics
- Substructuring
- Heat Transfer
- 3D Fluid Flow
- Turbulent Flow
- Composites/Sandwich
- CAD Interfaces
- Electromagnetics
- Design Optimization
- Crash Dynamics
- 15,000 Nodes 60,000 D.O.F.
- Automatic Adaptive Meshing
- H/P Method
- Fatigue
- Kinematics
- Ansys™, Nastran™, Patran™ Translators
- Thermal Plasticity
- Creep/Viscoelasticity
- Hyperelasticity
- Large Strain
- General 3D Contact
- Nonconservative Loading
- Large Deformations
- Kinematic Hardening
- Automatic Stepping
- Gaps/Friction
- Nonlinear Buckling

MAINFRAME NONLINEAR CAPABILITIES

FREE OFFER:
213-452-2158

For a limited time, SRAC will send you a FREE 100 node working version of COSMOS/M which will enable you to run your own statics, dynamics and heat transfer problems. Introductory user guide plus shipping and handling fee \$30.00.

ANSYS is the registered trademark of Swanson Analysis Systems Incorporated. NASTRAN is the registered trademark of NASA. Patran is the registered trademark of PDA Engineering. *Courtesy of ACD, Inc.

Structural Research
AND ANALYSIS CORPORATION

1661 Lincoln Blvd./Ste. 200/Santa Monica, CA 90404 USA
TEL: (213) 452-2158/TX: 705578/FAX: (213) 399-6421

performance by an average of 2 bits per pixel over that of standard differential pulse-code modulation, and by 0.5 bits per pixel over standard differential pulse-code modulation with a single-level Huffman code. Overall, the new system processes standard broadcast color television signals in real

time at the average rate of 1.8 bits per pixel, as compared with 3 to 4 bits per pixel in older predictive systems.

This work was done by Scott P. Barnes, Mary Jo Shalkhauser, and Wayne A. Whyte, Jr., of **Lewis Research Center**. For further information, Circle 54 on the TSP Request

Card.

This is the invention of a NASA employee, and a patent application has been filed. Inquiries concerning license for its commercial development may be addressed to the inventor, Wayne A. Whyte, LEW-14945

Checking Automated-Welder Programs by Computer

A personal-computer-based system, distinct from the welding-control computer, finds software errors.

Marshall Space Flight Center, Alabama

A computer system detects and displays actual and potential errors in programs for a computer-controlled electron-beam welder. Such programs occasionally contain errors that are not detected by the control computer itself. The programs are usually complex and long and must be checked for programming errors by at least two people. The programs must be further validated in full-power tests in the welding vacuum chamber — a procedure that takes 2 to 3 hours, including setup time. Even with all this checking and with built-in safeguards, it is still possible for a program error to go undetected and cause damage to the parts being welded.

The new checking system uses a personal computer, which is separate from the welding computer. The system is pro-

grammed specifically to highlight errors in a welding program. It eliminates the need for the preweld full-power test run and thus reduces checkout time to about half an hour. At the same time, the system assures much higher quality, damage-free welding.

In addition to the personal computer with dual disk drives, the system includes a color monitor, a multipen plotter, a paper-tape reader and punch, and a dot-matrix printer. The personal computer analyzes a welding program for proper syntax. Possible syntax errors are displayed and printed out for the programmer's review. The computer also produces an event-time analysis to ensure that welding operations have the proper durations. It draws a multicolor graph on the plotter, showing welding parameters for each step in the welding se-

quence. Any step can be isolated and plotted on an expanded scale for close scrutiny. With these plots, the programmer can spot such nonsyntax errors as improper welding speeds or beam currents.

The final corrected program is punched on tape for use by the welding machine. It is also stored on a disk for future recall and modification. The parameter plot and a printout of the event-time analysis are stored with the disk for future reference.

The personal computer system can also be used to create and edit new programs for the welder. The control computer is thereby freed for production.

The system may also be useful for checking programs for such other computer-controlled equipment as inertia welders, robots, machine tools, and heat

"NASA Tech Briefs generates high-caliber ad leads."

"As a manufacturer of automatic test equipment, Artisan has a wide and varied customer base. Limiting our advertising to test and instrumentation magazines proved too narrow an exposure and left a vast group of potential customers untapped. Through NASA Tech Briefs we were able to reach many qualified users of our products who were not available through other publications. We'll continue to use this proven method for creating new sales."



Michael Ryba
President/CEO,
Artisan Development
Corp.

Put The Power Of NASA Tech Briefs To Work For You.

Call (212) 490-3999 today for a complete marketing kit, or clip your business card to this ad and mail to:

NASA Tech Briefs

41 East 42nd St.,
Suite 921, New York, NY 10017

What is Desktop Super Computing all About?

- 25 to 450 MFLOPs and Beyond
- 1.6 G bytes/sec system bandwidth
 - Up to 144 Mbytes memory
 - Macintosh® & IBM® hosts (SUN® 4Q '90)
- Complete software development environment

It's About Time.



**DOLPHIN
SCIENTIFIC**

2698 Junipero Ave, Suite 104 Long Beach, CA 90806-2124
voice (213)988-8930 fax (213)988-8935

©1990 Dolphin Scientific, Inc. All Rights Reserved.
All other trademarks mentioned are held by their respective companies.

NUPRO Valves and Filters for Analytical Applications

NUPRO Valves and Filters offer these design and performance choices:

- **End Connections:** SWAGELOK® Tube Fittings, NPT, Tube Stub, Weld, CAJON VCO® & VCR®
- **Service Ratings:** vacuum to 6000 psi; temperatures to 900°F

STOCKED FOR IMMEDIATE DELIVERY
BY AUTHORIZED SALES AND SERVICE
REPRESENTATIVES.



METERING

Valves for precise flow control in laboratory and instrument systems

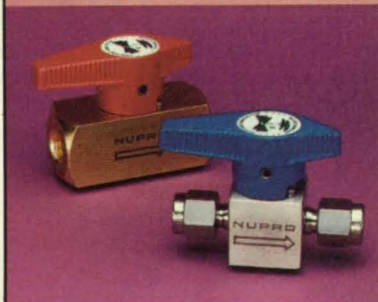
- accurate, repeatable flow adjustment with no initial surge
- compact, low dead space
- stem threads removed from system



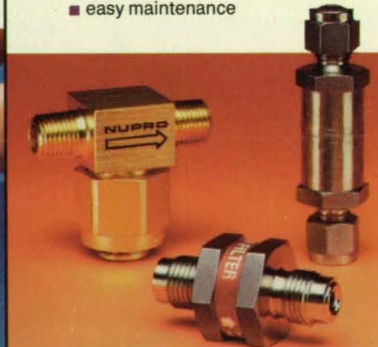
SHUT OFF

Compact valves for reliable flow regulation and shut off

- stem threads removed from system fluid
- compact designs
- ball tip or regulating stems



- quick-acting, 1/4 turn
- full flow
- easy maintenance



FILTRATION

Inline and tee type filters to protect instruments by removing hard particle contamination from fluid lines

- choice of sintered and wire mesh elements from 0.5 to 440 microns
- compact designs
- all metal construction

SWAGELOK — TM Crawford Fitting Company
CAJON, VCO & VCR — TM Cajon Company
© 1986 SWAGELOK Co., all rights reserved N-56fa

CHECK & RELIEF

Relief valves open at pre-set pressure; check valves allow unidirectional flow control

- cracking pressures 1/3 to 6000 psi
- smooth floating poppet
- positive back stop



treaters. The system could also be extended to display, on the color monitor, a plot of process parameters as they actually occur, superimposed on a display of the programmed parameters. Deviations in the process would thus be immediately evident.

This work was done by L. O. Damicone of Rockwell International Corp. for Marshall Space Flight Center. For further information, Circle 160 on the TSP Request Card. MFS-29006

Books and Reports

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

Laser Velocimetry in Low-Speed Wind Tunnels

Airflow velocity is measured with minimal perturbation.

The design and the performance of a three-dimensional and of a two-dimensional backscatter laser velocimeter, both used in low-speed (less than 100 m/s) wind tunnels, are described in a report together with a historical overview of the development of laser velocimetry (LV). LV provides measurements of airflow in wind-tunnel tests without the perturbing effects of probes and probe-supporting structures. LV may also be applicable in such related fields as ventilation engineering and possibly in the detection of wing vortices from large aircraft at airports.

The three-dimensional laser velocimeter has been optimized for use in a wind tunnel having test-section dimensions of 7 by 10 ft (2 by 3 m). It measures all three velocity components by means of three independent dual-backscatter channels at argon-ion laser wavelengths of 514.5, 488.0, and 476.5 nm.

The test point is positioned by movement of the entire instrument package on a digitally controlled platform and by the variable focusing of zoom optics. A high-speed minicomputer controls the stepping motors that move the package, the data transfer among the devices of the system, and the reduction of experimental data. To facilitate decisions for the operation of the system, a graphics display plots the reduced data as a function of position as the velocimeter scans over a range of test points. The system also displays histograms and sample statistics for immediate feedback to the experimenter.

The long-range laser velocimeter has a measurement range of 2.6 to 20 m and uses an 18 W argon-ion laser. It will be installed in a wind tunnel having test-section dimensions of 40 by 80 ft (12.2 by 24.4 m).

The optical system is mounted in a streamlined optical package in the wind-tunnel test section. The test-point position is varied by the lateral motion of the instrument along rails on the tunnel floor, by mechanical rotation of the instrument, and by the variable focusing of zoom optics within the optical system.

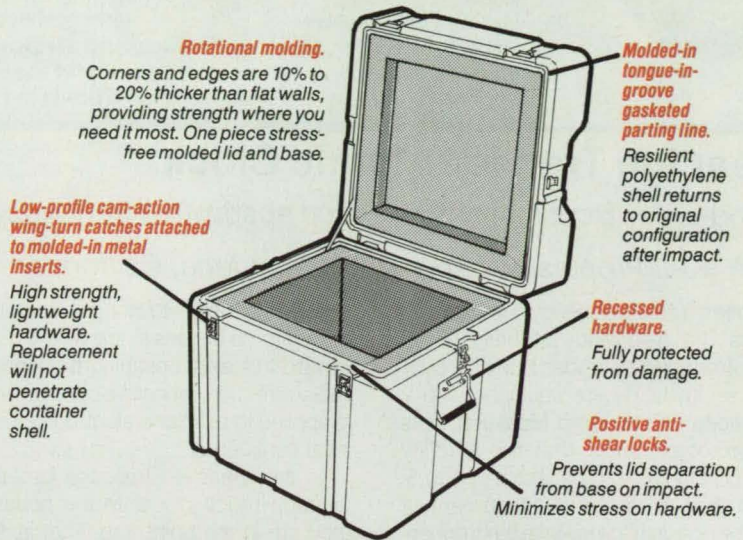
The instrument includes an onboard microprocessor controller and digital motor-control hardware. This unit is connected to the control electronics in the wind-tunnel control room. The velocimeter can be positioned by automatic or manual control. In either mode, the control circuitry displays the test-point position in wind-tunnel coordinates and the measured velocity.

This work was done by Kenneth L. Orloff, Philip K. Snyder, and Michael S. Reinath of Ames Research Center. Further information may be found in NASA TM-85885 [N84-16526], "Laser Velocimetry in the Low-Speed Wind Tunnels at Ames Research Center."

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.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 16]. Refer to ARC-11564.

FOR A TOUGH CASE GET HARDIGG



Rotational molding.
Corners and edges are 10% to 20% thicker than flat walls, providing strength where you need it most. One piece stress-free molded lid and base.

Low-profile cam-action wing-turn catches attached to molded-in metal inserts.

High strength, lightweight hardware. Replacement will not penetrate container shell.

Molded-in tongue-in-groove gasketed parting line.

Resilient polyethylene shell returns to original configuration after impact.

Recessed hardware.

Fully protected from damage.

Positive anti-shear locks.

Prevents lid separation from base on impact. Minimizes stress on hardware.

Lightweight, MIL-SPEC off-the-shelf protection against shock, vibration, moisture, temperature extremes.



HARDIGG INDUSTRIES, INC.

HARDIGG CONTAINERS

393 No. Main Street, P.O. Box 201, South Deerfield, MA 01373 (413) 665-2163 FAX: (413) 665-8061

Circle Reader Action No. 492

Special Offer

Celebrate America's return to space with this high-quality sweatshirt from NASA Tech Briefs. Striking four-color design of shuttle Atlantis on white cotton blend shirt.

Available in adult sizes: S, M, L, or XL. \$16.95 each + \$3.50 postage and handling. (NY residents add sales tax.)

Special Bonus: Order now and receive a Free Full-Color NASA Space Poster!

Rush me _____ Atlantis sweatshirt(s) in the following size(s): (please circle) S M L XL

Total Enclosed: \$ _____

Name _____

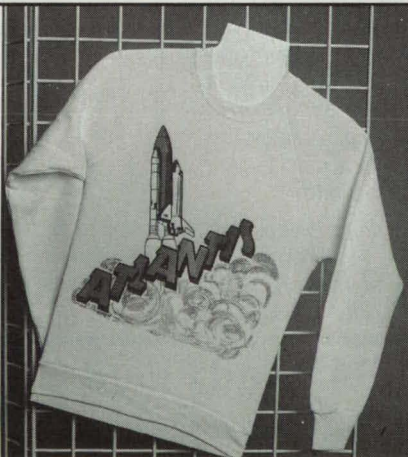
Company _____

Address _____

City _____ State _____ Zip _____

Mail to: NASA Tech Briefs, Dept. F,
41 East 42 St., New York, NY 10017

Remember: Order now and you will receive a free NASA poster with your order!



What is Desktop Signal Processing all About?

- 25 to 450 MFLOPs and Beyond
- 1.6 G bytes/sec system bandwidth
 - 8, 12 & 16 bit Analog I/O
- 32 bit Digital I/O up to 100 Mbytes/sec
 - Macintosh® & IBM® hosts (SUN® 4Q '90)
- Extensive Signal Processing Library

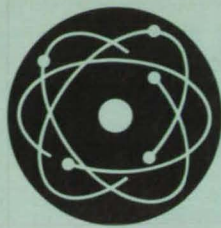
It's About Time.



DOLPHIN SCIENTIFIC

2698 Junipero Ave, Suite 104 Long Beach, CA 90806-2124
voice (213)988-8930 fax (213)988-8935

©1990 Dolphin Scientific, Inc. All Rights Reserved.
All other trademarks mentioned are held by their respective companies.



Physical Sciences

Hardware, Techniques, and Processes

- 44 Linear Ion Trap for Atomic Clock
- 44 Making Topographical Maps From SAR and Flood-Gauge Data

- 45 Concentrating Gaseous Contaminants for Monitoring
- 46 High-Pressure Promoted-Combustion Chamber
- 46 Catalytic Destruction of Toxic Organic Compounds
- 47 Computing Deformations of Rubbery Materials
- Books and Reports**
- 61 Behavior of Evaporating Liquid Drops in Clusters

- 61 Directional Solidification of Monotectic Alloys
- Computer Programs**
- 66 Calculating Performances of Fabry-Perot Etalons
- 67 Computing Impingements of Rocket Exhausts
- 68 Simplified Calculation of Solar Fluxes in Solar Receivers

Linear Ion Trap for Atomic Clock

Second-order Doppler shift of the ion absorption frequency is reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

A linear, radio-frequency ion trap increases the frequency stability of an atomic frequency standard device over that of a similar device equipped with a conventional point ion trap. Measurements on a prototype show that the stability should be increased by a factor of 4 to 5. With proper design and adjustment, it should be possible to increase the frequency stability to 10 times that of a device with a point trap.

The figure illustrates schematically the point and linear ion traps. All ion traps confine ions around the nodes or zero points of a radio-frequency electric field. Electrostatic repulsion between ions tends to keep them away from each other and away from the node of the trap. Away from the node, an ion is driven into motion by the radio frequency field and, consequently, the Doppler shift in its absorption frequency grows with its distance from the node. In a conventional single-node trap, the spread of ions around the node and the consequent motion results in a second-order Doppler shift about 10 times the minimum possible shift (which is the shift due to thermal motion at room temperature).

In contrast with the older point ion trap, which produces a single node, the linear ion trap produces a line of nodes of the

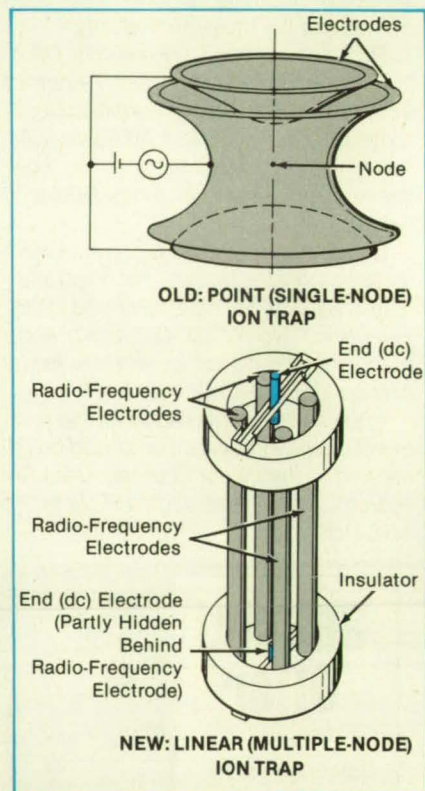
radio-frequency field along its axis. The resulting force on ions in this field is directed toward this axis, confining the ions in the radial direction. A positive constant voltage is applied to axial end electrodes to obtain axial confinement.

In the linear ion trap, the ions are on average much closer to the nodes than they are in the point trap. That is, for the same number of ions placed in the point and linear traps, the linear trap holds ions closer to the zero-field node line. Thus, the radio-frequency motion and the resultant Doppler shift are smaller in the linear trap. The improvement can be expressed quantitatively by

$$\frac{\text{frequency offset in linear trap}}{\text{frequency offset in point trap}} = \frac{\text{radius (R) of ion cloud in point trap}}{\text{length (L) of ion cloud in linear trap}}$$

Alternately, a linear trap can store (L/R) times the ion number as a conventional point trap with no increase in average second-order Doppler shift. This ratio is about 20 for the prototype linear trap. This increases the signal-to-noise ratio in the measured atomic resonance used to generate the stable output frequency.

This work was done by John D. Prestage of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 137 on the TSP Request Card. NPO-17758



The **Linear Ion Trap** confines ions with less radio-frequency motion than does the point ion trap.

Making Topographical Maps From SAR and Flood-Gauge Data

Data are processed and merged to obtain a variety of useful images.

Goddard Space Flight Center, Greenbelt, Maryland

A collection of computer programs processes image data obtained by synthetic-aperture radar (SAR) along with measurements of water levels taken at selected points on the ground to generate three-dimensional maps of the surveyed terrain. The information in the maps can be presented in a variety of useful ways particularly suited to the study of such phenomena as flooding, damage caused by floods, the flow of nutrients from forests to river and marine ecosystems, and the effects of subsidence of the ground or of rising sea levels.

Typically, the SAR input data are ac-

quired aboard an airplane, or spacecraft, equipped with radar that operates with wavelength angles of incidence and polarizations that enable penetration of forest canopies. The SAR images are obtained in flights over the surveyed region repeated at intervals of hours, days, months, or even years, the intervals depending on the temporal frequency of the phenomena being studied. Simultaneously with each SAR scan, data on the surface level of water are acquired by tide or flood gauges at selected points on the ground in the surveyed region.

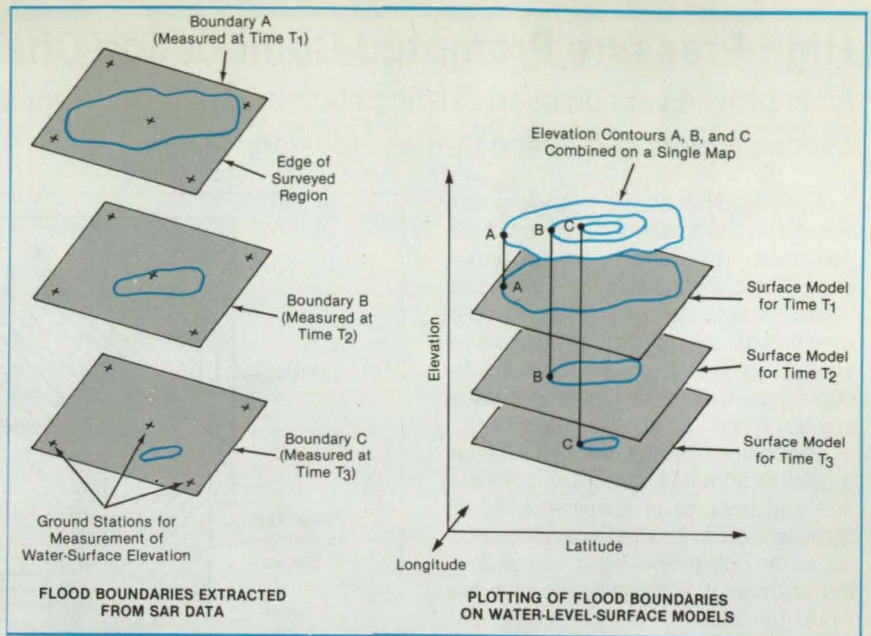
The SAR data are processed by a varie-

ty of statistical and filtering algorithms to generate image boundaries based on relative brightness. Brightness on the image is indexed to a flooded or nonflooded condition based on field observations or heuristics. If quad-polarized SAR data are available, boundaries of flooded areas are distinguished as lines of demarcation between adjacent areas in which polarization signatures are significantly different; e.g., signatures that indicate single vs. those that indicate double reflections. A bit-masking or boundary-tracing algorithm extracts the flood-boundary data from each SAR image.

The water levels measured on the ground during each SAR pass are entered into mathematical models (in effect, maps) of the water-surface elevation. The flood boundaries from the corresponding SAR imagery are geographically registered with the water-level models (see figure), yielding data on elevations along the flood boundaries. The resulting new data on elevations are compiled into a single composite map. An interpolation algorithm operates on the composite elevation data to generate a digital three-dimensional model of the elevation of the terrain. This information in this model can be presented in such forms as conventional topographical contour maps, perspective views, elevation-class maps, and inundation-frequency maps.

This work was done by Marc Lee Imhoff of Goddard Space Flight Center. For further information, Circle 17 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 16]. Refer to GSC-13212.



Flood Boundaries Extracted From SAR Data are combined with mathematical models of water-surface elevations extracted from water-level measurements taken on the ground. In effect, each boundary plotted on its corresponding surface is a raw surface-level contour similar to the contours on a conventional topographical map. The data compiled from all such plots are used to generate topographical contour or other three-dimensional maps of the surveyed region.

Concentrating Gaseous Contaminants for Monitoring

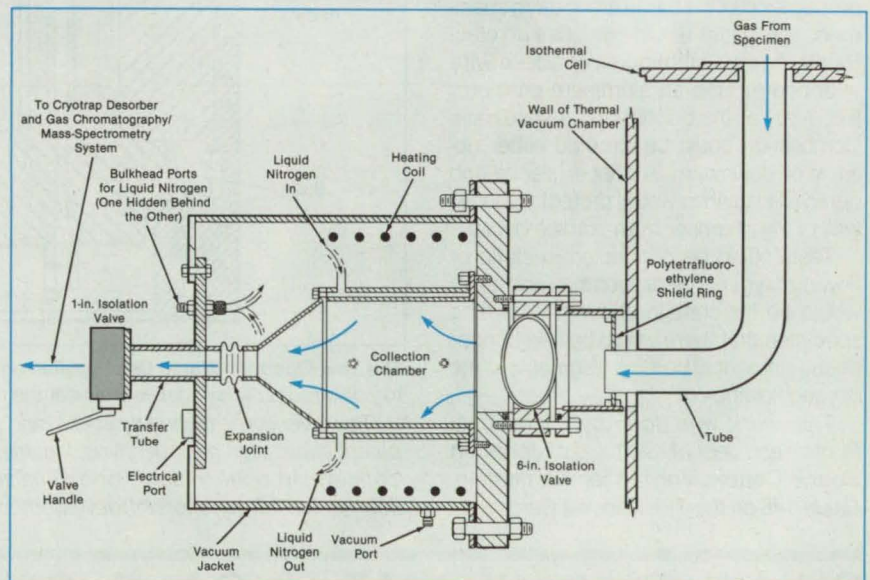
Amounts of outgassed substances can be analyzed as functions of time and temperature.

Lyndon B. Johnson Space Center, Houston, Texas

An apparatus concentrates contaminants outgassing from specimens in a vacuum and passes the concentrated contaminants to a gas-chromatography/mass-spectrometry system for analysis. The apparatus thus enables measurements of the fluxes of various contaminants as functions of time and/or temperature. The apparatus makes it possible to determine whether candidate materials for use in vacuum environments — for example, those in equipment used to manufacture semiconductors — will generate harmful substances.

The apparatus (see figure) uses thermal adsorption and desorption to collect and concentrate the outgassed substances. The specimen to be evaluated is placed in an isothermal cell in a thermal vacuum chamber where it is maintained at a preselected constant temperature. A tube carries outgassed substances from the specimen to a collection chamber. The hollow wall of the collection chamber is cooled by liquid nitrogen so that it will adsorb the outgassed products on its surface.

After a preset interval, the inlet isolation valve is closed, sealing the collection chamber from the specimen. The wall of the collection chamber is then heated to drive the adsorbed substances from its surface. The outlet isolation valve is opened to let the substances flow to a gas



The **Cold Wall of the Collection Chamber** adsorbs gases from a specimen in an isothermal cell. When the wall is subsequently heated, the plate desorbs the gases so that they can be analyzed. The collection chamber is maintained at a low pressure throughout the adsorption and desorption process.

chromatograph and mass spectrometer for analysis.

The measurements are repeated at various temperatures of the specimen and various collection times. The data thus provide time and temperature plots of out-

gassed species and concentrations.

This work was done by William C. Mahone of Lockheed Engineering & Management Services Co., Inc., for Johnson Space Center. No further documentation is available. MSC-21424

High-Pressure Promoted-Combustion Chamber

An improved version of an existing chamber would burn specimens in oxygen.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed combustion-testing chamber would burn specimens of materials in a fully contained, high-pressure oxygen atmosphere. The chamber would be an improved version of one now used for evaluation of materials for use in such high-pressure oxygen equipment as regulators, valves, turbopumps, medical equipment, and deep-sea-diving apparatus, for example.

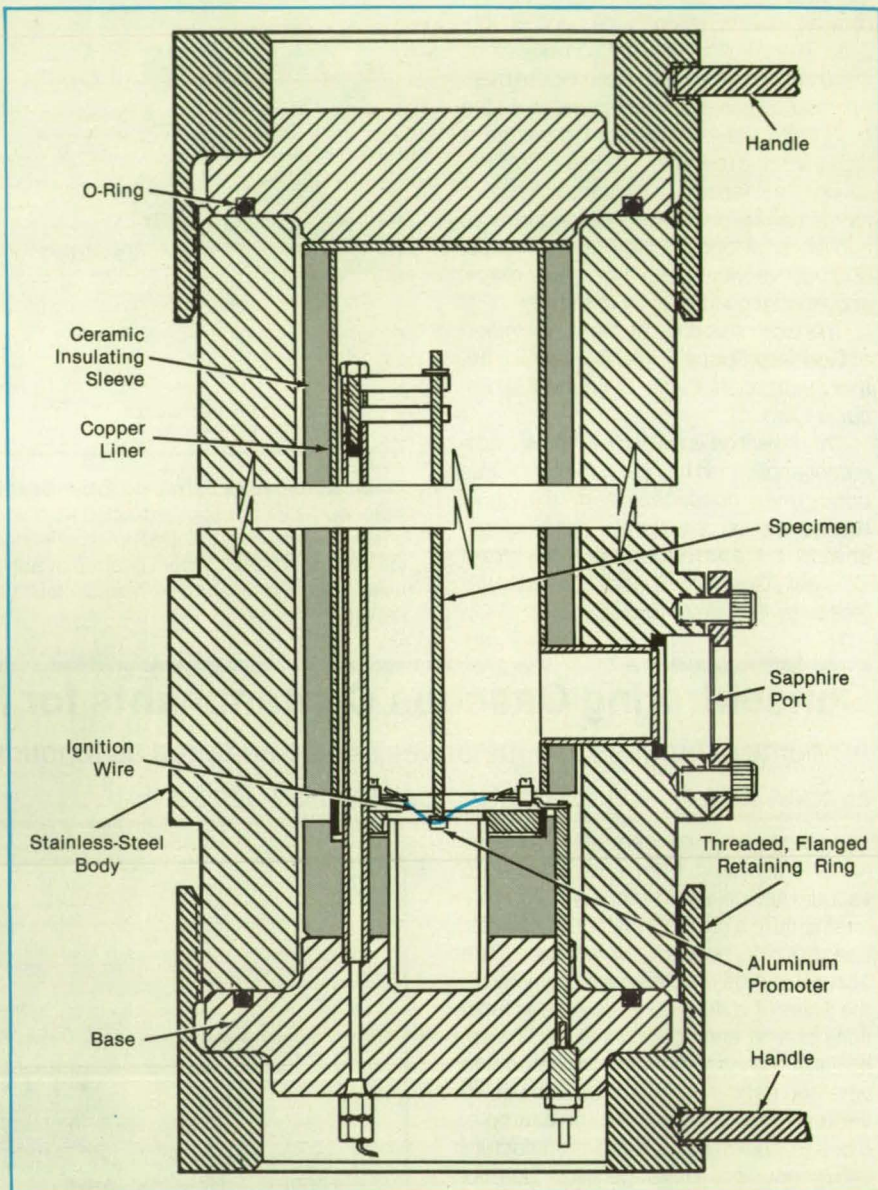
The chamber (see figure) would feature a quick-closure seal to facilitate the insertion and removal of specimens. Specimens would be mounted in a holder introduced through an opening at the bottom of the chamber. Each end of the chamber would be sealed by a plate, O-ring, and threaded retaining ring.

The holder would keep the specimens precisely vertical and position them repeatedly in the same place. The chamber would be able to withstand internal pressures up to 10,000 lb/in.² (69 MPa). The relatively large internal volume of 760 in.³ (12.5 L) would provide ample oxygen for combustion.

The stainless-steel body of the chamber would contain four sapphire ports so that tests can be observed with a two-color optical pyrometer, video camera, and x-ray camera. Thermopiles would monitor the propagation of the flame along each specimen. The igniter would comprise an electrically-heated aluminum/palladium wire wrapped around an aluminum promoter (i.e., fuze) at the bottom of the specimen. Combustion could be directed either upward or downward. A copper sleeve and ceramic insulation would protect the inner wall of the chamber from burning debris.

Tests could be conducted in static or flowing oxygen. The oxygen inlet and outlet would be far enough above the burning specimen that there would be little danger of entrainment of burning fragments in the oxygen flowing out.

This work was done by Michelle A. Rucker and Joel M. Stoltzfus of Johnson Space Center. For further information, Circle 145 on the TSP Request Card.



The Test Operator Would Use Handles on threaded retaining rings to attach or remove the top or bottom plates that would seal the combustion chamber.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development

should be addressed to the Patent Counsel, Johnson Space Center [see page 16]. Refer to MSC-21470.

Catalytic Destruction of Toxic Organic Compounds

A conceptual fuel-efficient system promises nearly complete oxidation to harmless substances.

NASA's Jet Propulsion Laboratory, Pasadena, California

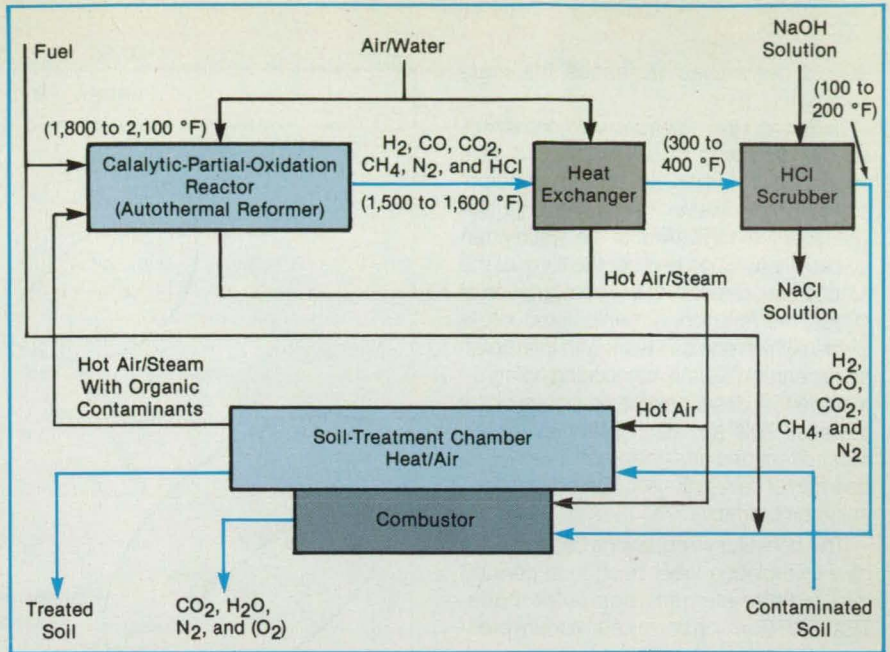
A proposed process would dispose of toxic organic compounds in contaminated soil or carbon beds safely and efficiently. The process would oxidize the toxic materials without producing such other

contaminants as nitrogen oxides (NO_x). Using air, fuel, catalysts, and steam, the system would consume less fuel and energy than do decontamination processes currently in use.

According to the concept, the process by which the toxic material is destroyed would have three stages: (1) catalytic "autothermal reforming" of the organic contaminants that have been driven from the

soil or carbon bed; (2) caustic scrubbing of the partially oxidized contaminant species from the effluent gas; and (3) catalytic combustion of the resulting contaminant-free combustible gas stream. By separating the oxidation process into two separate steps and by implementing steam into the first step, the process requires lower temperatures than are normally used in a conventional single-stage combustion process. No free carbon and minimal thermal NO_x would be produced. The amount of fuel required to sustain the process would be lower than in conventional processes — particularly inasmuch as products of the extracted contaminants would be recycled as fuel.

In one version of the process, shown in the figure, contaminated soil would be transported through a vessel in which the soil would be heated to temperatures high enough to volatilize the organic contaminants. A limited quantity of air and/or steam would be swept over the hot soil and fed into the autothermal reformer. The steam would help to vaporize the organic contaminants. In the autothermal reformer, the steam would also serve as an oxidant, along with air, to convert catalytically the organic compounds, along with some additional fuel added to the process, to reducing compounds. The use of steam not only reduces the amount of air needed to convert the organic contaminants and fuel, but also reduces the resultant dilution of the combustible material by nitrogen that would occur if more air were used. The reduction in the flow of air and the injection of steam would reduce the amount of heat generated in this stage, and the consequent additional amount of heat required to sustain the reactions in the catalyst bed would be supplied by the preheating of the steam, air, and fuel fed into the chamber. The decontaminated soil would have been heated to much lower temperatures than in conventional kiln operations, where the soil must be heated to the same high temperatures required for the single-stage



An **Autothermal Reformer** incorporated into a contaminated-soil-treatment system promises nearly complete oxidation of contaminants at reduced costs.

combustion process, resulting in lower heat losses to the system.

The exhaust gases from this stage would flow into a conventional scrubber, where the gases containing the heteroatomic species from the original toxic organic compounds, which are now in the form of simple "reducing" gases, would be removed from the gas stream. (These gases include such compounds as hydrogen chloride, hydrogen bromide, hydrogen sulfide, and ammonia.) The effluent gas stream, which is made up of hydrogen, carbon monoxide, methane, carbon dioxide, and nitrogen, is then fed to a combustor, preferably a catalytic combustor, where the gases are reacted with air at very fuel-lean conditions. This results in low flame temperatures that are below those at which thermally produced NO_x is generated. This combustion process can either be operated directly in conjunction with the soil-treatment step or indirectly

with the heat derived from it and used subsequently in the soil treatment. In either case, additional fuel necessary to produce adequate heat to elevate the soil to temperatures necessary for volatilizing the organic compounds can be added. Effluent products from the second stage combustor are carbon dioxide, nitrogen, excess oxygen, and water vapor.

A similar process could regenerate carbon beds that are used in water-treatment plants. The system would be operated in such a manner that the carbon beds would not have to be removed from the plant and regenerated off-site. The hot steam needed to regenerate the carbon beds would be produced from the two combustion stages.

This work was done by Gerald E. Voecks of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 111 on the TSP Request Card. NPO-17669

Computing Deformations of Rubbery Materials

Better use is made of experimental data in finite-element computations.

NASA's Jet Propulsion Laboratory, Pasadena, California

A new formulation of the constitutive equations of a rubbery, nonlinearly elastic material enables the finite-element analysis of boundary-value stress-and-strain problems that involve arbitrary shapes and loads. In the development of this formulation, principal stretches (as contrasted with the more traditional principal invariants of strain) are used as arguments of the strain-energy-density function. However, unlike in the traditional formulation, there is no need to calculate the strain-energy-density function explicitly in the application of this form-

ulation to a specific load-versus-deformation problem. Instead, readily available experimental data on loads versus deformations, interpolated where necessary, are used in a more direct manner.

The change in shape, caused by elastic deformation, of the infinitesimal part of a body surrounding a particle that was at a specified reference position when the body was undeformed, can be expressed as a deformation gradient, F , that is the product of a rigid-body-rotation tensor, R , and a stretch tensor, U , that specifies principal

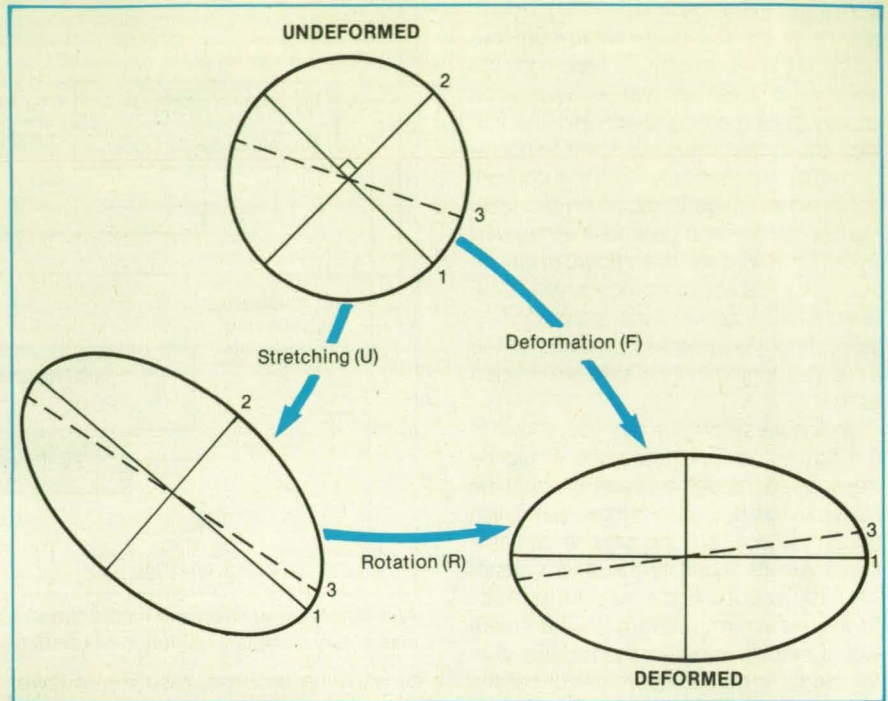
stretches (or compressions). The figure illustrates the geometrical relationships among F , R , and U . In the traditional approach, a polynomial or other form of the strain-energy-density function is fitted to the experimental load-versus-deformation data, and stresses are calculated by taking the first and second derivatives of this function with respect to the strains. This procedure is disadvantageous in that the fitting function may not interpolate the experimental data accurately, and the inevitable noise introduced by the computa-

tion of derivatives increases the inaccuracy.

In deriving the new approach, the strain-energy density is initially expressed as a separable function, w , of the principal stretches. However, because only the values of the derivatives of the strain-energy-density function and not the form of the function are needed for the computation of stress, the function is manipulated into a form in which one can work with interpolated experimental data, calculating points on a curve that describes the response of the material. This approach provides for the most direct and straightforward use of experimental data in the solution of boundary-value problems.

The constitutive equations based on the new formulation have been incorporated into a finite-element computer code, TEXLESP-S, which solves equilibrium problems for three-dimensional, incompressible, hyperelastic bodies. The code has been demonstrated by using it to analyze stretching of thin, biaxial test specimens by various amounts up to 90 percent.

This work was done by Steven T. J. Peng of Caltech and Eric B. Becker and Trent M. Miller of Becker and Miller for NASA's Jet Propulsion Laboratory. For further information, Circle 93 on the TSP Request Card. NPO-17670



The **Deformation of Material** in the vicinity of a point can be represented by stretching, which transforms a circle fixed to the material into an ellipse, followed by a rotation of the ellipse.

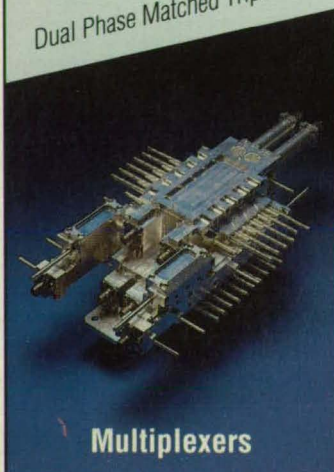
EXPERIENCE • FACILITIES • TECHNOLOGY

Designing and Building Space Qualified Components for over 25 Years

TELEDYNE MICROWAVE

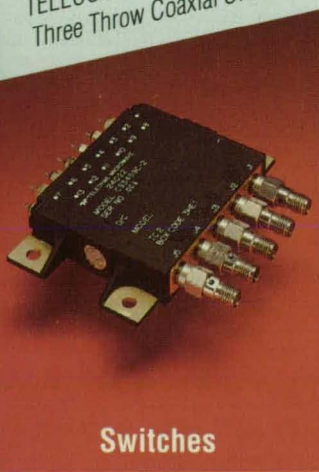
1290 Terra Bella Avenue
Mountain View, California, USA 94043
(415) 968-2211
FAX (415) 966-1521

Dual Phase Matched Triplexer



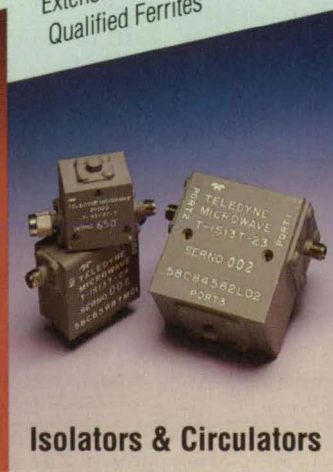
Multiplexers

TELECOM II Double Pole,
Three Throw Coaxial Switch



Switches

Extensive Selection of Space
Qualified Ferrites



Isolators & Circulators

Dedicated
Hi-Rel Assembly Facilities



- 
- **Tap Into The Latest NASA Technology**
 - **Meet Top Government/Industry R&D Experts**
 - **Find Innovative Ideas For New Products**

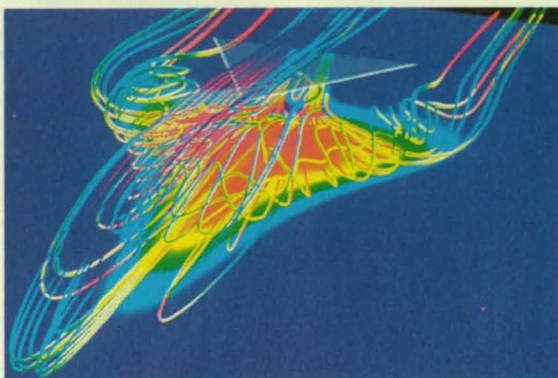
TECHNOLOGY 2000

**the first national conference and exhibition
of NASA's technology for transfer**

**Washington DC Hilton Hotel
November 27-28, 1990**

NASA Invites You To The High-Tech Event of 1990

TECHNOLOGY 2000



**Washington, DC Hilton Hotel
November 27-28, 1990**

- ❖ access technology from NASA and its contractors
- ❖ meet government/industry tech transfer experts
- ❖ find new partners for R&D ventures
- ❖ discover the latest innovations in a variety of high-tech fields
- ❖ explore future applications of space-based research

A Gold Mine Of Technology Awaits You

Designed to bolster U.S. competitiveness in the global marketplace, **TECHNOLOGY 2000** is the first national conference and exhibition of NASA technology and technology transfer. NASA programs of the past three decades have created a vast store-house of technology that is available *now* for use by industry in developing new products and processes. **TECHNOLOGY 2000 will show you how to tap into this multi-billion dollar resource to improve your productivity and gain a competitive edge.**

In two action-packed days, government and industry trailblazers will bring you up to speed on the latest innovations in computer technology, electronics, materials, biomedicine, and other key fields -- with a focus on potential commercial applications. Between and after these sessions visit the idea-stocked exhibit hall and meet experts from all nine NASA field centers as well as many of the top high-tech companies and universities nationwide.

TECHNOLOGY 2000 presents a unique opportunity to interact with these leaders, to develop contacts with potential R&D partners, and to discover what's directly ahead in a variety of high-tech fields.

Thousands of firms have picked up NASA's ideas and run with them, creating successful new products. Others have used space-based technology to hone their internal operations or improve their manufacturing systems. You too can benefit from this wealth of government-sponsored research. Join NASA, its major contractors, and other high-tech companies at **TECHNOLOGY 2000**, November 27-28, 1990.

Explore The Cutting Edge

The **TECHNOLOGY 2000** program will feature over 100 presentations by top NASA researchers and industry leaders in the following areas:

- ❖ Artificial Intelligence
- ❖ Computer Technology and Software Engineering
- ❖ Environmental Science
- ❖ Human Factors Engineering and Life Sciences
- ❖ Information and Data Management
- ❖ Manufacturing and Fabrication Technology
- ❖ Materials Science
- ❖ Optics and Communications
- ❖ Power, Energy, and Control Systems
- ❖ Robotics
- ❖ Sensors and Measurement Technology
- ❖ Superconductivity

TECHNOLOGY 2000

P R O G R A M

Tuesday, November 27

Plenary Session I

8:30 a.m. - 11:00 a.m.

8:30 - **Keynote Address: Vice President Dan Quayle** (invited)

9:00 - **A View To The Future**

Senior NASA administrators will define three of NASA's primary missions:

- ◆ The Space Exploration Initiative (SEI), which will establish a permanent lunar base and then extend man's presence beyond Earth orbit to Mars;
- ◆ The Mission To Planet Earth Program, which will use an array of orbiting platforms to study global changes in an effort to understand global warming and other environmental problems;
- ◆ The National Aero-Space Plane (NASP) Program, which will strengthen U.S. leadership in civil and military aviation by developing a vehicle that can take off from a runway like an ordinary jet, climb into space or fly intercontinental "hops" at up to 25 times the speed of sound, and then land on a runway. Presenters will focus on the technical achievements needed to meet the mission objectives of these programs.

Special emphasis will be placed on technical innovations that will be available for commercialization in the near future, including advances in structures, high-temperature materials, robotics, systems reliability, sensors, computers, high data rate management, large-scale modeling, and cryogenics.

Concurrent Technical Sessions

2:30 p.m. - 5:30 p.m.

Session A

Computer Technology and Software Engineering (Part 1)

The Virtual Environment Display System

Dr. Michael McGreevy, James Humphries and Warren Robinett, Aerospace Human Factors Research Div.; Ames Research Center

Ames scientists have developed a head-mounted, wide-angle, stereoscopic display system that enables the user to explore a 360-degree "virtual" environment and viscerally interact with its components. System configuration, applications, and research directions will be described.



Virtual Acoustics Displays

Dr. Elizabeth Wenzel, Research Psychologist; Ames Research Center

Dr. Wenzel will describe an innovative signal processing device capable of generating externalized, three-dimensional sound cues for headphone presentations in real time. Applications involve any context in which the user's spatial awareness is important, particularly when visual cues are limited or absent. Examples include air traffic control displays, advanced teleconferencing, telerobot monitoring, and scientific "visualization" of multi-dimensional data.

FAST: A Multi-Processed Environment For Visualization Of Computational Fluid Dynamics

Gordon Bancroft, Fergus Merriitt, Todd Plessel, Paul Kelaita, R. Kevin McCabe and Al Globus; Sterling Federal Systems Inc.

This presentation will spotlight the Flow Analysis Software Toolkit (FAST), a software system for visualization and analysis of complex fluid flows. Developed by Sterling under contract to NASA's Ames Center, FAST handles a diverse range of problems, is extensible, and can be adapted to new software and hardware configurations through the use of modular structured programming methods, a graphics library standard, and common network communication protocols (such as UNIX sockets) for the distribution of processing.

Hypercube Technology

Presenter to be determined

The MARKIII hypercube supercomputer designed at Jet Propulsion Laboratory (JPL) has been successfully applied to a broad problem set including electromagnetic scattering, discreet event simulation, plasma transport, matrix algorithms, neural network simulation, image processing, and graphics. Currently, problems that are not homogeneous are being attempted, and through these "real world" applications the software is evolving to efficiently handle heterogeneous class problems.

The Hyperswitch Communication Network

Presenter to be determined

JPL researchers have developed a high-speed, fault-tolerant communication architecture based on the Hyperswitch chipset for use in the next generation of hypercube supercomputers. This architecture reduces overall message reception latency by two to three orders of magnitude and has a data transmission bandwidth thirty times greater than that of existing hypercube computers.

Biological Neural Networks As Model Systems For Designing Future Parallel Processing Computers

Dr. Muriel Ross, Research Scientist; Ames Research Center

Biological neural networks are highly successful computational systems which function as massively parallel, distributed processors of information. Dr. Ross' research team is studying the three-dimensional organization of a simple biological neural network found in inner ear organs of balance (vestibular maculas) to uncover the fundamental principles of neural organization, and to understand the relationship between neural organization and functioning through modeling. The findings will have applications in computer technologies and robotics.

Session B

Human Factors Engineering and Life Sciences (Part 1)

Biomedical Applications Of NASA Technology

Donald Friedman, Chief, Office of Commercial Programs, Goddard Space Flight Center; and Dr. Russell Eberhart, program manager, Biomedical Programs, Johns Hopkins University Applied Physics Laboratory

An array of technologies that promise new solutions to biomedical problems will be described, including the

Programmable Implantable Medication System, which offers a way to free insulin-dependent diabetics from daily injections; the Biomedical Implantable Thermal System, capable of accurately measuring and relaying deep internal body temperatures; and the Implantable Functional Electrical Stimulation System, which aims to improve paralyzed functions. The presenters will also cover biomedical applications of neural networks and the use of astronomy technology to detect glaucoma.

Direction-Discriminating Hearing Aid System

Dr. Murzy Jhabvala, Chief Engineer, Instrument Microelectronics and Detectors Branch; Goddard Space Flight Center

Individuals who suffer a severe hearing loss in one ear have difficulty discerning the direction from which sounds originate. A basic approach to solving this problem is to detect sound from two directionally-oriented microphones mounted on the user. Sounds are then amplified and compared; the stronger signal is shown on a visual display which notifies the user of the direction from which the received sound emanated. The electronic portion of the system is based on a custom-developed CMOS integrated circuit.

X-Ray Imaging Microscope For Cancer Research

Richard Hoover, Astrophysicist, Space Science Laboratory; Marshall Space Flight Center

This presentation will focus on the design of the Water Window Imaging X-Ray Microscope, configured to operate within a narrow regime of the x-ray spectrum that lies between the K absorption edges of oxygen and carbon. In this "water window," carbon is highly absorptive and water is highly transmissive. Therefore, the microscope should be able to delineate -- with high spatial resolution and contrast -- carbon-based structures within living cells. It affords strategies for examining living tumor cells without the need for dyes, stains, or exogenous chemicals that produce limiting artifacts.

Mechanical Response Tissue Analyzer For Estimating Bone Strength

Dr. Sara Arnaud, Research Scientist, Ames Research Center; Anthony Mauriello, President, Gait Scan Inc.; and Dr. Charles Steele, Professor of Applied Mechanics, Stanford University

A new instrument called the Mechanical Response Tissue Analyzer uses a low-frequency vibratory stimulus to provide a direct measure of a mechanical property of bone. It shows promise for both diagnosis of osteopenic bone disease and monitoring effects of activity or treatment on bone strength.

Adaptation Of NASA Technology For The Optimization Of Orthopedic Knee Implants

Dr. Dimitrios Saravanos and Dale Hopkins, Lewis Research Center; Dr. Dwight Davy, Chairman, Bioengineering Dept., Case Western Reserve University

NASA technology originally created to optimize composite engine blades has been adapted to produce improved knee implants. Researchers have developed a method for tailoring the implant to the environment of the tibial bone. The shape and composition of the implant components are optimized such that the stresses in the tibia are favorably controlled to minimize bone degradation and prevent failures. This innovation should provide the means for improving knee prosthesis and tailoring the implant to individual patients.

Session C

Information And Data Management

Optical Storage Device

Sharon Welch, Aerospace Technologist; Langley Research Center

This presentation will focus on a new holographic information storage device that uses four-wave mixing in two photorefractive crystals. In previous studies of holographic storage using photorefractive crystals, the information was typically stored in a single crystal. This technique has the disadvantage that once the incident object (write) beam is removed, the stored information, or holographic grating, can be read out only once before being destroyed. By using four-wave mixing in two photorefractive crystals, it is possible to store a holographic image and read out the information an infinite number of times.

Rewriteable Optical Disk Recorder

Dr. Thomas Shull, Branch Head, and Pamela Rinsland, Assistant Branch Head, Electronics Branch; Langley Research Center

A NASA program to develop a high-performance rewriteable optical disk recorder for spaceflight applications will be presented. An expandable, adaptable system concept is proposed based on disk drive modules and a modular controller. System goals are up to 160 gigabyte capacity at up to 1.8 gigabits per second rate with concurrent I/O, asynchronous data transfer, and two to five year operating life in orbit.

Monitoring And Analysis Of Data From Complex Systems

Thomas Dollman, Team Leader, Software and Data Management Division; Marshall Space Flight Center
As flight systems become more complex and longer-lived, it becomes increasingly difficult to monitor and analyze their data. One method being developed to address this problem is the use of information systems in ways that enable the engineer to relate the data to the system design more readily. Another method is to encode knowledge about the system's operation into the computer system itself, to serve as a backup to the engineer's analysis and conclusions. These methods, now being tested at the Marshall Center, promise to help maintain the high productivity levels of the telemetry analyst over long periods.

High Data Rate Systems For The Future

John Chitwood, Head, RF Technology Section, Microwave Instrument and RF Technology Branch; Goddard Space Flight Center

Information systems in the next century will transfer data at rates much greater than those in use today. To meet these future needs, work is under way to improve systems that operate at RF, microwave, millimeter wave, and optical frequencies. As high data rate systems employ large bandwidths, efforts have been concentrated in areas that use optical wavelengths and millimeter wave frequencies around 60 GHz. Potential applications include high-resolution multi-channel television, high-speed videotext, and large-volume data dissemination services.

Advanced X-Ray Compression Technique

Richard Galle, Technology Utilization Officer; Stennis Space Center

Electronic storage and transmission of radiological data are areas that significantly impact the medical community's everyday operations. Current data compression schemes are inefficient and result in excessive volumes of stored data. Further, much time is required to electronically transfer x-ray information to remote sites. Stennis engineers have developed a highly efficient and dependable x-ray compression scheme that has achieved compression ratios of 40:1 or greater; the compression algorithms presently in use rarely achieve ratios greater than 5:1. The technology is currently undergoing clinical trials at a highly respected medical institution and a production prototype should be available in the near future.

DAVID: The Distributed Access View Integrated Database

Dr. Barry Jacobs, Senior Research Computer Scientist; Goddard Space Flight Center

NASA is developing methodologies that will enable space scientists, managers, and system developers to universally access data over heterogeneous systems without having to learn the specific access methods of the constituent systems. The technological approach involves the development of heterogeneous access methods over several classes of data: databases, spreadsheets, manuscripts, images, graphics, maps, audiovisuals, indexes, serials, kits, books, experts, and objects. NASA's end goal is to transfer the technology to the private sector using Small Business Innovative Research (SBIR) and other funding.

Three-Dimensional Perspective Visualization

Kevin Hussey, Supervisor of the Visualization and Earth Science Applications Group; Jet Propulsion Laboratory

Mr. Hussey will describe JPL's efforts to create highly realistic computer-simulated flights over very large, remotely-sensed digital databases, through algorithm development and application of advanced computer hardware.

Session D

Materials Science (Part 1)

High-Performance Polymer Development

Paul Hergenrother, Senior Polymer Scientist; Langley Research Center

As part of an effort to develop high-performance adhesives and composite matrices for aerospace applications, NASA Langley's polymer work has focused on innovative polyimides, poly (arylene ethers), and blends of reactive monomers and oligomers with thermoplastics. Langley has developed several new polyimides that exhibit excellent adhesive, composite, and film properties at temperatures up to 232 degrees C. In the area of poly (arylene ethers), heterocyclic units such as quinoxaline, triazole, imidazole, and oxadiazole incorporated within the polymer have resulted in higher glass transition temperatures and high tensile strengths and moduli. Several blends of reactive monomers and oligomers with high-performance thermoplastics have yielded cured resins with excellent high-temperature adhesive and composite properties. The chemistry, mechanical and physical properties, and potential uses of representative polymers will be highlighted.

Industrial Applications Of

Graphite Fluoride Fibers

Dr. Ching-Chee Hung, Research Physicist; Lewis Research Center

Graphite fluoride fiber is a new material whose physical properties can be tailored to meet the requirements of various engineering designs. Properly-processed graphite fluoride, for example, can be a thermally-conductive insulator. It therefore could be used as a heat sinking printed circuit board material that keeps the board's densely-packed circuits from overheating. Further, its coefficient of thermal expansion (CTE) could be tailored such that its composite is CTE-compatible with silicon. By using such a composite as printed circuit board material, the cracks of the tiny solder joints between the silicon chip's pins and the boards at high temperatures due to CTE mismatch could be avoided.

Fluoroepoxy Compounds As Adhesives For Fluoroplastics

Dr. S. Yen Lee, Materials Branch; Goddard Space Flight Center

Fluoroepoxy compounds are made by reacting a fluoroepoxy resin with a curing agent such as an adduct amine. While the compound is sufficiently liquid to wet a fluoroplastic surface, it can be applied to a fluoroplastic adherend, such as Teflon, to be employed as an adhesive in the formation of bonds and various fluoroplastic products. No surface treatment is required. Another application involves

the creation of fluropolymer foams with controllable amounts of inert-gas fillings in the foam cells. Unlike thermoplastic fluoropolymers, the thermosetting fluoropolymers do not require foaming additives that leave undesirable residues and can be formed at relatively low pressures and temperatures. Potential applications include coatings, electrical insulation, and wire products such as coaxial cables and power lines.

Dual Beam Process Diamond-Like Films For Industrial Applications

Michael Mirtich, Bruce Banks, and James Sovey, Lewis Research Center; Michael Kussmaul, Sverdrup Technology

A unique dual ion beam system developed by these scientists enables low-temperature deposition of diamond-like carbon coatings on plastics, quartz, silicon, metals, and a variety of other materials. The patented process can be used to coat relatively large objects and produces films with high electrical resistivity, extreme hardness and clarity, and chemical inertness -- making them well suited for optics and electronics applications.

Plasma-Polymerized Coating For Polycarbonate: Single-Layer, Abrasion-Resistant, And Antireflective

Dr. T. Wydeven, Research Scientist; Ames Research Center

Dr. Wydeven developed a process for depositing plasma-polymerized vinyltrimethoxy silane films on transparent polycarbonate substrates. The adherent, clear films protect the substrates from abrasion and also serve as antireflection coatings. Post-treatment of the films in an oxygen glow improves the abrasion resistance. The patented process is currently used by the world's largest manufacturer of non-prescription sunglasses to protect the plastic lenses from scratching.

The PM200 Lubrication System

Harold Sliney, Senior Scientist, Lewis Research Center; and William Waters, TU Materials Consultant, Waters & Associates

Several years ago, Harold Sliney developed PS200, an award-winning high-temperature lubricant which is plasma-sprayed onto bearings and seals. Current plasma spray processes cannot be used, however, for small parts such as bushings. PM200 contains the same constituents as PS200, but is designed to form small parts using powder metallurgy processes, and therefore offers an increased range of applications.

Session E

Manufacturing And Fabrication Technology

Robotics In Space-Age Manufacturing

Chip Jones, Metals Processes Branch; Marshall Space Flight Center

The Marshall Center is developing robotics technologies to improve manufacturing of space hardware. This presentation will cover applications such as robotic welding for the space shuttle and space station Freedom programs; manipulation of high-pressure water for shuttle solid rocket booster refurbishment; automating the application of insulation materials; precision application of sealants; and automation of inspection procedures. Commercial robots are used for these development programs, but they are teamed with advanced sensors, process controls, and computer simulation to form highly productive manufacturing systems. Many of the technologies are being actively pursued for use in private sector manufacturing operations.

Variable Polarity Plasma Arc Welding

Ernest Bayless, Branch Chief, Metals Processes Branch; Marshall Space Flight Center

The Variable Polarity Plasma Arc (VPPA) welding process was developed at the Marshall Center for manufacture of the space shuttle aluminum alloy external tank. This unique computer-controlled

welding process significantly improves the weldability of aluminum alloys by eliminating internal defects and reducing thermal distortion as well as preweld cleaning and joint preparation requirements. The VPPA is currently being adapted for applications on the advanced solid rocket motor (ASRM) high-strength steel material and the space shuttle main engine (SSME) nickel-based alloys. Further enhancements to the process will include sensor control of seam tracking, weld beam profiling, and wire feed entry control.

High-Pressure Water Jet Cutting And Stripping

David Hopp, Aerospace Technologist, Tooling Applications Branch; Marshall Space Flight Center High-pressure water jet cutting techniques have a wide range of applications to the American space effort. Hydroblasting techniques are used, for example, during refurbishment of the space shuttle's solid rocket motors. The process can be controlled to strip a thermal protective ablator without damaging the painted surface underneath by employing a nozzle which rotates at 1500 rpm and discharges water under 15,000 psi pressure. This is a slow and costly operation, however, and is extremely hazardous. Marshall researchers have automated the process using a computer-controlled robot mounted on a transportable platform. The six-degree-of-freedom robot can be used to reach almost any position quickly and efficiently; an operation which requires an hour manually can be performed in 20 minutes. The robotic system has already saved millions of dollars and hours of processing time during refurbishment of solid rocket motors at Kennedy Space Center.

Cost-Efficient Manufacturing Of Composite Structures

W. Tom Freeman, Aerospace Technologist, and Dr. John Davis, Head of the Structures Technology Program Office; Langley Research Center In the Advanced Composites Technology (ACT) program, NASA is seeking research breakthroughs that will allow structures made of epoxy-type resins to replace metal in the wings and bodies of future aircraft. The agency's goals are to reduce acquisition cost by 20-25 percent, structural weight by 40-50 percent, and the number of individual parts by half compared to current production aluminum aircraft. This presentation will focus on the innovative structural concepts, materials, and fabrication techniques emerging from the ACT program, and will discuss the relationship between aerospace developments and industrial, commercial, and sporting goods applications.

Rapid Induction Bonding Of Composites, Plastics, And Metals

Dr. John Buckley, Materials Research Engineer, Fabrication Division; Langley Research Center Langley researchers have created a rapid electromagnetic induction bonding system that joins composites, plastics, metals, and combinations of these materials. The equipment is self-contained, portable, and uses only 100-400 watts. It allows heat to be directly applied to the bond lines and/or the adherends without heating the entire structure, supports, and fixtures of a bonding assembly. Bonding times for laboratory specimens have been cut by a factor of 10 to 100 compared to standard press or autoclave bonding.

Reliability And Risk Assessment Of Structures

Dr. Christos Chamis, Senior Aerospace Scientist, Lewis Research Center; and Dr. Michael-Chu-Yu Shiao, Research Scientist, Sverdrup Technology Inc. Many structures that require high performance, reliability, and durability operate under complex environments including random excitations and temperatures. These excitation and temperature variations not only degrade the material but also cause an additional randomness in the uncertain material behavior. To account for the aforementioned problems, a methodology was developed at NASA

Lewis for a probabilistic structural analysis applicable to a wide variety of structures. The presenters will describe this methodology, which consists of a probabilistic structural analysis by a specialty computer code NESSUS (Numerical Evaluation of Stochastic Structures Under Stress), a generic probabilistic material property model, and a probabilistic fatigue analysis. The structural reliability and associated risk obtained by this methodology are useful in evaluating the traditional design, setting, quality control, and inspection requirements, and for certifying to authorities the assured safety and useful life of the structural systems.

A Semi-Automated Process For The Production Of Custom-Made Shoes

Dr. Franklin Farmer, Manager of Biomedical Application Projects; Langley Research Center More than one-half million Americans require custom-made shoes. These shoes are extremely expensive because their design and manufacture is a highly-skilled and labor-intensive process. The costs could be reduced by using a CAD/CAM process based primarily on NASA-developed software programs such as NACAD and APT. Dr. Farmer will describe the process and demonstrate its products.

Lightweight, Fire-Retardant, Crashworthy Aircraft Seat Cushioning

Dr. Leonard Haslim, Program Manager, Advanced Plans and Programs Office; Ames Research Center Dr. Haslim has designed an innovative seat cushion that offers a comfortable, lightweight, cost-efficient alternative to the polyurethane foam cushions presently used in aircraft, automobiles, and many types of home furniture. These cushions support combustion and pose a toxic gas hazard when exposed to fire. Dr. Haslim's improved model employs a fire-blocking configuration of self-extinguishing materials that produces virtually no hazardous fumes.

Session F Power, Energy, And Control Systems

Civil Air Transport: A Fresh Look At Power-By-Wire And Fly-By-Light

Gale Sundberg, Deputy Chief, Electrical Components and Systems Branch; Lewis Research Center Power-by-wire (PBW) is a key element under subsonic transport flight systems technology with potential savings of over ten percent in gross takeoff weight and fuel consumption compared to today's transport aircraft. PBW technology substitutes electrical actuation in place of centralized hydraulics, uses internal starter-motor/generators, and eliminates the need for variable engine bleed air to supply cabin comfort. The application of advanced fiber optics to the electrical power system controls, to built-in-test equipment, and to fly-by-light flight controls provides additional benefits in lightning and high energy radio frequency immunity over existing mechanical controls. This presentation will give a snapshot of the key technologies and their benefits to all future aircraft.

The Free-Piston Stirling Engine -- From Space Technology To Terrestrial Applications

James Dudenhoefer, Chief, Stirling Technology Branch; Lewis Research Center The Stirling engine is a candidate high-capacity dynamic power source for space systems in the late 1990s and into the next century. Space power requirements include high efficiency, very long life, high reliability, and low vibration. The free-piston Stirling has the potential to be a highly reliable engine with long operating life because it has only a few moving parts, noncontacting gas bearings, and can be hermetically sealed. These attributes also make it a viable candidate for terrestrial applications. Industry teams are currently completing designs for two advanced Stirling conversion systems utilizing technology developed under NASA's Civil Space Technology Initiative program.

Solar-Powered Stirling Cycle Electricity Generator

Richard Shaltens, Senior Project Manager; Lewis Research Center

The 25 kW free-piston Stirling cycle electricity generator developed for space use is being combined with a parabolic mirror solar heat concentrator to produce an economical solar-powered electricity generator for terrestrial applications. Such units could be used for "topping" power cycles by utilities, especially in the Sunbelt. They also offer tremendous potential in the Third World, much of which lies in tropical areas with lots of available sunshine. Mr. Shaltens will describe current development efforts and possible application areas.

Four Quadrant Control Of Induction Motors

Irving Hansen, Research Engineer; Lewis Research Center

Induction motors are our workhorse, being the motor of choice in most applications due to their simple rugged construction. It has been estimated that the country's electricity use could be reduced by 14-27 percent by incorporating adjustable speed drives. Until now, however, induction motors have not been suited for variable speed or servo drives due to the inherent complexity, size, and inefficiency of their variable speed controls. Work at NASA Lewis on field-oriented control of induction motors using a pulse population modulation method holds promise for the desired drive electronics. The system allows for a variable voltage of frequency ratio, which enables the user to operate the motor at maximum efficiency while having independent control of its speed and torque in all four quadrants of the speed torque map.

Bi-Polar Battery Technology

Dr. Gerald Halpert, Technical Group Supervisor, Battery Systems Group; Jet Propulsion Laboratory Dr. Halpert will explain how advances in increasing the energy storage capability of high-power lead-acid batteries have paved the way for their potential use in previously unattractive applications such as electric-powered vehicles.

New CCD Technologies At JPL

James Janesick, Member of Technical Staff; Jet Propulsion Laboratory

Mr. Janesick will describe recent work on charge-coupled devices (CCDs) which has resulted in unprecedented performance in the areas of read noise, charge collection efficiency, charge transfer efficiency, and quantum efficiency. Further, these technologies have enabled the fabrication of ultra-large CCDs (4096 x 4096 pixels).

Advanced Thermal Technology For Commercial Applications

Ted Swanson, Senior Engineer, Thermal Engineering Branch; Goddard Space Flight Center Future space facilities such as space station Freedom and a lunar base will require advanced thermal control technologies. One promising concept is the capillary pumped thermal transport loop, or CPL, which is similar to a heat pipe in that it can transport large quantities of heat over long distances with negligible temperature drop. The CPL, however, offers a two-order-of-magnitude improvement over current heat pipe technology. Mr. Swanson will discuss CPL development efforts and potential spinoff applications.

Session G Robotics

ROBOSIM, A Simulator For Robotic Systems

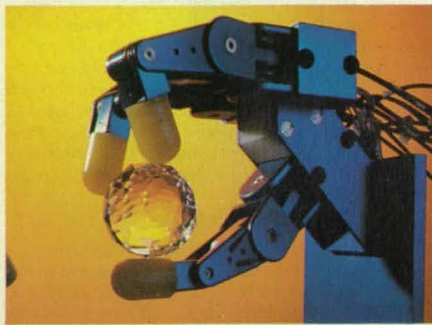
Dr. Ken Fernandez, Software and Data Management; Marshall Space Flight Center

ROBOSIM was created by NASA to aid in the rapid prototyping of automation. It has enabled the development of improved robotic systems concepts for both Earth-based and proposed on-orbit applications while significantly reducing development costs. ROBOSIM has been adapted for use in the classroom as a safe and cost-effective way to allow

students to study robotic systems. Dr. Fernandez will provide an update on new application areas, improvements made to the simulator's design, and efforts under way to ensure the timely dissemination of this technology.

Control System Software, Simulation And Robotic Applications

Harry Frisch, Head, Robotics Applied Research Section; Goddard Space Flight Center
Goddard has developed multibody dynamics programs which can be used to create dynamics simulation models of any system. The system can be modeled as a collection of hinge-connected rigid bodies acted upon by both internal and external loads. During the past decade, these programs have been used for an extremely broad range of problems and have proven to be the only logical method for reducing the cost of in-depth analysis. Mr. Frisch will describe several applications of this technology, including muscle dynamics modeling in support of eye movement research; modeling and simulation of neural prosthesis; study of gait for the handicapped; and comparison of operational options, man versus robot.



Discover the latest advances in telerobotics.

Telerobotic Electronic Materials Processing Experiment

Stanford Ollendorf, Chief, Office of Telerobotic Engineering; Goddard Space Flight Center
Mr. Ollendorf will describe an experiment designed to investigate the potential for developing in-space facilities for the automated production of microelectronic devices. An experiment will be flown in which a telerobot will transport samples of solar cell materials between stations where the material can be stored, processed, and/or analyzed. Processes will include various types of thin film deposition and annealing which relate to the production and reconditioning of solar cells.

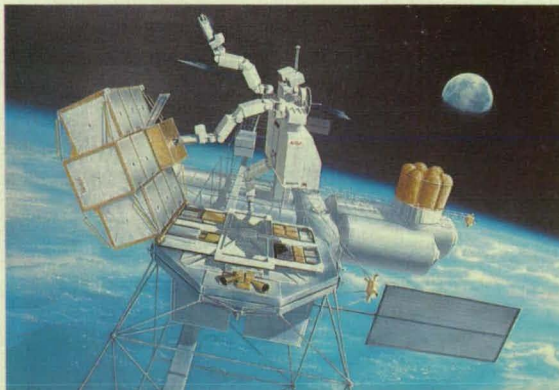
Advanced Mechanisms For Robotics

John Vranish, Aerospace Electrical Engineer, Electro-mechanical Branch; Goddard Space Flight Center
Recent robotics work at Goddard has focused on end effectors and related mechanisms, robot-friendly payload latching mechanisms, compliant joints, and collision avoidance/management skin for robotic arms. Mr. Vranish will detail significant developments in these areas and their commercial potential.

The Flight Telerobotic Servicer And Technology Transfer

James Andary, FTS Systems Manager, FTS/Development Test Flight Project; Goddard Space Flight Center

The Flight Telerobotic Servicer (FTS) will help astronauts build and maintain space station Freedom, thereby reducing crew extravehicular activity requirements. The highly dexterous robot will combine teleoperation -- the use of a human operator to direct the machine -- and autonomous capabilities for performing tasks on its own but under an astronaut's supervision.



This presentation will focus on present FTS research in areas such as advanced computer vision and autonomous planning, the technologies that will result from this research, and potential terrestrial applications.

FARMS: The Flexible Agricultural Robotics Manipulator System

Paul Gill, Electrical Aerospace Engineer; Marshall Space Flight Center
Marshall and the University of Georgia have jointly developed a robotic end effector for the processing of live plant material. The robotic device is designed to improve efficiency and productivity in commercial nurseries and green house systems, and could be applied to future space projects such as manned space stations and planetary communities requiring large-scale food production.

Diverse Applications Of Advanced Man-Telerobot Interfaces

Douglas McAfee, Member of Technical Staff; Jet Propulsion Laboratory
Advances in man-machine interfaces and control technologies used in space telerobotics have potential application wherever human operators need to manipulate multidimensional spatial relationships. Mr. McAfee will explain how bilateral six-degree-of-freedom position and force cues exchanged between the user and a complex system can broaden and improve the effectiveness and intuitiveness of several diverse man-machine interfaces.

Session H

Sensors And Measurement Technology (Part 1)

Urodynamic Pressure Sensor

Thomas Moore, Aerospace Engineering Technician; Langley Research Center
A need for measuring the simultaneous, circumferential closing forces along the entire active length of the female urethra has been recognized in order to significantly improve diagnostic capabilities for the treatment of pathological anomalies in this organ. A sensor system providing six simultaneous measurements -- one in the bladder and five at discrete locations within the urethra -- has been developed in response to this need. By integrating a microcomputer into the system, one can perform analysis functions such as data smoothing, peak pressure arrival time, and muscle recovery times.

Electron Tunnel Sensor Technology

William Kaiser, Thomas Kenny, and Steven Waltman; Jet Propulsion Laboratory
The presenters will discuss development of monolithic silicon electron tunnel sensors that combine high performance, low cost, low power consumption, compact volume, and array compatibility. This technology is expected to provide a new approach for the implementation of sensors for acceleration, force, radiation, acoustic signals, and other applications.

Practical Approaches For The Application Of Resistance-Type Strain Gages On High-Temperature Composites

Thomas Moore, Langley Research Center
Installation of strain gages on any surface subjected to temperatures above 315 degrees C requires innovative techniques and appropriate gaging materials. High-temperature metal matrix and carbon-carbon composites requiring strain measurements of 815 degrees C and higher make the application of strain gages even more difficult. Mr. Moore will describe several approaches for obtaining reliable strain data on high-temperature composites for both field and laboratory test scenarios.

Space Shuttle Engine Plume Measurements

Richard Eskridge and W.T. Powers, Aerospace Technologists, Propulsion Systems Division; Marshall Space Flight Center
The Marshall Center has developed several new instruments to diagnose shuttle main engine exit plane conditions, including an Optical Plume Anomaly Detector, an Exit Plane Spectrometer, an Infrared Emission/Absorption Temperature Profiling System, a Laser Schlieren Shock/Imaging System, and a dedicated spectrometer for resonance line absorption measurements. These systems will provide valuable data on the instantaneous plume species emissions for health monitoring and will profile the temperature and species number densities for water and trace alkali metals in the engine plume.

AI Mass Spectrometers For Shuttle Health Monitoring

J. David Collins, Chief, Instrumentation Section, Kennedy Space Center
The Kennedy Space Center uses mass spectrometers to detect fuel leaks in the space shuttle main engines. These systems are very complex and require large amounts of time for maintenance and validation. Artificial intelligence (AI) programs currently being developed for real-time system health checks will reduce maintenance/validation time and allow operators to concentrate on the critical leak detection data.

Instrumentation For Optical Ocean Remote Sensing

Dr. Wayne Esaias, Oceanographer, Oceans and Ice Branch; and Fran Stetina, Aerospace Technical Manager, Laboratory for Hydrospheric Processes; Goddard Space Flight Center
Instruments used in ocean color remote sensing algorithm development, validation, and data acquisition suitable for commercial development and marketing will be discussed.

Wednesday, November 28

Concurrent Technical Sessions

8:30 a.m. - 11:00 a.m.

Session A

Artificial Intelligence

Intelligent Computer-Aided Training And Tutoring

Robert Savely, Chief, Software Technology Branch, Johnson Space Center; and Dr. R. Bowen Loftin, Professor, University of Houston
Long-duration space shuttle missions, space station Freedom, and future lunar/Mars missions will require the creation of simulation-based training systems for crew, flight controllers, and ground-based support personnel. The application of artificial intelligence technology to simulation training will allow individu-

alized training to be delivered to large numbers of personnel in a distributed workstation environment. Intelligent Computer-Aided Training (ICAT) systems simulate the behavior of an experienced instructor observing a trainee, responding to requests for help, diagnosing and remedying trainee errors, and proposing challenging new training scenarios. The general architecture for ICAT systems will be presented, and the design and evaluation of specific ICAT applications will be discussed in detail. In addition, the transfer of ICAT technology to the educational sector will be covered within the context of the Intelligent Physics Tutor Project.

CLIPS: A Tool For The Development And Delivery Of Expert Systems

Gary Riley, Computer Engineer, Software Technology Branch; Johnson Space Center
CLIPS is a forward chaining rule-based language developed at NASA Johnson that provides a complete environment for the construction of rule-based expert systems. It is designed for high portability, low cost, and easy integration with external systems. Other key features include a powerful rule syntax, an interactive development environment, extensibility, documentation, and source code availability.

Distributed, Cooperating Knowledge-Based Systems

Walter Truszkowski, Head, Automation Technology Section; Goddard Space Flight Center
Mr. Truszkowski will address the development and application of distributed, cooperating knowledge-based systems in the spacecraft ground operations environment. Because of the increasing size, complexity, and cost of planned systems, conventional procedural approaches to the architecture of automated systems will give way to a more comprehensive knowledge-based approach. A hallmark of these future systems will be the integration of multiple knowledge-based agents which "understand" the operational goals of the system and cooperate with one another and the humans in the loop. Current work includes the development of a formal model of cooperating knowledge-based agents; the creation of a reference model for knowledge base management; the establishment of an object-oriented model of an intelligent end-to-end (spacecraft to user) system; and the use of a test bed for prototyping and evaluating various knowledge-based concepts.

Electronic Neural Network Technology

Dr. Anil Thakoor, Technical Group Supervisor, Neuroprocessing and Analog Computing Devices; Jet Propulsion Laboratory
Derived from biological neural network models, electronic neural network technology promises powerful, high-speed computing alternatives for a variety of complex, ill-defined, and fuzzy tasks not easily accomplished by conventional AI and digital techniques. Dr. Thakoor will discuss the state of neural network hardware technology and current work at JPL.

Intelligent Vision System For Autonomous Vehicle Operations

Dr. Maria Scholl, Member of Technical Staff; Jet Propulsion Laboratory
Dr. Scholl will describe the application of advanced optical correlator technology to develop intelligent vision sensors for autonomous operation of complex mobile systems.



Session B

Computer Technology and Software Engineering (Part 2)

Software Reengineering

Ernest Fridge, Deputy Chief, Software Technology Branch; Johnson Space Center
Today's software systems generally use obsolete technology, are not integrated properly with other software systems, and are difficult to maintain. The discipline of reverse engineering is becoming prominent as organizations try to move their systems up to more modern and maintainable technology. The Johnson Center created a significant set of tools to develop and maintain FORTRAN and C code during development of the space shuttle; this tool set forms the basis for an integrated environment to reengineer existing code into modern software engineering structures which are then easier to maintain and which allow a fairly straightforward translation into other target languages. The environment will support these structures and practices even in areas where the language definition and compilers do not enforce good software engineering.

Transportable Applications Environment (TAE) Plus: A NASA User Interface Development And Management System

Martha Szczur, TAE Project Manager, Software and Automation Systems Branch; Goddard Space Flight Center
Designed to operate on graphic workstations supporting MIT's X Window System, TAE Plus is a WYSIWYG (What You See Is What You Get) tool for designing, building, and tailoring an application's user interface (UI) and for controlling the UI throughout the application's execution. The system's main component is the WorkBench, which allows the application developer to interactively construct the layout of an application screen and manipulate a set of interaction objects (menus, buttons, icons, dials, strip charts, etc.). Ms. Szczur will describe how a developer would use the WorkBench to create an application's user interface and will discuss the software architecture. Moreover, she will summarize how TAE Plus is being used to prototype and build user interfaces for a variety of NASA and non-aerospace applications.

Applications Of Fuzzy Logic To Control And Decision Making

Robert Lea, Aerospace Engineer, Johnson Space Center; and Dr. Yashvant Jani, Senior Corporate Scientist, Lincom Corp.
Fuzzy logic technology has shown to be powerful and robust in interpreting imprecise measurements and generating appropriate control decisions for many space operations. The presenters will describe several ongoing applications projects at the Johnson Center's Software Technology Laboratory, including an intelligent sensor system to support traffic management and proximity operations around space station Freedom.

Genetic Algorithms

Lui Wang, Computer Engineer; Johnson Space Center
Genetic algorithms provide powerful techniques for optimization, search, and machine learning. Mr. Wang will describe current efforts to build a genetic algorithm tool for use in robot path planning, scheduling, and resource allocation.

Vertical Bloch Line (VBL) Memory

Presenter to be determined
The VBL memory is an improvement on magnetic bubble memories. Like bubble memories, it is nonvolatile, radiation-hard, and has no moving parts. This presentation will focus on current development efforts and potential application areas.

Session C

Environmental Technology

Physical/Chemical Closed-Loop Water Recycling

Dr. Cal Herrmann, Water Quality Specialist, Bionetics Inc.; and Dr. Ted Wydeven, Research Scientist, Ames Research Center
New computer modeling and simulation technologies are being developed at NASA Ames for the Physical/Chemical Closed-Loop Water Recycling Project. Water needs, sources, and means for recycling water are examined in terms appropriate to the water-quality requirements of a small crew during long-duration exploration missions. Recommendations are made for development of new water recycling technology and improvement of existing technology for near-term application to life support systems for humans in space. These pioneering technologies are equally applicable to water needs on Earth, in regions where extensive water recycling is required or where advanced water treatment is essential to meet EPA health standards.

Water Quality Analyzer

Warren Kelliher, Aerospace Technologist, Langley Research Center
This presentation will illustrate the design and capabilities of a new miniaturized X-ray Fluorescence Spectrometer used to analyze water quality. Developed by NASA and the EPA, the portable unit provides on-site, real-time analysis of toxic metal contamination. There are patents pending on the invention and a commercial manufacturer is being sought.

New Research On Bioregenerative Air/Water Purification Systems

Dr. Anne Johnson, Research Biologist, Stennis Space Center
Dr. Johnson will describe the Stennis Center's efforts to characterize bioregenerative mechanisms of air and water purification. Studies include utilization of vascular plants for wastewater treatment, desalinization, and heavy waste removal. Foliage plants are also being evaluated to determine their role in the removal of toxic organics from ambient air. Similarly, researchers are examining the possibility of producing food from plants and fungi within a closed system while obtaining drinking water through the process of evapotranspiration. As plants die within the wastewater treatment system, they are used for compost to grow vegetables. Thus, this technology offers the potential for air and water revitalization as well as food production using strictly biological means.

Environmental And Facilities Management System (EFMS)

Bruce Davis, Geographer, Stennis Space Center
Centered around Geographic Information System technology, the EFMS will use information gathered by remote sensing and in situ sensor systems to create a digital database for Stennis and the surrounding region. The database will aid in monitoring the environmental impact of NASA's propulsion test operations, enabling Stennis program managers to identify potential problems and make better informed decisions.

The Land Analysis System

Dr. Yun-Chi Lu, Project Manager, LAS Project; Goddard Space Flight Center
Dr. Lu will describe the Land Analysis System (LAS), an interactive software system for the analysis, display, and management of multispectral and other digital data. Available in the public domain, LAS provides 240 applications functions and utilities, a flexible user interface, complete on-line and hard-copy documentation, extensive image data-file management, reformatting, and conversion utilities.

Potential Commercial Use Of EOS Remote Sensing Products

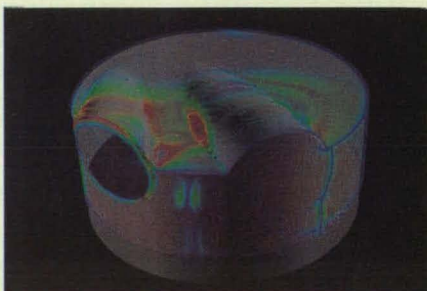
Leslie Thompson, Senior Systems Engineer, Sensor Concepts and Development Branch; Goddard Space Flight Center
This presentation will focus on projected products that will be available at launch from Earth Observing System (EOS) instruments and will highlight potential commercial uses of EOS data after value-added processing. Specific instruments or collections of instruments could provide vital information for crop futures trading, mineral exploration, media news products, land management and planning, digital map directories, harvest forecasts, and numerous other areas.

Session D

Human Factors Engineering And Life Sciences (Part 2)

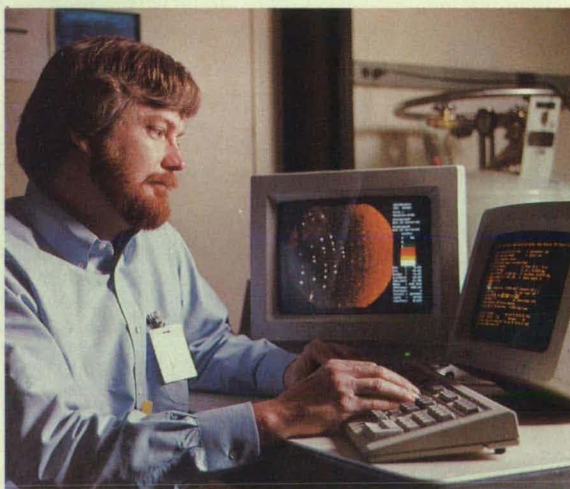
Simulation Of Blood Flow Through An Artificial Heart

Dr. Stuart Rogers and Dr. Dochan Kwak, Ames Research Center; Cetin Kiris and Dr. I-Dee Chang, Stanford University
Using computational fluid dynamics (CFD) techniques first developed for the space shuttle program, scientists have created a computer model of the incompressible viscous flow through an artificial heart. The three-dimensional simulation will help medical researchers to better understand the heart's complex flow field and should lead to improved pump designs.



Three-Dimensional Structure Of Human Serum Albumin

Dr. Daniel C. Carter, Xiao-min, and Pamela Twigg, Space Sciences Laboratory; Marshall Space Flight Center
Using a technique called x-ray crystallography, researchers at NASA Marshall have uncovered the three-dimensional structure of human serum albumin, the principal protein of the circulatory system. Their discovery could lead to major advances in drug design and genetic engineering.



A Noninvasive Measure Of Minerals And Electrolytes In Tissue

Dr. Sara Arnaud, Research Scientist, Ames Research Center; and Dr. Burton Silver, Chairman of the Board and Director of Research, Intracellular Diagnostics Inc.

A novel technique that determines the concentration of ions in the rapidly regenerating cells of the mouth's sublingual area has been applied to the problem of detecting metabolic changes in astronauts during space flight. It uses x-ray microanalysis to quantify the ion concentration in cells that are obtained by scraping the surface of the oral mucosa, a noninvasive means of obtaining tissue. The technique can be adapted to monitor changes in patients with metabolic disease.

Oxygen Production Using Solid-State Zirconia Electrolyte Technology

Dr. Jerry Suitor, Technical Group Supervisor, Thermal Power Conversion Group; Jet Propulsion Laboratory
Because of its ability to conduct ionic oxygen, a solid-state zirconia electrolyte cell can separate oxygen from air and other oxygen-containing gases such as CO₂ and SO₂. Present systems can produce one liter of oxygen per minute. Dr. Suitor will discuss potential applications within the medical field, NASA, the military, and a variety of energy-intensive industries.

Monitoring And Control Technologies For Bioregenerative Life Support Systems

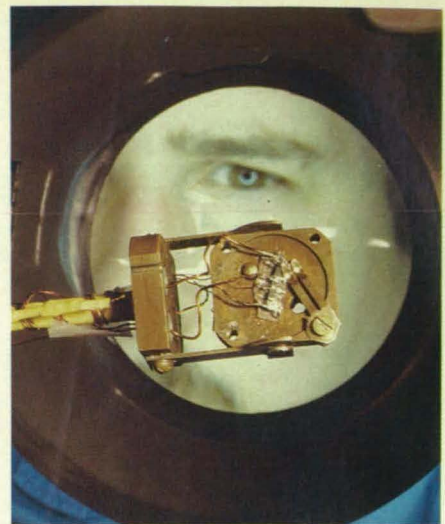
Dr. William Knott, Biological Sciences Officer; Kennedy Space Center
Dr. Knott will describe NASA's efforts to develop monitoring and control technologies for the various modules of a controlled ecological life support system (CELSS). Researchers are developing computer hardware and software, advanced sensors, and other technologies needed to operate biomass production and processing, food preparation, and water recycling modules.

Session E

Materials Science (Part 2)

Silicon Carbide, An Emerging High-Temperature Semiconductor

Dr. Lawrence Matus, Research Scientist, and J. Anthony Powell, Senior Research Physicist; Lewis Research Center
NASA Lewis is developing silicon carbide as a semi-conducting material for operation at temperatures in excess of 600 degrees C. Research is focused on crystal growth, characterization, and device fabrication technologies necessary to produce a family of silicon carbide electronic devices and integrated electronic sensors. Aerospace applications for high-temperature electronic devices include engine ground test instrumentation, engine control and conditioning monitoring systems, and power



Explore new developments in materials science, including advanced ceramics, plastics, and metals.

conditioning and control systems for satellites. Industrial uses include deep-well drilling instrumentation, nuclear reactor instrumentation and control, and automotive sensors.

Flexible Fluoropolymer-Filled Protective Coatings

Bruce Banks, Chief, Electro-Physics Branch, and Michael Mirtich, Research Physicist; Lewis Research Center
Metal oxide films such as SiO₂ provide an effective barrier to the transport of moisture and gaseous species through polymeric films. Such thin film coatings have a tendency to crack upon flexure of the polymeric substrate. Sputter co-deposition of SiO₂ with 4%-15% fluoropolymers has been shown to produce thin films with glass-like barrier properties that have significant increases in strain-to-failure, thus improving the tolerance to flexure on polymeric substrates. Deposition techniques for producing these films are suitable for durable food packaging and oxidation/corrosion protection applications.

A Conformal Oxidation-Resistant, Plasma-Polymerized Coating

Dr. Morton Golub, Dr. Theodore Wydeven, and Dr. Narcinda Lerner, Research Scientists; Ames Research Center
In this presentation Ames scientists will report results from a comparative study of the surface recession (etching) of thin films of plasma-polymerized tetrafluoroethylene (PPTFE), ion-beam sputter-deposited polytetrafluoroethylene, and PTFE exposed to ground-state atomic oxygen [O₃P] downstream from a nonequilibrium RF O₂ plasma. A thin, conformal coating of PPTFE was found to protect an underlying reactive polymer against attack by O₃P until the PPTFE was fully etched away. A plasma-polymerized fluorocarbon coating such as the one prepared and studied in this work may be used in space to protect polymers that are sensitive to oxidation or degradation by oxygen atoms.

Flame-Retardant Composite Materials

Demetrius Kourtides, Materials Engineer; Ames Research Center
Mr. Kourtides will review the thermal and flammability properties of composites fabricated with epoxy and other thermally-stable resin matrices. Factors to be evaluated include limiting-oxygen index, smoke evolution, thermal degradation products, total-heat release, heat-release rates, mass loss, flame spread, ignition resistance, thermogravimetric analysis, and selected mechanical properties.

Meet top NASA researchers, including Dr. Daniel Carter, NASA inventor of the Year.

Superplastic Forming Of Al-Li Alloys For Lightweight, Low-Cost Structures

Stephen Hales, AS&M; and John Wagner, Materials Div., Langley Research Center

Superplastic forming (SPF) of advanced aluminum alloys is being evaluated as an approach for fabricating lightweight, high-efficiency structures at lower cost. Superplasticity is the ability of specially processed material to sustain very large forming strains without failure under controlled deformation conditions. SPF technology can be used to create complex structural parts in a single operation while reducing fabrication costs by up to 40 percent compared to conventional multiple-step forming operations. Details involved in the application of this technology to commercial aluminum-lithium alloys will be discussed.

Localized Corrosion Of High-Performance Metal Alloys In An Acid/Salt Environment

Lewis MacDowell, Materials/Corrosion Engineer; Kennedy Space Center

Various vacuum-jacketed cryogenic supply lines at the space shuttle launch site in Florida use convoluted flexible expansion joints. The atmosphere at the launch site has a very high salt content, and during a launch fuel combustion products include hydrochloric acid. This extremely corrosive environment has caused pitting corrosion failure in the thin-walled 304L stainless steel flex hoses. In this presentation, Mr. MacDowell will describe NASA's search for a more corrosion-resistant material. The search focused on 19 metal alloys which were evaluated using electrochemical corrosion testing, accelerated corrosion testing in a salt fog chamber, and long-term exposure at a beach site. As a result of this work, several nickel-based alloys were found to have very high corrosion resistance.

Session F

Optics And Communications

Digital Codec For Real-Time Processing Of Broadcast-Quality Video Signals

Mary Jo Shalkhauser, Digital Systems Engineer, and Wayne Whyte, Jr., Communications Systems Engineer; Lewis Research Center

Advances in very-large-scale integration and recent work in bandwidth-efficient digital modulation techniques have combined to make digital video processing technically feasible and potentially cost-competitive for broadcast-quality television transmission. A hardware implementation has been developed for a DPCM-based digital television bandwidth compression algorithm which processes

standard NTSC composite color television signals and produces broadcast-quality video in real time at an average of 1.8 bits/pixel. The presenters will describe the data compression algorithm and the hardware implementation of the codec, and provide performance results.

Recent Advances In Coding Theory For Near-Error-Free Communications

Dr. Leslie Deutsch, Manager of Telecommunications and Data Acquisition Technology Development; Jet Propulsion Laboratory

Recent developments in the design and theory of error-correcting codes and data compression techniques have led to increased channel performance and efficiency. Also, new algorithmic techniques have made the corresponding codes easier to implement using microelectronics technology.

Microwave Integrated Circuits For Space Applications

Dr. Regis Leonard, Chief, Solid State Technology Branch; Lewis Research Center

The Lewis Center has sponsored development of a number of state-of-the-art microwave integrated circuits, principally for use in satellite communications systems but with potential application in any microwave/millimeter wave system, including radar and Earth observation systems. Chips developed include high-efficiency power amplifiers at 14, 20, 32, and 60 GHz; low-noise receivers at 32 GHz; and phase shifters at 20, 32, and 60 GHz. The chips employ advanced materials and structures such as AlGaAs HEMT and pseudomorphic HEMT to achieve high power and low noise at millimeter wave frequencies. A discussion of how such modules can be used in phased array antennas will be included.

Optical Communications For Space Missions

Dr. Michael Fitzmaurice, Assistant Chief for Communications Programs, Instrument Div.; Goddard Space Flight Center

Dr. Fitzmaurice will describe the NASA/Goddard Center program in space optical communications. NASA missions likely to benefit from this technology will be discussed and the state of the art in key subsystems will be addressed, as will potential commercial applications.

Optical Shutter Switching Matrix

Charles Grove, Chief, CCMS Engineering Section; Kennedy Space Center

A microminiature optical shutter switch has been developed for ground and space control, command, communications, and telemetric sensing systems. The optically-controlled RF switching module can directly

replace existing electrical or electromechanical switches. It has the potential to replace the contents of five or six large cabinets of switching hardware with a single drawer.

Fiber Optic Tactical Local Area Network (FOTLAN)

Randall Bartman, Member of Technical Staff; Jet Propulsion Laboratory

FOTLAN is a synchronous high-speed fiber optic LAN that supports ordinary data packet traffic over a common channel. The technique can be applied to any deterministic class of data packet networks, including multi-tier backbones that must transport stream data.

High-Precision Applications Of The Global Positioning System

Dr. Stephen Lichtin, Technical Group Supervisor, Earth Orbiter Systems Group; Jet Propulsion Laboratory

The satellite-based Global Positioning System (GPS) provides users with a precise determination of position and time. GPS-based techniques can be utilized for land, sea, air, and space-related applications. In the future, it is expected that GPS or similar receiving equipment will be mass-produced and standardized, bringing the benefits of modern satellite technology to numerous individuals and businesses as well as to the scientific community.

Session G

Sensors and Measurement Technology (Part 2)

Quantitative Nondestructive Evaluation -- Requirements For Tomorrow's Reliability

Dr. Joseph Heyman, Head, Nondestructive Measurement Science Branch; Langley Research Center

Quantitative Nondestructive Evaluation (QNSE) is a technology of measurement, analysis, and prediction of the state of material/structural systems for safety, reliability, and mission assurance. Dr. Heyman will highlight some of the new sciences and technologies that are part of a safer tomorrow, including thermal QNDE to aircraft structural integrity, ultrasonic QNDE to materials characterization, and technology spinoff from aerospace to the medical sector.

Robotic Inspection Verification

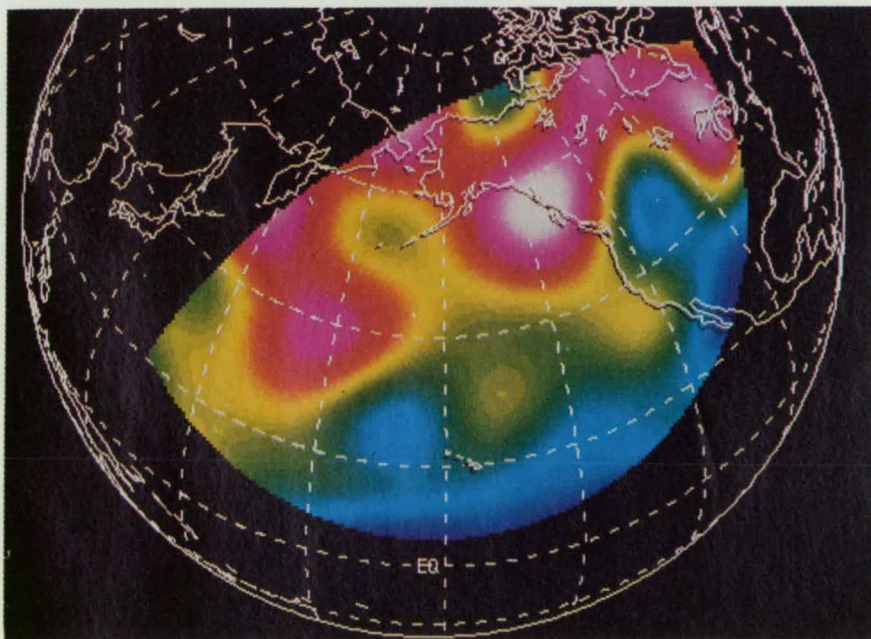
V. Leon Davis, Chief, Robotics Section; Kennedy Space Center

Kennedy researchers have developed nondestructive evaluation devices for processing the space shuttle. One is a tool used to measure the step and gap between the shuttle tiles. Another is an orbiter radiator inspection tool. Both devices are designed to be used as end effectors for robotic mechanisms. A robot is being built to transport the radiator inspection tool along the longitudinal axis of the orbiter while an optical device scans the radiators for cuts, dents, and punctures.

The Transfer Of A Technology To Measure Skin Burn Depth In Humans

Dr. William Yost and Dr. John Cantrell, Aerospace Technologists; Langley Research Center

The use of high-frequency ultrasound for non-destructive evaluation applications has led to the design and development of an instrument to measure skin burn depth. The interaction between theoretical efforts to understand the mechanisms involved in the dynamics of the burn process and the design requirements for a viable burn-depth measurement instrument will be shown as a valuable paradigm for technology transfer. The processes from inception of the idea to transfer of the instrument to a manufacturer will be traced.



NASA experts will describe commercial applications of remote sensing research.



Technology 2000 will spotlight an array of NASA spinoffs, such as an automobile engine that runs on virtually any kind of fuel.

Frequency Domain Laser Velocimeter Signal Processor

James Meyers, Electronics Engineer; Langley Research Center

Langley engineers collaborated with researchers at the Old Dominion University Research Foundation to create an innovative scheme for processing signals from laser velocimeter systems. Their invention is a "smart" digital instrument that reconfigures itself, based on the input signal characteristics, to achieve highly accurate measurements. It can solve fluid flow problems requiring a low signal-to-noise ratio, as in flare conditions associated with near surface measurements, or high accuracy, as in laminar flow measurements.

Field-Deployable Digital Acoustic Measurement System

David Gray, Head, Acoustics and Vibrations Instrumentation Section; Langley Research Center
A portable digital acoustic measurement system has been developed to support acoustic research programs at NASA Langley. The system digitizes acoustic inputs at microphones that can be placed up to 1000 feet from the van housing the acquisition, storage, and analysis equipment. Digitized data from up to 12 microphones is recorded on high-density 8mm tape and analyzed by a microcomputer system. Synchronous and non-synchronous sampling is available with maximum sample rates of 12,500 and 40,000 samples per second respectively. The high-density tape storage system can store five gigabytes of data at transfer rates up to one megabyte per second. System overall dynamic range exceeds 83 dB.

Laser Optical Disk Position Encoder With Active Heads

Eric Osborne, Aerospace Technologist, Instrument Structures Section, Electromechanical Branch; Goddard Space Flight Center

Mr. Osborne will describe an angular position encoder that minimizes the effects of eccentricity and other misalignments between the disk and read stations by employing heads with beam steering optics that actively track the disk in directions along the disk radius and normal to its surface. The device adapts features prevalent in optical disk technology towards the application of angular position sensing.

Session H Superconductivity

Applications Of High-Temperature Superconductors

Dr. Vernon Heinen, Research Scientist; Lewis Research Center

Lewis researchers are creating high-temperature superconductors for aerospace applications, including electronics and space-based power and propulsion. Electronics applications under investigation are chiefly thin film devices for microwave systems. Among the power applications being pursued are superconducting magnetic energy storage and power transmission lines. In the propulsion area efforts are directed toward the application of high-temperature superconducting magnets to magnetoplasmadynamic thrusters, magnetic nozzles, and magnetic bearings. In support of these applications, research is under way to determine and improve the characteristics of superconducting materials in the space environment.

Superconducting Microwave Electronics At NASA Lewis

Dr. Kul Bhasin, Senior Research Scientist; Lewis Research Center

Over the last three years, NASA Lewis has investigated the application of newly-discovered high-temperature superconductors to microwave electronics. Using thin films of YBaCuO deposited on a variety of substrates -- including strontium titanate, aluminum gallate, and magnesium oxide -- a number of passive microwave circuits have been fabricated and evaluated. These include circular microstrip resonators (35 GHz), a cavity resonator (60 GHz), a microstrip filter produced in conjunction with COMSAT Laboratories, and a superconducting antenna array. Performance of these circuits will be reported as well as suggestions for other applications.

Superconductive Wires And Devices For Cryogenic Applications

Dr. John Buckley, Materials Research Engineer, Langley Research Center

Dr. Buckley will discuss methods of fabricating practical electronic circuit elements such as conductors, coils, and connectors with high-temperature ceramics by recognizing the brittle nature of these materials and designing the elements to their greatest advantage. All other known thick film technologies being developed for these materials involve ways of incorporating flexibility into the free-standing ceramic material and its various shapes. Their relative lack of success has inhibited development of actual components and devices. Dr. Buckley will describe the first practical working devices.

Melt-Processed Bulk Superconductor Fabrication And Characterization For Power And Space Applications

Dr. Arthur Thorpe, Professor of Physics; Howard University

Melt-processed bulk superconductors with large current-carrying capacity will be described. Large pieces with controlled oriented microstructure have been fabricated and shaped into cylinders, bars, and plates. Current densities up to 10^4 A/cm² at 77 K have been obtained magnetically and by direct current measurement. The high current density and critical field make these materials attractive for use in areas such as motors and generators, superconducting magnetic storage for power handling, and passive and active levitation bearings for space applications.

Large Gap Magnetic Suspension System Ground-Based Experiment

Nelson Groom, Aerospace Technologist; Navigation, Guidance, and Control Systems; Langley Research Center

The Large Gap Magnetic Suspension System (LGMSS) is a ground-based experiment which will be used to investigate the critical technology issues associated with magnetic suspension, accurate suspended element control, and accurate position sensing at large gaps. This technology will be applicable to future efforts ranging from magnetic suspension of wind tunnel models to advanced spacecraft experiment isolation and pointing systems. Mr. Groom will describe the system and present an analytical model.

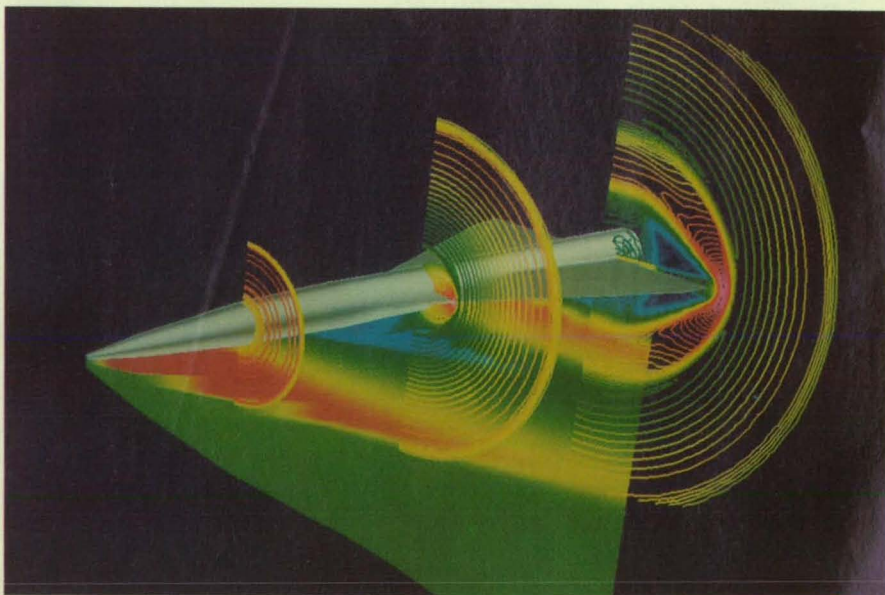
Plenary Session II

2:30 p.m. - 5:30 p.m.

Tapping Into NASA's Technology Storehouse

NASA technology transfer experts will outline the various ways in which conference participants can access NASA's technology and benefit from the agency's scientific and engineering expertise. Attendees will learn:

- ◆ how to get NASA's help in solving technical problems;
- ◆ how to obtain NASA patents and licenses;
- ◆ how to acquire NASA-developed software;
- ◆ how to participate in joint NASA-industry applications engineering projects in which existing aerospace technology is reengineered to meet non-aerospace needs;
- ◆ how to apply for Small Business Innovative Research (SBIR) awards;
- ◆ how to enter into joint research and development projects with NASA.



WHO SHOULD ATTEND TECHNOLOGY 2000

If you are a research director, project leader, design engineer, scientist, technology transfer agent, or small business owner/president, you cannot afford to miss TECHNOLOGY 2000. Top technology managers and researchers have already registered from the aerospace, electronics, computer, industrial equipment, defense, communications, biomedical, materials, power, transportation, and chemical industries. Reserve your place today!

Show Hours

Symposia are scheduled for the 8:30 to 11:00 a.m. and 2:30 to 5:30 p.m. time slots on both Tuesday and Wednesday, November 27 and 28.

Exhibits will be open from 11:00 a.m. to 5:00 p.m. both days.

The Location

All sessions will be held at the Washington Hilton Hotel and Towers, 1919 Connecticut Ave., NW, Washington, DC 20036. A final program will be distributed at registration indicating session room assignments and location. Registrants may then choose which sessions they wish to attend.

Registration Fees

Preregistration: Full registration fee is \$150 and includes technical sessions and exhibits for both days. One-day registration is \$100. Preregistrants may visit the exhibit hall only at a cost of \$20/day. Your badge will be waiting for you in the registration area at the show; a registration confirmation form will be sent to you via mail.

On-site Registration: Full registration will be \$200; one-day registration will be \$125; exhibit hall only will be \$25/day. Registration will be open from 7:30 a.m. to 3:00 p.m. both days.

Save time and money: Preregister using the convenient form below. Clip and mail with your payment to: Technology Utilization Foundation, 41 East 42nd St., Suite 921, New York, NY 10017.

Hotel Accommodations

The following special rates have been negotiated with the Washington Hilton Hotel for TECHNOLOGY 2000 attendees: single room - \$125; double room - \$145. Reservations will be accepted on a first-come, first-served basis and must be made directly with the Washington Hilton Reservations Dept., (202) 483-3000.

Transportation

Ground: The Washington Hilton Hotel is conveniently located near the DuPont Circle stop on the Metro Red Line, and offers plenty of indoor parking.

Air: Special arrangements have been made with United Airlines through Travel Services Group for discounted air fares to attend TECHNOLOGY 2000. You can save up to 40% on coach fares or receive an additional 5% off already discounted fares (with restrictions). Make your reservations as soon as possible to assure the flight schedule of your choice. Call 1-(800)-336-0227 between 9:00 a.m. and 5:30 p.m. Eastern time, Monday through Friday.

The Sponsors

TECHNOLOGY 2000 is sponsored by NASA, NASA Tech Briefs magazine, and the Technology Utilization Foundation, a not-for-profit organization dedicated to technology transfer. For further information contact Joseph Pramberger, show manager, at (212) 490-3999.

SPACE AT TECHNOLOGY 2000 IS LIMITED; RESERVE YOUR PLACE TODAY.

REGISTRATION FORM

DEADLINE FOR RECEIPT: NOVEMBER 9, 1990

Please use separate form for each registrant. Type or print clearly.

Name _____

Title _____ Phone _____

Company _____

Address _____

City/State/Zip _____

Which of the following best describes your industry or service?

- | | | |
|----------------------|----------------------|------------------------|
| A ___ Aerospace | G ___ Government | S ___ Computers |
| D ___ Defense | E ___ Electronics | Q ___ Industrial Eqpt. |
| X ___ Communications | R ___ Research Lab. | C ___ Chemicals |
| Y ___ Consumer gds. | M ___ Materials | U ___ Education |
| P ___ Power/Energy | K ___ Consultant | B ___ Bio-Medical |
| L ___ Library | T ___ Transportation | Z ___ Other _____ |

Your major responsibility is: (Check one)

- | | |
|---|-------------------|
| 1 ___ Management other than engineering | 3 ___ Engineering |
| 2 ___ Engineering management | 4 ___ Research |
| 5 ___ Other (specify) _____ | |

- | | |
|---|----------------------------------|
| 1 ___ General & Corporate Management | 4 ___ Basic Research |
| 2 ___ Design & Development Engineering | 5 ___ Manufacturing & Production |
| 3 ___ Engineering Service-Tests/Quality | 6 ___ Purchasing & Procurement |
| 8 ___ Other (specify) _____ | |

Your engineering responsibility is:

- | | |
|--------------------------------|------------------------------|
| A ___ Manage Engineering Dept. | C ___ Manage a Project |
| B ___ Manage a Project Team | D ___ Member of Project Team |
| E ___ Other (specify) _____ | |

REGISTRATION FEES

Full registration \$150 \$ _____

One day \$100/day (Circle day: Tues. Wed.) \$ _____

Exhibits only \$20/day (Circle day: Tues. Wed.) \$ _____

Total amount due: \$ _____

Full and one-day registrations are transferable, and may be cancelled until Nov. 8 subject to a \$50 cancellation charge. After that date, no cancellations will be accepted and no money will be refunded.

Return with your payment to: Technology Utilization Foundation, 41 East 42nd St., Suite 921, New York, NY 10017

TECHNOLOGY 2000 EXHIBITS: A SHOWCASE OF CUTTING-EDGE TECHNOLOGY

The following companies and research institutions will be among the more than 150 exhibitors displaying new products and technologies at **TECHNOLOGY 2000**. Exhibit hours are 11:00 a.m. to 5:00 p.m. on both Tuesday and Wednesday, November 27 and 28.

Ames Research Center
Aerospatiale
AMP Inc.
Arthur D. Little
Astro-Med
Carnegie Mellon Robotics Institute
Computer Software Management and Information Center (COSMIC)
Corning Inc.
County of Loudoun, Virginia
Cybernet Systems
Datatape Inc.
Deltek Systems
Design And Evaluation
Dimension Technologies
Dolphin Scientific
Eastman Kodak Company
EG&G Idaho
Fairchild Space
Goddard Space Flight Center
GRAFkit
Grumman Space Systems
Hewlett Packard Co.
High Tech Services
Hitachi Chemical Electro-Products
Hi Techniques
Hughes Aircraft
Hyperception
Ideas Inc.
Inductron Corp.
Information Development Inc.
Information Handling Services
Instrument Technology Inc.
Jet Propulsion Laboratory
Johnson Space Center
JP Technologies
JR 3 Inc.
Kennedy Space Center

Langley Research Center
Lewis Research Center
Lockheed Missiles & Space Co.
Lucas Datalab
Marshall Space Flight Center
Martin Marietta Astronautics Group
Martin Marietta Manned Space Systems
Mechanical Technology Inc.
MGA Inc.
Micro Industries Corp.
Micro Surface Corp.
Mikron Instrument Co.
Motorola Inc.
NASA Industrial Applications Center (NIAC)/Applied Research
NASA Technology Utilization Program
National Standards Association
National Technology Transfer Society
NERAC Inc.
Nicolet Instrument Corp.
Novespace
Numerical Algorithms Group
OCA Applied Optics Inc.
OCA Lambda
Olympus Industrial Fiber Optics Div.
Optical Coating Lab Inc.
Pacific Precision Labs Inc.
Pantech Inc.
PMS Electro Optics
Primavera Systems Inc.
Ramtek Corp.
Raytheon/BSA
RGB Spectrum
RG Hansen & Associates
Ribbon Technology Corp.
Rocketdyne

Rockwell International
Rotating Memory Services
Satellite Data Systems
Scientific and Technical Information Facility (STIF)
Sensor Developments Inc.
Silicon Graphics
Southern Technology Applications Center (STAC)
Stennis Space Center
Stephens Analytical
Structural Research & Analysis Corp.
Symbolics Inc., MACSYMA Div.
Technology Application Center (TAC)
Tennessee Technology Foundation
Texas Innovative Information Network System
Textron Specialty Materials
Thermion Inc.
Thiokol
Tiodize
TRW Space and Technology
Turbomixer Corp.
University of Dayton Research Institute
University of Florida
United Technologies USBI
Valcor Engineering Corp.
Vermont Research Corp.
Vetronix Research Corp.
Virginia Center for Innovative Technology
VI Corp.
Water Filter Company of America
Wave Shield Technology
WL Gore & Associates Inc.
Wolfgram Research
Zircar
Zitel

These high-tech leaders will be displaying a wide array of inventions and products available for license or sale, including 3D computer monitors, CD-ROM databases, scientific and engineering software, high-performance workstations, real-time video systems, remote sensing equipment, remote vision instruments, dexterous robot controllers, fluid control components, cryogenic systems, high-strength composites, film deposition techniques, high-temperature lubricants, advanced engine concepts, HeNe lasers, optical components, desktop signal processors, digital signal processing software, digital storage oscilloscopes, and much, much more!

NASA exhibits will feature such innovations as high-tech exercise hardware, an ingestible temperature pill, a medical information management system, an electro-expulsive aircraft deicing system, a "smart" hydrogen sensor, an advanced liquid hydrogen transfer pipe, neural network technologies, and a PC-based image display system for scientific applications.

For information on having your company exhibit at **TECHNOLOGY 2000**, contact Joseph Pramberger or Evelyn Mars at (212) 490-3999.

Books and Reports

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

Behavior of Evaporating Liquid Drops in Clusters

Progress in understanding combustion of sprayed fuels and related phenomena is discussed.

A report presents a critical analysis of methods, developed during recent years, for calculating the behavior of evaporating liquid drops in dense and dilute clusters. These methods are essential to understanding the variety of physical and chemical phenomena that occur in the combustion of sprayed fuels and in the sprays used in agriculture, the food industry, and painting. The report includes an extensive review of contributions made by the author and others and presents insights on important aspects of two-phase flow.

The first section of the report is an introduction. It discusses the motivations for studies of this kind, then presents a summary of previous studies in the context of both the previously evolving and current partial understanding of the phenomena. It includes a topic that is essential to understanding the remainder of the report: the characterization of sprays by the simultaneous use of widely different length scales. These include the scale of the enclosure, if any, where the liquid is sprayed; the many scales associated with the turbulence; the scale of interactions among drops; the average distance between drops; and the sizes of the drops. The wide disparities (typically, many orders of magnitude) among these scales makes an accurate mathematical description at all scales impractical. One way to circumvent this difficulty is to perform detailed calculations on behavior of the macroscale (which is the scale where the phenomena of interest to engineers occur) while computing the behavior on the much smaller microscale in an approximate and global manner.

The coupling between the two scales must be achieved through the boundary conditions at the microscale level. A microscale formulation is also sometimes called a subscale or subgrid model because the phenomena that are involved occur at a scale much smaller than that of the grid size used to solve the macroscale problem computationally. Inherent to this two-level description is the understanding that the sub-

scale models are more approximate than the macroscale models are and lack the detail that the latter ones are required to have in order to be useful.

The second section of the report presents a survey of mathematical models that pertain to interactions among a few drops. While these models are of interest in helping to understand departures from models of single, isolated drops, they cannot realistically represent the behavior of large numbers of drops, and, therefore, are not candidate subgrid models. Moreover, these models are not economically suitable as subgrid models because they require excessively large computational resources.

The third section discusses the approach taken by the author and her coworkers in the mathematical modeling of interactions among many drops. The topics in this section include (1) constant-volume (variable-pressure) cluster models of evaporation of drops and (2) constant-pressure (variable-volume) cluster models of evaporation of drops, ignition and combustion of drops, and evaporation and dispersion of electrically charged drops. It is shown that despite some shortcomings, the approach described may be useful in the development of subgrid models.

The fourth section draws conclusions from the various models and from the results of specific computations performed with them. In particular, it describes the major differences between the evaporation, ignition, and combustion behaviors of dense and dilute clusters of drops. It suggests ways in which understanding of the phenomena in sprays can be improved by future research.

This work was done by Josette Bellan of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Liquid Drop Behavior in Dense and Dilute Clusters," Circle 119 on the TSP Request Card.

NPO-17843

Directional Solidification of Monotectic Alloys

Conditions that promote the formation of aligned fibers are sought.

A report describes experiments in the directional solidification of Cu/Pb and Bi/Ga monotectic alloys. (A monotectic alloy is one in which the temperature-versus-composition phase diagram is characterized by

Cryogenic and Vacuum Magnetic Shields

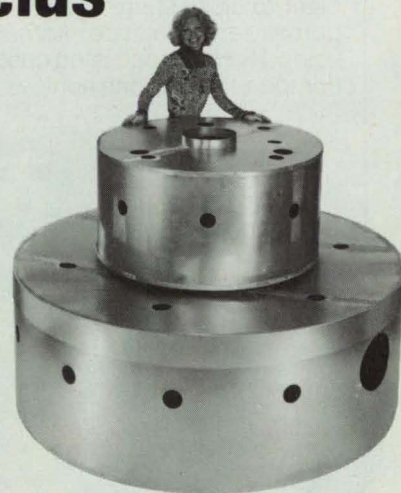
Provide maximum attenuation of interference from Earth's field, pumps and accessories.

Shields are constructed from our high permeability CO-NETIC Alloy, fully annealed after fabrication.

Send For New CV-1 Catalog



MAGNETIC SHIELD CORP.
PERFECTION MICA CO.
740 North Thomas Drive
Bensenville, IL 60106, USA
Phone 708-766-7800
TWX 910-256-4815
FAX 708-766-2813

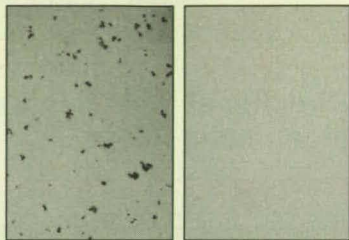


Please Call or Write
For Design Assistance

HOWMET PROVIDES TOLL HIP SERVICES TO THE ENTIRE CASTING INDUSTRY.

It's not surprising that some people still think Howmet provides Hot Isostatic Pressing only to the aerospace industry. Because that's where we built our reputation for excellence.

In fact, Howmet is one of the largest suppliers of HIP to the chemical, medical, and elec-



Photomicrograph shows microshrinkage in as-cast condition A356 aluminum. Magnification: 3x

Microshrinkage was eliminated by HIP (970° F/15,000 PSI/2 hours). Magnification: 3x

tronics industries and the entire casting industry. With our 6 HIP units, Howmet can handle small prototype work or large structural castings up to 57" in diameter. With temperature capabilities up to 4000° F and pressure to 45,000 psi.

HIP subjects components to a high inert gas pressure at elevated temperatures sufficient to close shrinkage porosity and eliminate internal voids. By HIP processing cast components you can achieve

the same consistency expected of forgings. HIP is bill of material on most titanium and many superalloy components with performance improvements noted in steel, bronze, cast iron, ceramics and aluminum.

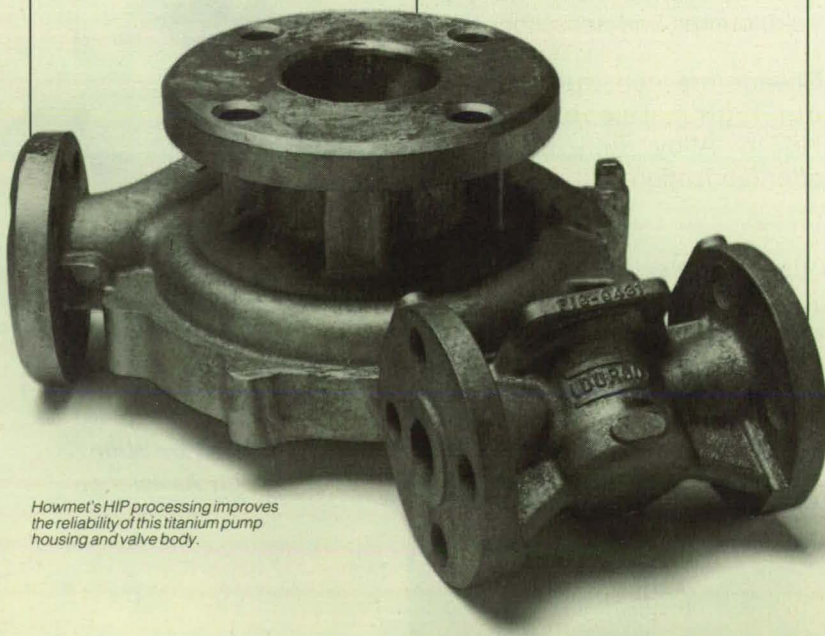
HIP has become a significant factor in materials engineering. It enhances performance, improves fatigue strength, and reduces scrap. By incorporating HIP into the casting process, a more reliable and consistent component can be manufactured.

At Howmet our engineers work in partnership with you. For example, we can design a parametric evaluation to determine the benefits of HIP on your particular application. We welcome your challenges.

For more on Howmet's HIP services, write our Sales Department, Howmet Corporation, 475 Steamboat Road, Greenwich, CT 06836-1960. Or contact the manager of the Whitehall HIP Division, 1600 South Warner Road, Whitehall, MI 49461, telephone (616) 894-5686.



Partners. Challenge by Challenge.
WHITEHALL HIP DIVISION, WHITEHALL, MI



Howmet's HIP processing improves the reliability of this titanium pump housing and valve body.

a dome-shaped region in which two liquid metals are immiscible.) This study was motivated by the need to understand the physical mechanism that governs the formation of rodlike or fiberlike aligned structures in the solidifying alloy and to determine the process conditions that favor such structures.

In this study, samples of the alloys were directionally solidified both upward and downward in normal gravitation at various furnace-translation rates and temperature gradients. Similar experiments were performed in simulated low gravitation aboard a KC-135 airplane flying along a parabolic trajectory. Solidified specimens were cut along and across the axes of solidification, ground, polished, and photographed under both visible-light and scanning electron microscopes. Compositions were measured by x-ray microanalysis in the scanning electron microscope.

The hypomonotectic Cu/Pb alloys (those with nonimal Pb contents below the monotectic composition) were found to have solidified with equiaxed copper grains containing trapped intragranular lead. The absence of convection and sedimentation in low gravitation resulted in larger copper grains.

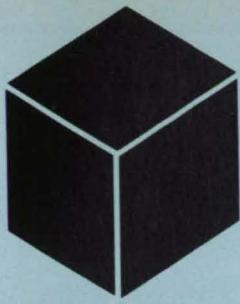
The formation of fibrous composite structure can be explained in terms of a version of a previously enunciated mechanism for the engulfment and pushing of particles. In a hypermonotectic Cu/Pb alloy, at a low speed of the solidification front, the lead droplets are apparently either pushed by the solidifying interface, occasionally becoming engulfed, or coalesce and form lead-rich bands. At a high speed, the droplets are apparently continuously engulfed to form fibers.

High gravitation was found to be more favorable than is low gravitation for the initiation of growth of fibers. However, once fibers have started to form, they continue to grow in low gravitation. The distances between fibers formed in low gravitation were slightly greater than those formed in high gravitation.

In the Bi/Ga samples, the dominant structure consisted of Ga-rich droplets in a Bi matrix. Short fibers grew only at very high rates of solidification. When the differences between the properties of Bi/Ga and Cu/Pb were taken into account, these observations were found to be consistent with the details of the theory of pushing and engulfment.

This work was done by B. K. Dhindaw, D. M. Stefanescu, A. K. Singh, and P. A. Currier of the University of Alabama for Marshall Space Flight Center. To obtain a copy of the report, "Directional Solidification of Cu-Pb and Bi-Ga Monotectic Alloys Under Normal Gravity and During Parabolic Flight," Circle 122 on the TSP Request Card.

MFS-26080



Materials

Hardware, Techniques, and Processes

63 Making Self-Lubricating Parts by Powder Metallurgy

63 Milder Etchant for Penetrant Inspection

Books and Reports

64 Process for Autoclaving HMW PMR-II Composites

Making Self-Lubricating Parts by Powder Metallurgy

Thick parts can be made with minimal waste.

Lewis Research Center, Cleveland, Ohio

Compositions and parameters of powder-metallurgical fabrication processes have been determined for a new class of low-friction, low-wear, self-lubricating materials. These materials can be used in oxidizing or reducing atmospheres (e.g., air or hydrogen, respectively) in bearings and seals, for example, at temperatures from below 25 °C to as high as 900 °C.

The new composites are derived from plasma-sprayed self-lubricating coating compositions previously developed at Lewis Research Center. Plasma spraying is unsuitable for making such thick or freestanding parts as bearings, bushings, valve seats, and gears. Plasma spraying also wastes material — an especially important consideration where precious metals are components of the compositions. Furthermore, in plasma spraying, it is difficult to control the composition of the deposited alloy because the different components have different deposit efficiencies.

A representative alloy of the new type is specified from among the following components and ranges of compositions:

- 30 to 70 weight percent of chromium carbide, hafnium carbide, or other carbide resistant to oxidation;
- 5 to 20 weight percent of soft noble metal, usually silver or gold;
- 5 to 20 weight percent of high-temperature solid lubricants, which consist of fluorides of metals of group I or II of the periodic table, fluorides of rare-earth metals, or mixtures of such fluorides; and
- 20 to 60 weight percent of a metal binder, which can be an alloy of nickel, cobalt, or both.

The component powders are blended in the desired proportions, then processed into parts by one or more powder metallurgical processes. For example, in one case cold mechanical pressing might be followed by cold or hot isostatic pressing, then by sintering. In another case, there might be a single step involving hot mechanical pressing. Typical processes and their parameters include the following:

- Cold mechanical pressing at a temperature of 25 °C and a pressure of 5 to 20 kpsi (35 to 140 MPa);

- Cold isostatic pressing at 25 °C and a pressure of 40 to 80 kpsi (280 to 560 MPa);
- Sintering at 900 to 1,200 °C for 10 to 30 min in hydrogen or inert gas at a pressure of 1 atm (0.1 MPa);
- Hot isostatic pressing at 900 to 1,200 °C, at a pressure from 20 to 60 kpsi (140 to 420 MPa); or
- Hot mechanical pressing at 900 to 1,200 °C, at a pressure from 20 to 60 kpsi (140 to 410 MPa), in an atmosphere of hydrogen or an inert gas.

This work was done by Harold E. Sliney and Christopher DellaCorte of Lewis Research Center. For further information, Circle 42 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 16]. Refer to LEW-14902.

Milder Etchant for Penetrant Inspection

The etchant does not introduce artifacts that can be mistaken for defects.

Marshall Space Flight Center, Alabama

The use of a new etching solution for chemical penetrant inspection of Inconel* 718 castings and weldments avoids ambiguous indications. A batch of the solution is composed of

- 250 g ferric chloride hexahydrate,
- 200 mL hydrochloric acid, reagent grade,
- 70 g oxalic acid, dihydrate, and
- 250 mL methanol, absolute.

It replaces a prepenetrant etchant, composed of 50 percent hydrochloric acid and 50 percent hydrogen peroxide, that tended to overetch, causing pitting and intergranular attack. After that penetrant is applied, such artifacts are difficult to distinguish from the original defects and, like the original defects, were unnecessarily removed by machining grinding.

The new etchant can be applied by swabbing or by immersion. The previous

etchant was applied by swabbing the surface to be inspected; then if not removed after 10 to 30 seconds, any additional time is sufficient to overetch the material. In contrast, the dwell time for the new etchant is 120 to 180 seconds. The user therefore has more time to apply the solution thoroughly and prepare for penetrant inspection. Even when the dwell time is doubled over that recommended, there is no overetching. Moreover, because the new solution does not effervesce during application, the surface is not obscured, and the progress of the etch can be monitored visually.

The solution has a long shelf life. It can therefore be prepared in the laboratory under controlled conditions and stored until use, so that there need be no risk of incorrect mixing in the shop. The solution presents no hazards when used according

to standard safety procedures. It can also be used to detect unwanted residues of Niro* (or equivalent) gold brazing alloy on type 347 stainless steel.

*"Inconel" is a registered trademark of the INCO family of companies.

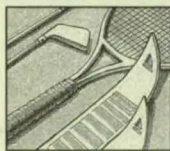
*"Niro" is a registered trademark of WESGO Division, GTE Products Corp.

This work was done by Joseph E. O'Tousa and Clark S. Thomas of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-29645.

COMPOSITE BRAIDING

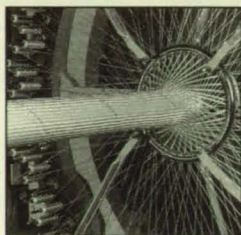
It's faster than filament winding,
cheaper than pre-preg roving,
and cleaner than in-line impreg.



Wardwell composite braiders produce rocket-motor exit cones and ignitors, rotor and propeller blades, thermoplastic airframe stiffeners, windmill spars, pressure vessels, skis, bicycle frames, tennis racquets, and more. Composite braiding deals more effectively with complex surfaces, offers superior parts versatility, tremendous hoop strength, and works with a wide variety of materials, including Kevlar, fiberglass, and carbon fibers. Find out how Wardwell's experience can help you bring life to your most challenging assignments.

Our experience is the difference

Call (401) 724-8800
or write for our composite story.



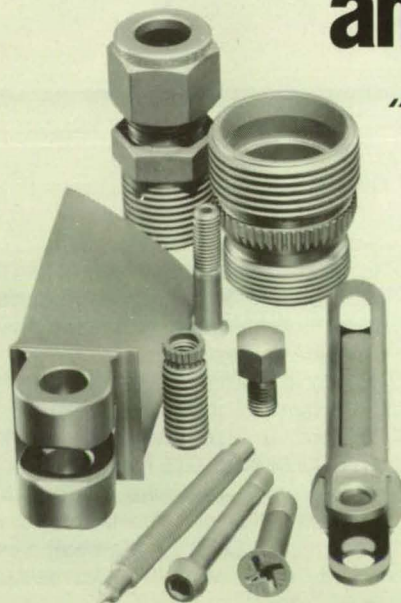
WARDWELL

WARDWELL BRAIDING MACHINE CO.

1211 High Street, Central Falls, RI 02863 USA
(401) 724-8800 Fax: (401) 723-2690 TWX: 710 384-1305

Circle Reader Action No. 396

The TIODIZE PROCESS and Titanium



"Created for Each Other"

- STOP GALLING
- REDUCE FRICTION
- PREVENT CORROSION
- CORRECT EMISIVITY

The TIODIZE PROCESS is an electrolytic conversion coating that produces anti-galling, wear resistant properties in titanium and its alloys with no dimensional change.

The TIODIZE PROCESS can be combined with a multitude of coatings to help solve your problems.

Contact TIODIZE for more information.

TIODIZE®



15701 INDUSTRY LANE • HUNTINGTON BEACH, CA 92649
(714) 898-4377 • FAX: (714) 891-7467

Circle Reader Action No. 422

Books and Reports

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

Process for Autoclaving HMW PMR-II Composites

The qualities of autoclaved parts are equivalent to those of compression-molded parts.

Parts made of graphite-reinforced, high-molecular-weight (HMW) PMR-II polyimide are easy to fabricate by autoclaving, a study has found. The study, described in a 16-page report, showed that autoclaved HMW PMR-II parts are equal in quality to those made by compression molding. The PMR-II parts are well suited to use at temperatures up to 700 °F (371 °C). In aircraft engines, for example, they offer the advantages of strength and light weight.

The study was aimed at improving the processability of low-flow HMW formulations of PMR-II polyimides. The HMW PMR-II resins provide improved thermooxidative stability over low-molecular-weight formulations but are much less tractable and require high molding pressures.

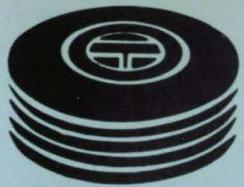
The study resulted in the development of a new autoclave curing process for HMW PMR polyimide composite materials. The process requires the use of high vacuum for consolidating the material before it advances to the intractable state and requires pressures of 200 psi (1.38 MPa) or less.

Graphite-fiber reinforced laminates were prepared with HMW PMR-II resin using both high-compression and autoclave fabrication processes. The laminates were isothermally exposed in the air at 650 °F (343 °C) and 700 °F (371 °C). After 500 hours exposure at 700 °F (371 °C), specimens lost only 8 percent of their weight, while specimens exposed longer than 750 hours at a lower temperature lost only 5 percent. All the exposed specimens retained greater than 90 percent of their original elevated-temperature flexural and interlaminar shear strengths.

This work was done by Raymond D. Vannucci and Diane Cifani of Lewis Research Center. Further information may be found in NASA TM-100923 [N88-24712], "700 °F Properties of Autoclave Cured PMR-II Composites."

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-14839

NASA Tech Briefs, September 1990



Computer Programs

- 65 Computing Scattering Matrices for Circular Waveguides
- 66 Diffraction Analysis of Distorted Reflector Antennas
- 66 Calculating Performances of Fabry-Perot Etalons
- 67 Computing Impingements of Rocket Exhausts
- 68 Simplified Calculation of Solar Fluxes in Solar Receivers
- 68 Flexible Animation Computer Program
- 68 SINDA '85/FLUINT, Version 2.2

COSMIC: Transferring NASA Software

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

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

If you don't find a program in this issue that meets your needs, call COSMIC directly for a free review of programs in your area of interest. You can also purchase the annual *COSMIC Software Catalog*, containing descriptions and ordering information for available software.

COSMIC is part of NASA's Technology Utilization Network.

COSMIC®—John A. Gibson, Director, (404) 542-3265
The University of Georgia,
382 East Broad Street,
Athens, Georgia 30602

Computer Programs

These programs may be obtained at a very reasonable cost from COSMIC, a facility sponsored by NASA to make computer programs available to the public. For information on program price, size, and availability, circle the reference number on the TSP and COSMIC Request Card in this issue.



Electronic Components and Circuits

Computing Scattering Matrices for Circular Waveguides

This program computes scattering at junctions between sections on a common axis.

Accurate computer modeling of passive circular waveguide components is often required during design for optimization of frequency response and/or determination of the tolerances required of components in order to meet radio-frequency specifications. Many circular waveguide devices can be represented either exactly or approximately as series of circular waveguide sections that have a common axis. In addition, smooth tapers and horns of arbitrary profile can be approximated by series of small steps. The Scattering Matrix Program for Circular Waveguide Junctions computes the scattering matrix for a series of circular waveguide sections. These sections must have the same axis, but the radius and length of each section are completely arbitrary.

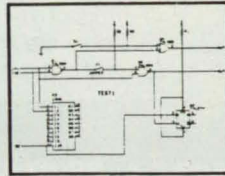
Devices that can be analyzed include a simple waveguide step discontinuity like that used in a dual-mode horn, a stepped matching section, or a corrugated waveguide section with constant or varying slot depth. Certain types of corrugated horns can also be analyzed with this program. The mathematical model used in the program accurately predicts the reflection and transmission characteristics of such devices, taking into account the excitation (if it occurs) of modes of higher order as well as multiple reflections and energy stored at each discontinuity.

For a device that is large with respect to a wavelength, in which many modes can propagate, the reflection and transmission

NASA Tech Briefs, September 1990

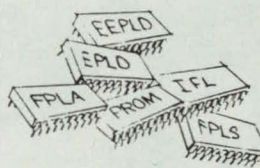
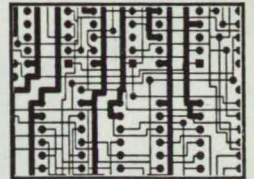
SCHEMA MEANS PERFORMANCE

Over 15,000 engineers have chosen SCHEMA CAE products. Why? SCHEMA products offer the most power, the features, ease of use, and support that serious designers need...at an affordable price.



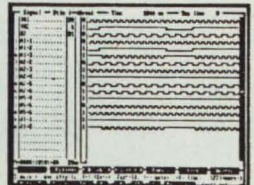
SCHEMA III, a powerful PC-based schematic capture system with workstation features such as unlimited hierarchies, smooth pan, direct PCB interface, AutoCAD DXF block output, 7000+ unique part library & extensive DRC's. Not copy protected. \$495 worldwide!

SCHEMA PCB board layout tool with autoplacement, autoroute, graphic and manufacturing output options. 3,500+ part library. Act now and receive PCB, with Autorouter & Photoplot output for only \$1495, a savings of over 20%!



SCHEMA PLD logic compiler. Rapid design & selection of PLD's. Schema III, truth tables, equation, or state machine entry. Five minimization techniques. JEDEC output. Not copy protected. Only \$495.

SCHEMA SUSIE interactive logic simulator. Verify design in unit delay mode or actual timing to 10 picoseconds for TTL, CMOS, MPU, PLD and other devices. Auto test vector generation. From \$995



FREE DEMO DISKS

FREE 1-800 SUPPORT

30 DAY MONEY BACK GUARANTEE

1-800-553-9119

OMATION

Circle Reader Action No. 338

properties may be required for a mode of higher order or for a series of modes exciting the device. Such interactions are represented best by defining a scattering matrix for the device. The matrix can be determined by matching modes at each discontinuity. The results for individual discontinuities are then cascaded to obtain the matrix for the entire device.

This program was written in FORTRAN 77 for execution on a UNIVAC 1100 series computer. IMSL subroutines are required. This program was developed in 1987.

This program was written by Daniel J. Hoppe of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 121 on the TSP Request Card. NPO-17245

Diffraction Analysis of Distorted Reflector Antennas

The effects of systematic distortions of surfaces on radiation patterns are predicted.

The increasing use of multiple- and contour-beam satellite and low-sidelobe tracking-radar reflector antennas demands accurate estimates of the sidelobe levels and overall characteristics of patterns in terms of errors of the reflector surfaces. These estimates are important in evaluating the levels of isolation between beams for a non-

interfering multiple-beam communication system and for systems with stringent sidelobe requirements.

In predicting the performance of antenna systems, it has been found that far-field patterns can be very different from statistically computed average patterns because of irregularities induced by such factors as gravitation, heat, mechanical movement, and manufacturing irregularities. The computer program for Diffraction Analysis of Reflector Antennas Subject to Systematic Distortions addresses these problems by predicting the performance of reflector antennas subject to sinusoidal, thermal, or gravitational distortions.

Particular attention is given to a situation in which the antenna surface is described only at discrete points. In many cases, the prescribed discrete points do not lie on a regular grid — a condition that typically makes the task of locating them more complex. This program provides a local interpolation algorithm that can be readily applied to a nonregular distribution of data.

The program was developed in UNIVAC FORTRAN 77 for a UNIVAC computer. The IMSL library or similar subroutines are required. Some of the routines were written for use with JPL's Athena FORTRAN compiler (TFOR) and may not compile directly on a standard compiler. Since TFOR is a subset (with minor discrepancies) of FORTRAN 77, it should be a simple task to upgrade the code to FORTRAN 77 standards. Tips for removing UNIVAC-dependent features are included in the update documentation. The program was written in 1985 and updated in 1987.

This program was written by Yahya Rahmat-Samii and Jeffrey H. Mumford of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 45 on the TSP Request Card. NPO-16818

When you need to get a better grip, you need MSI.



Some tracking, positioning and control problems simply call for getting a better grip. In these cases, MSI offers handgrips with a virtually open-ended choice of push button, trigger, and thumb-activated auxiliary controls. All of our grips can be custom configured to your most exacting specifications or unique requirements.

For any environment or application

demanding the ultimate in hands on technology, specify and insist on MSI controls. All quality built for maximum value.

When you need a solution to a technical control problem, call us and we'll be there. More information about MSI precision engineered handgrips, joysticks, trackballs and other controls is yours for the asking.



Hands on Technology Measurement Systems, Inc.,

121 Water Street, Dept. 194 South Norwalk, Connecticut 06854 USA
Phone: (203) 838-5561 Fax: (203) 853-6244

A Dover Technologies Company



Physical Sciences

Calculating Performances of Fabry-Perot Etalons

Effects of changes in design can be determined quickly.

Fabry-Perot etalons are optical filters used to select wavelengths in lasers, radiometers, and other electro-optical devices. The Etalon Model computer program implements a stand-alone mathematical model of an etalon. It is designed to perform calculations over many wavelengths. The model can be used to determine the sensitivity of a filter to changes in temperature, thickness tolerances, or alignment angles of an etalon design. A pre-processor and postprocessor are included to facilitate case studies.

The Etalon Model program calculates several performance parameters of etalons. NASA Tech Briefs, September 1990

lons by use of equations in closed form. It calculates the transmission as a function of wavelength and uses the transmission data to determine additional performance parameters. The calculations are done for two etalons. The first etalon, which is the collimated, untilted etalon, is considered to be placed in a collimated optical beam with the beam at normal incidence; the second etalon, which is the uncollimated, tilted etalon, is considered to be placed in a converging beam at nonnormal incidence. The program is intended to be used for comparison of measurements of an etalon in a collimated beam with the performance of the etalon in an alternative system. The program calculates the parameters for multiple passes through the etalon.

The Etalon Model program was developed on an IBM PS/2 Model 80-071 computer using the Microsoft version 4.01 FORTRAN compiler. It has been implemented under DOS 3.21 and has a memory requirement of 167K. The Etalon Model program was developed in 1988.

This program was written by Patricia L. Cross and Clayton H. Bair of Langley Research Center. For further information, Circle 68 on the TSP Request Card. LAR-14055

Computing Impingements of Rocket Exhausts

The user can choose among a variety of configurations, data, and theories.

SFPLIMP, the Source Flow Plume Impingement Program, computes the forces, moments, contamination, and heating rates caused by the impingement of plumes on orbiting spacecraft from jets firing at high altitudes. A mathematical model can be developed for any type of jet impinging on a wide range of configurations defined by the user.

Input data on jets include the number of jets, location and/or orientation, and the chemical composition of the plume (each species and its mole fraction). A table of chemical species containing heating-rate data, vapor-pressure data (where available), and evaporation-rate data (where available) is provided. Species not in the table can be used if heating rates are not required. Species for which vapor-pressure data do not exist are assumed to stick to surfaces, no matter what flow-field conditions exist. Evaporation-rate data for species not provided by SFPLIMP may be inserted by the user.

The target can be modeled mathematically by combining flat plates and three-dimensional shapes. Available subshapes include right triangles, rectangles, circles, circular cones, circular cylinders, spheres, and polynomials of revolution. Temperature can be calculated globally or for each component in the target.

Forces and moments on the spacecraft are computed for the continuum, transition, and free-molecular regions. Results from continuum regions have been enhanced through the incorporation of tables of data for orbiter primary and vernier reaction-control-system jets. The user has control over the impact theory used. Choices are Newtonian, modified Newtonian, or corrected modified Newtonian. Contamination levels are modeled mathematically through the determination of maximum deposition rates on each subshape of the configuration or the net deposition (including evaporation) on each subshape. Free-molecular heating rates are computed in the far-field region. Convective laminar and turbulent-boundary-layer heating rates in the continuum region are computed for each subshape. Samples include mathematical models of several space-station configurations and the Hubble Space Telescope.

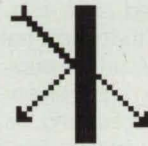
SFPLIMP is written in FORTRAN 77 (99 percent) and VAX DCL screen-management utilities (1 percent, not essential) for use on a DEC VAX 11/780 computer running under VAX VMS 4.6. Version 3.2 was developed in 1988.

This program was written by M. Cerimele and B. Drake of Lockheed Engineering & Management Services Co. for Johnson Space Center. For further information, Circle 87 on the TSP Request Card. MSC-21419

Thin Film Coating Design on the Macintosh™

TFCalc™ software features:

- optimization • dispersion •
- absorption • reflection •
- transmission • phase shift •
- electric field • finite substrate •
- illuminant, material, and substrate files • stack formulas •
- coatings on both sides of substrate •
- computes up to 2000 layers/sec •
- easy to use • excellent graphics •
- complete Macintosh interface •
- demo package available •
- new, low price: \$995 •

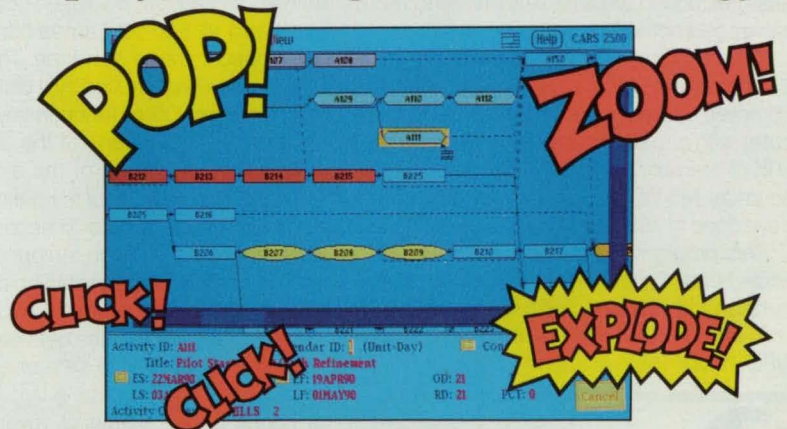


SOFTWARE SPECTRA, INC.
11070 Overland Avenue
Culver City, CA 90230

Phone: (213) 204-6589
Fax: (213) 838-3018

Circle Reader Action No. 509

Primavera introduces some important new project management terminology.



Primavera Project Planner® 4.0 works like you think. Visually. Graphically. Intuitively. As quickly as "pop", "click", "zoom"! Keeping you in touch with the big picture while giving you instant access to all the details.

Create an activity? Point, click-click. Define a relationship? Two clicks and done. Updates? Double click and enter progress. P3® 4.0 gives you copy, cut and paste, group and mark, and dozens of other powerful scheduling tools.

Now, the world's best high-performance project management software is even easier to use, and offers more capability. And it's available now, running under DOS.

See Primavera Project Planner 4.0 in action. Call 1-800-423-0245 today for your FREE video demo.



PRIMAVERA SYSTEMS, INC.
Project Management Software

Two Bala Plaza • Bala Cynwyd, PA 19004 • (215) 667-8600 • FAX: (215) 667-7894

Simplified Calculation of Solar Fluxes in Solar Receivers

Results compare favorably with those of more complicated programs.

The Simplified Calculation of Solar Flux Distribution on the Side Wall of Cylindrical Cavity Solar Receivers computer program employs a simple solar-flux-calculation algorithm for a cylindrical-cavity-type solar receiver. Applications of this program include the study of solar energy and the transfer of heat, and space power/solar-dynamics engineering.

The aperture plate of the receiver is assumed to be located in the focal plane of a paraboloidal concentrator, and the geometry is assumed to be axisymmetric. The slope error of the concentrator is assumed to be the only surface error; it is assumed that there are no pointing or misalignment errors. Cone optics and the contour error method are used to handle the slope error of the concentrator. The distribution of solar flux on the side wall is calculated by integration of the energy incident from cones emanating from all the differential elements on the concentrator. The calculations are done for any set of dimensions and properties of the receiver and the concentrator and account for any spillover on the aperture plate.

The results of this algorithm compared excellently with those predicted by more complicated programs. Because of the utilization of axial symmetry and overall simplification, it is extremely fast. It can be easily extended to other axisymmetric receiver geometries.

The program was written in FORTRAN 77, compiled using a Ryan McFarland compiler, and run on an IBM PC-AT computer with a math coprocessor. It requires 60K of memory and has been implemented under MS-DOS 3.2.1. The program was developed in 1988.

This program was written by Pradeep Bhandari of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 149 on the TSP Request Card. NPO-17732



Mechanics

Flexible Animation Computer Program

Vibrations, thermal distortions, and stresses are animated in color.

Heat, radiation, vibration, and stress can all influence the structure of a space-

craft. FLEXAN (Flexible Animation) is a computer program that animates structural dynamics on an Evans and Sutherland PS300-series graphics workstation with a VAX/VMS host computer. A typical application of FLEXAN, which was developed for the Spacecraft Analysis Branch of NASA's Langley Research Center, is the animation of a spacecraft undergoing structural stresses caused by thermal and vibrational effects. The animation displays the distortions in the shape of the spacecraft. Changes in the colors of elements in the display represent variations in temperature.

FLEXAN can display a single natural mode of vibration, a mode history (multiple modes), or any general deformation of a flexible structure. Elements of a structure can be animated through changes in color to reflect thermal information, stresses, etc. Selected parts of a structure can also be rotated through time. FLEXAN does not generate structural geometries or calculate any influences on structures; it displays only data generated from other computer programs and/or experimental data.

A structure is represented on the workstation as a three-dimensional wire-frame object. Solid objects or raster representations are not supported by this program. The VAX/VMS computer calculates the animation frames and sends them to the workstation. The workstation displays these frames in real time. Rotation, scaling, and translation are provided by the dials of the workstation. The workstation is not a true real-time machine, but it does provide a very close approximation. The animation can be displayed forward or backward at 1 to 50 frames per second or stepped 1 frame at a time. The speed of animation is controlled by a dial and two function keys. Other function keys toggle on and off various parts of the display or enable different views of the structure.

FLEXAN is capable of animating two independent sets of data in separate windows on the workstation. An optional third window displays a superposition of the two sets of data. This capability is useful for displaying the differences between design iterations or displaying sets of analytical versus experimental data. A large number of nodes and/or elements (over 200), a large number of animation frames (over 1,000), and the use of color require large amounts of memory. The FLEXAN examples are based on the assumption that a PS390 with 4 MB is available.

FLEXAN was written in FORTRAN77 and is specific to the Evans and Sutherland PS300 family of graphics workstations. It was implemented on a VAX/VMS computer system. The program requires a virtual memory of about 15 MB without the link libraries. FLEXAN was developed in 1989.

This program was written by Scott S. Stallcup of Computer Sciences Corp. for Langley Research Center. For further information, Circle 6 on the TSP Request Card.

LAR-14102

SINDA '85/FLUINT, Version 2.2

An established software system for thermal and fluid analysis is updated.

SINDA, the Systems Improved Numerical Differencing Analyzer, is a software system developed for solving physical problems governed by diffusion-type equations that can be modeled by lumped-parameter representations. The system is most widely used as a general thermal analyzer with resistor-and-capacitor-network representations, but may be adapted to a wide range of problems represented by such differential equations as those of Fourier, Poisson, or Laplace. SINDA can numerically solve almost any set of ordinary differential equations, which can be used to represent the transient behavior of a lumped-parameter system; or any set of nonlinear algebraic equations, which might represent the steady-state condition of a physical system. FLUINT, the FLUID INTEgrator, is an advanced, one-dimensional fluid-analysis program that solves the equations of arbitrary fluid-flow networks.

For user-decision flexibility, SINDA offers a number of numerical solution techniques. These include such finite-difference formulations of the explicit method as the forward-difference explicit, DuFort-Frankel, exponential, and alternating-direction approximations. SINDA also offers such formulations of the implicit method as the backward-difference implicit and Crank-Nicolson approximations. Many physical problems, particularly those of thermal analysis, can be readily solved with the SINDA system.

The SINDA system consists mainly of a preprocessor and a subroutine library. The SINDA preprocessor accepts programs written in the SINDA language and converts them into standard FORTRAN programs. The SINDA language is designed for working with lumped-parameter representations and finite-difference solution techniques. The SINDA library consists of a large number of prewritten FORTRAN subroutines that perform a variety of commonly needed actions. The user can call these subroutines from their SINDA language program, thus greatly reducing the programming effort required to solve many problems. Most of the subroutines in the SINDA library were developed for use in solving thermal-analysis problems. As a

thermal analyzer, SINDA can handle such interrelated complex phenomena as sublimation, diffuse radiation within enclosures, transport delay effects, sensitivity analysis, and thermal-network error correction.

SINDA can easily account for pumps, valves, and heat exchangers during a thermal analysis. The user-written SINDA-language program determines the input data required and the information to be produced as output by the program.

A pressure/flow analysis of a system containing an arbitrary network of tubes can be performed simultaneously with the thermal analysis during transient or steady-state solutions. This permits the mutual influences of thermal and fluid problems to be included in the analysis. This fluid-network analysis capability is called FLUINT.

The most recent VAX version of SINDA includes several enhancements. Significant expansions of the FPROP blocks have been made. The user can enter data on two-phase fluids in one of two forms: (1) simplified, using handbook property values, or (2) advanced, wherein the user may enter pseudo-FORTRAN descriptions of the properties of fluids. Major changes have taken place in the heat-transfer options. Input formats for subblocks and GNET, HX, MGSEG, and CAPPMP macros have changed, invalidating old formats; all other input formats are still valid. CAPPMP junctions may now be tied to a thermal node. Phase suction from junctions or from FASTIC tanks is now legal. New tabulation-style output routines are available.

SINDA is available by license for a period of 10 years to approved licensees. The licensed program product includes the source code and supporting documentation. Additional documentation may be purchased separately at any time.

SINDA is written in FORTRAN and ASSEMBLER. The VAX version has been implemented on a DEC VAX-series computer operating under VMS. SINDA was developed in 1971, and fluid capability was added to it in 1975. The VAX version was last updated in 1988.

This program was written by Brent Cullimore, Richard Goble, Steven Ring, and Carl Jensen of Martin Marietta Corp. for Johnson Space Center. For further information, Circle 48 on the TSP Request Card.

MSC-21528

Is your subscription about to expire?

Check the expire date. If it is less than 6 months now is the time to fill out a new qualification form before your subscription expires.

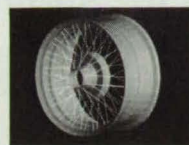
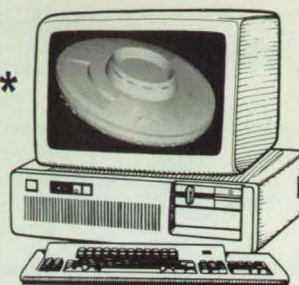
ALGOR FEA—Design and Stress Analysis \$889*

For 286 or 386 desktop computers

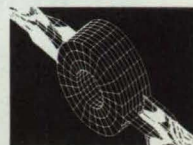
- **Finite Elements:** truss, beam, 2-D solid, 3-D solid, membrane, plate/shell, pipe, boundary, rigid link, non-linear gap, thin and thick shell/plate composites.
- **Stress Analysis:** point load, pressure, temperature, accelerations, centrifugal loads, deflections.
- **Dynamic Analysis:** mode shapes, frequencies, time stress history, response spectrum, direct integration, random vibration.
- **Heat Transfer Analysis:** 2-D/3-D conduction, convection, radiation, heat source, temperature, steady state and transient.
- **Graphics:** 3-D models; hidden line removal; light source shading animation; stress, displacement, temperature and flux contours w/optional shading; deformations; pan; zoom; node/element numbers; color.
- **Modeling:** 2-D/3-D mesh, cylinders, extrusions profile-path, warped surfaces; boundaries, loads, materials. SUPERDRAW II and parametric model generation.
- * **Full Capability, no size restrictions:** 3-D drawing, Computer Aided Design, solid modeling, design visualization, finite element stress analysis, and graphic post-processing.

GSA Contract #GS00K89AGS6270

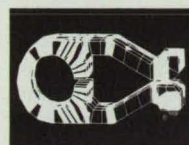
Design the future with Algor.



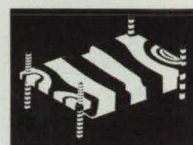
Wire wheel model



Propeller hub/blade



Stress contour on clip



Temperature contour electronic part

Algor has the largest base of installed FEA software in the world!

TEL: (412) 967-2700 FAX: (412) 967-2781



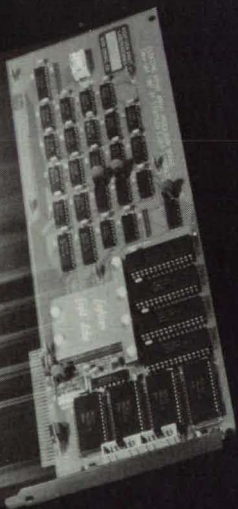
ALGOR

Quality Engineering Software Since 1977

ALGOR INTERACTIVE SYSTEMS, INC.
260 Alpha Drive, Pittsburgh, PA 15238

Circle Reader Action No. 361

Breaking the Speed Barriers in High Performance Computation



Floating Point Array Processor

- Dramatically increases the dynamic range and speed of desktop computing with IBM PC, XT, AT and other compatibles.
- Ideal for image processing, neural networks, seismic analysis, surface defect detection and vibration analysis.
- Saves time writing programs. Includes 'Tool Box'

Library of 473 powerful micro-coded functions and pre-written support routines.

- Accelerates compute-bound C, Fortran or Pascal programs with a processing rate of 12.5 MFlops per PL1250... Run time software supports up to eight PL1250s running in parallel within a single PC providing 100 MFlops performance.

- The PL1250 with software... \$2,695.

Eighteen Eight Laboratories

1247 Tamarisk Lane
Boulder City, NV 89005

Tel. 702-294-1051
1-800-888-1119



Mechanics

Hardware, Techniques, and Processes

- 70 Offset Joint for Segmented Pressure Vessel
- 70 Measurement of Water Sprays Generated by Airplane Tires

- 71 Precise Hinge Has Low Friction
- 72 Simulating a Massive, Mobile Structure
- 73 Dissipation of Energy in Extension of Cracks
- 74 Radial Profilometry
- 75 Redundant, Confined-Explosive Severance Device

- 76 Pressure-Measuring Diaphragm Transmits Optical Signals
- 76 Simple, Internally Adjustable Valve
- 77 Predicting Unsteady Aeroelastic Behavior
- Books and Reports**
- 78 Acoustic Reduction of Separation of Flow
- 79 Analysis of Stepped Labyrinth Seals
- Computer Programs**
- 68 Flexible Animation Computer Program
- 68 SINDA '85/FLUINT, Version 2.2

Offset Joint for Segmented Pressure Vessel

A slight offset reduces joint gap under pressure.

Marshall Space Flight Center,
Alabama

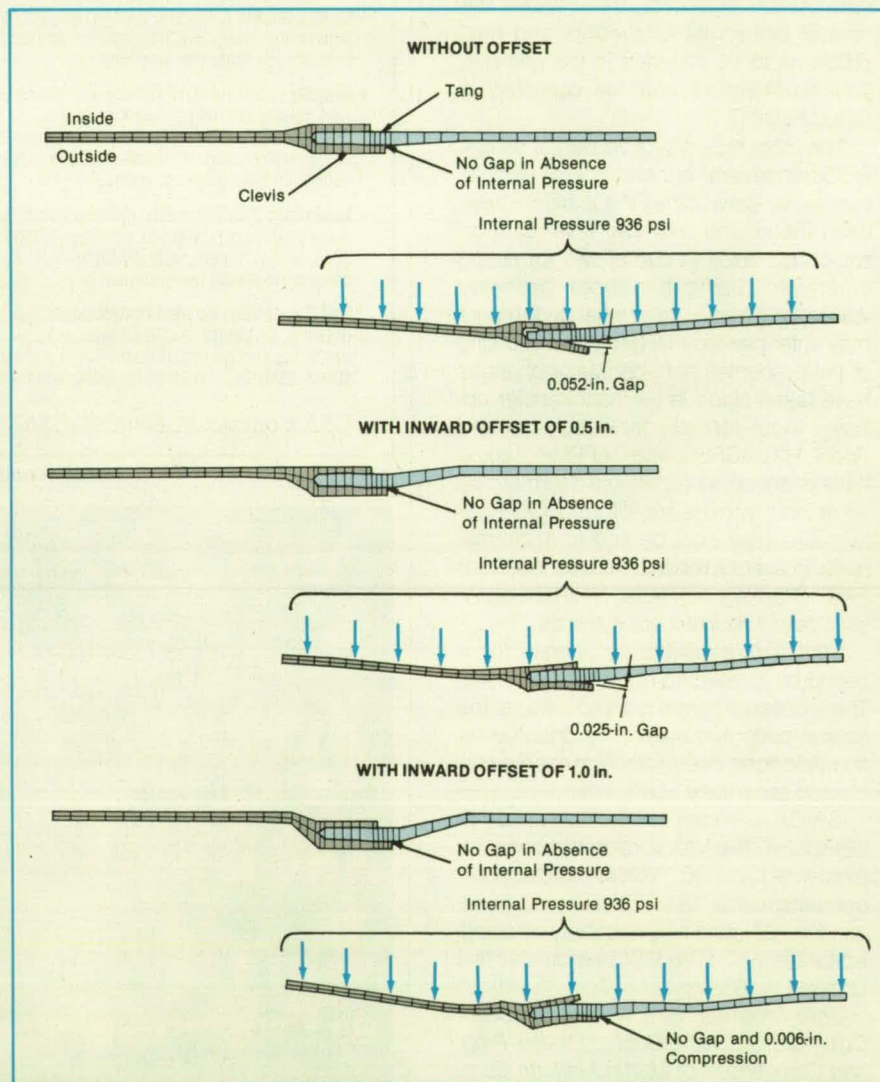
A concept for increasing the reliability of a segmented pressure vessel has been proposed. According to the concept, an inward offset of the tang and clevis bands of the encircling joint between segments can reduce or eliminate the gap that opens between the tang and inner leg of the clevis in response to pressure in the vessel.

The concept is an outgrowth of an analysis of the Space Shuttle Challenger accident. The analysis showed that when the 12-ft (3.66-m)-diameter solid-rocket case was pressurized by the burning solid fuel, the bulging wall rotated the tips of the tang and clevis outward, increasing the gap between the tang and the clevis. At an internal pressure of 936 lb/in.² (6.45 MPa), the gap is 0.052 in (1.32 mm). The opening of the inner gap, which carried the O-ring seals, is believed to have contributed to the failure of the segmented joint.

A slight inward offset, however, creates a moment arm under pressure that compresses the tang and clevis and tends to close the gap. A finite-element analysis program, SPAR, was used to analyze the effects of geometry in the proposed offset joint. An offset of 0.5 in. (1.27 cm), for example, would reduce the gap to 0.025 in. at the stated internal pressure. For the same pressure, an offset of 1 in. would create interference of 0.006 in. (0.15 mm) between the tang and clevis.

This work was done by Carleton J. Moore of Marshall Space Flight Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28365.



Internal Pressure causes a gap to open between the tang and clevis portions of a circular-band joint between cylindrical segments of a pressure vessel. The amount of opening can be reduced or eliminated by designing the tang-and-clevis band to have an initial (when unpressurized) inward offset.

Measurement of Water Sprays Generated by Airplane Tires

Water sprays produced by tires on wet runways are simulated and analyzed.

Langley Research Center, Hampton, Virginia

All aircraft designed to take off and land on a conventional runway must be able to operate when the runway is wet. Sprays

thrown up by the aircraft tires into the intakes of engines pose a danger: if sufficient water is ingested, a jet engine can undergo

compressor stalls or even flameout, either of which can be especially dangerous if it occurs on the takeoff roll near rotation

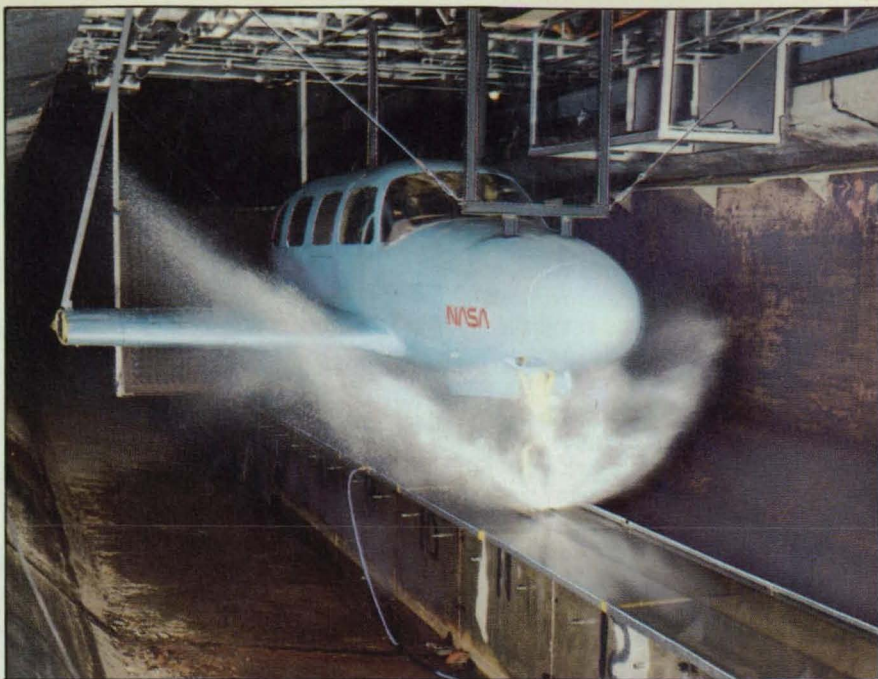
speed. Numerous studies to determine whether aircraft are susceptible to the ingestion of water spray have typically been carried out after the aircraft were built. It is desirable to have a technique that makes it possible to configure an aircraft and its engines in a geometry that eliminates the potential for the ingestion of spray.

An experimental investigation was conducted at the NASA Langley Research Center to measure the rate of flow and the trajectory of water spray generated by a tire operating on a flooded runway. Tests were conducted in the Hydrodynamics Research Facility, which contains a 2,900-ft (600-m)-long enclosed water tank approximately 12 ft (3.7 m) deep and 24 ft (7.3 m) wide. The tests made use of a partial airframe and a nose wheel (see figure).

To capture the water, two different collectors were built. The first collector consisted of an 8-by-8 array of tubes spaced at intervals of 3 in. (7.6 cm) between axes. Later in the test program, a larger water collector was fabricated with a 22-by-22 array of tubes with the same spacing as that of the previous collector. Each tube in the array was a clear plastic cylinder with a 1.625-in. (41.28-mm) inside diameter and with a removable rubber stopper placed in the aft end.

A collector was mounted on the carriage behind and to the right of the test tire to sample the water spray generated by the nose tire as it ran through the flooded runway. The collector was slightly tilted with the aft end low, so that the collected water remained in the tubes when the carriage decelerated. After the test, the volume of water collected in each tube was measured to obtain an indication of the rate of flow at that position.

A video camera showed whether a complete sampling of spray was obtained. Additional data were obtained by use of high-speed movie film in cameras, mounted both aboard the moving carriage and along the side of the runway, aimed at the test wheel. The movies helped to define the trajectory of the water spray relative to the ground.



The Water Spray Generated by a Tire on a Wet Runway was simulated by use of part of an airframe with a nose wheel in a test facility.

The water collector was positioned for each test run at a selected location to the side of the centerline of the nose wheel. The water-collector-mounting hardware allowed the collector to be moved in three directions. Each test run was begun by accelerating the carriage to the desired speed. The nose tire ran up an entrance ramp to load the tire, traversed the flooded runway, and then ran down an exit ramp. Then the carriage was slowed to a stop. The effects of forward speed, load on the tire, and depth of water on water-spray patterns were evaluated.

Water ejected from the side of the tire footprint was found to have the most significant potential for ingestion into engine inlets. Forward speed increased rates of flow and moved the spray pattern inboard. Increased loads on tires caused the spray to become less dense. Near the tire, increased depths of water caused rates of flow to increase. Tests using a fuselage and partial wing along with the nose gear

showed that for certain configurations, the aerodynamics of the wing can cause a concentration of spray above the wing. Tests showed virtually identical spray-pattern and flow-rate behavior when comparing tires of bias-ply versus radial-ply construction. The methodology and the results of the tests have potential for application to both aircraft and automotive industries, with particular application to manufacturers of tires.

This work was done by Robert H. Daugherty and Sandy M. Stubbs of Langley Research Center. Further information may be found in NASA TP-2718 [N87-24458], "Measurements of Flow Rate and Trajectory of Aircraft Tire-Generated Water Spray."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LAR-14030

Precise Hinge Has Low Friction

Blade-in-groove rotation allows free movement through a limited arc.

NASA's Jet Propulsion Laboratory, Pasadena, California

A precise hinge rotates with minimal friction and without "slop" — a deadband of loose, ineffectual movement at the beginning or end of rotation. The hinge is based on knife blades turning in grooves. The axis of rotation is at the central axis of a concentric, self-retaining assembly. The blades are in the same plane, and both the edges of the blades and the apexes of the grooves lie along the same line, allowing free rotation without either binding or slop.

A middle blade rests in a V-groove in a

block, as do two flanking blades pointing in the opposite direction (see figure). In the view along the axis, blades are T-shaped with curved tops that fit in a rotor frame and rotor housing. A blade makes contact with a V-groove only at its edge; hence, the low friction.

The assembly of the hinge begins with the insertion of the three groove blocks into a stator housing, where they are retained by locating pins. The rotor frame is slid axially over the stator housing. The knife

blades are inserted through cutouts in the rotor frame; the curved arms of the blades form a continuation of the cylindrical body of the rotor frame and fill the cutouts so as to keep the blades in place.

Finally, the rotor housing — a contiguous cylindrical shell — is pressed axially over the rotor frame. It locks the blades in the frame and holds the entire assembly together.

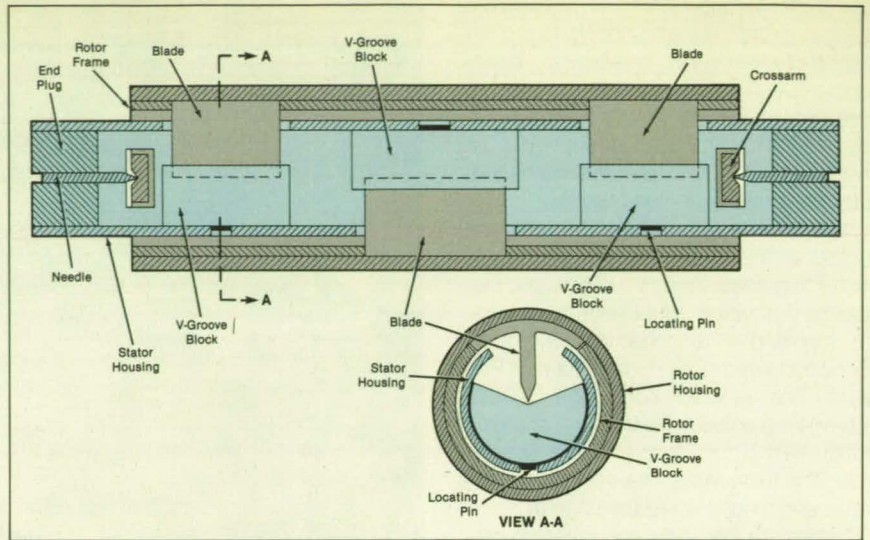
For mounting purposes, the stator-housing tube projects axially beyond the rotor-

housing tube at both ends. The projecting ends of the stator can be press-fit or fastened by setscrews to bores in a mounting frame. The rotor-housing tube can be similarly fastened to rings on the object to be pivoted.

Point-contact stops at both ends prevent axial movement of the hinge without adding significant friction. End plugs on the stator housing hold needles that make contact with conical holes in crossarms mounted on the rotor frame. Slots in the stator housing allow the crossarms to move with the rotor through a limited arc.

The hinge creates no centering or restoring torque; therefore, the rotor stays in its new position when rotation stops. If return torque is needed, a simple coil spring can be wound around the rotor, with one end connected to the rotor and the other to the stator.

This work was done by Earl R. Collins, Jr., of Caltech for NASA's Jet Propulsion



Blades on the Rotor Engage Grooves on the Stator. Blades can pivot about their edges through an arc defined by slotted openings in the stator housing.

Laboratory. For further information, Circle 3 on the TSP Request Card. NPO-17749

Simulating a Massive, Mobile Structure

The mass of the mobile structure can be varied.

Lyndon B. Johnson Space Center, Houston, Texas

A simulator replicates, kinematically and dynamically, the mating of a large, massive mobile structure with a similarly large and massive fixed structure. The simulator was developed for testing a berth-

ing-and-latching mechanism.

The simulator consists of a fixed section and a mobile section, representing the fixed and mobile structures (see figure). The fixed section holds an active berthing-

and-latching mechanism and its motor control system with an optical encoder to maintain synchronization among the four latches in the mechanism. A tripodal load-cell network gathers data on the load

Our new MIL-STD-1553 interfaces provide the critical test capabilities of the RT Validation Test Plan combined with extensive real-time emulation in one module. Available now for PC-AT, VME, VXI, and HP DIO.

NEW!
MIL-STD-1553 Products

Digital Technology, Inc.
A DYNATECH COMPANY
1-800-852-1252 or 513-443-0412
2300 Edwin C. Moses Blvd.
Dayton, OH 45408

NASA Tech Briefs Presents
THE SPACE SHUTTLE ART COLLECTION

A portfolio of ten gorgeous color posters reproducing paintings by noted space artists. Prints include a stunning acrylic rendition of a night launch; the Shuttle seconds after liftoff; and the triumphant craft gliding towards the landing strip. All are suitable for framing. 11x14 inches (each). Shipped flat.

Only \$13.95 for the set of ten posters.

I have enclosed \$ _____ plus \$3.00 for postage and handling. Rush me _____ sets of Shuttle Art.
Total enclosed: \$ _____ (NY residents add sales tax)

Name _____
Address _____
City _____ State _____ Zip _____

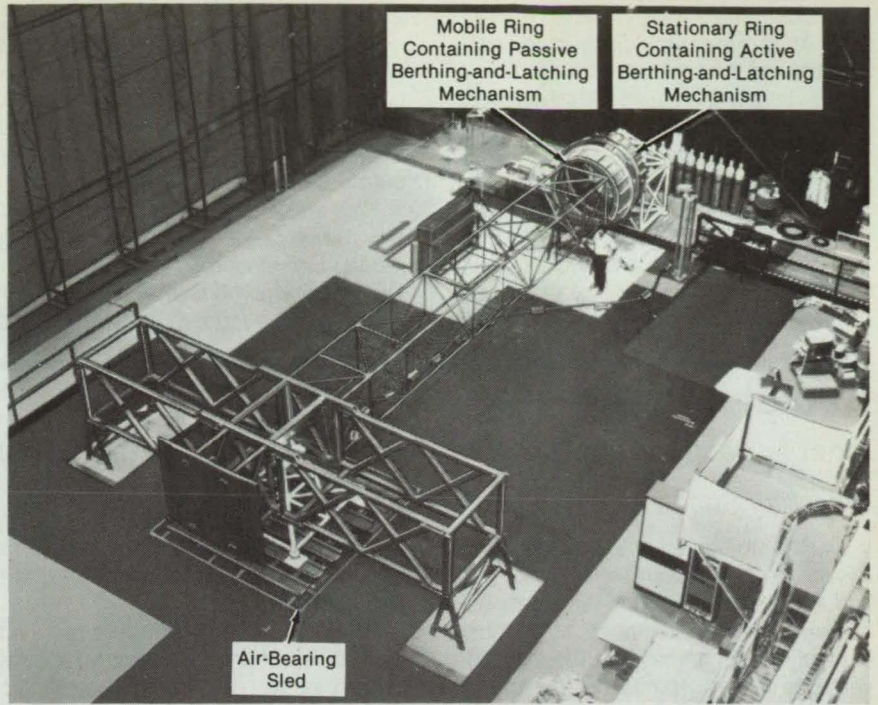
Send check or money order to:
NASA TECH BRIEFS,
Dept. F, 41 East 42nd St.
New York, NY 10017

history of a berthing operation, and an infrared tracking system that includes light-emitting diodes produces data for the position history.

The mobile structure holds a 30,000-lb (13,600-kg) passive berthing mechanism. It is a truss structure on a large sled supported by air bearings. A large spherical roller bearing between the truss and its support provides two degrees of freedom of movement. The sled provides an additional three degrees of freedom. The mass of the mobile structure can be varied by adding 500-lb (227-kg) ballast plates. The ballast plates can be arranged in a variety of configurations to alter the distribution of mass.

For a berthing test, the air bearings on the sled are activated, and the mobile structure is placed in various orientations with respect to the fixed structure, within the 4-in. (10.1-cm) reach of the latching mechanism. A test is completed when the four latches have linked the mobile structure to the fixed one.

This work was done by Peter M. Fantasia, Jon B. Kahn, and Benny B. Sprague of Johnson Space Center. For further information, Circle 147 on the TSP Request Card. MSC-21482



The **Mobile Truss** is cantilevered from the sled-based structure at the left. The sled moves on air bearings supplied through the snaking tube on the floor. The fixed structure (behind the man) holds the active berthing-and-latching mechanism in the large ring.

Dissipation of Energy in Extension of Cracks

Dissipation in an elastic-plastic material is calculated by a two-dimensional finite-element method.

Langley Research Center, Hampton, Virginia

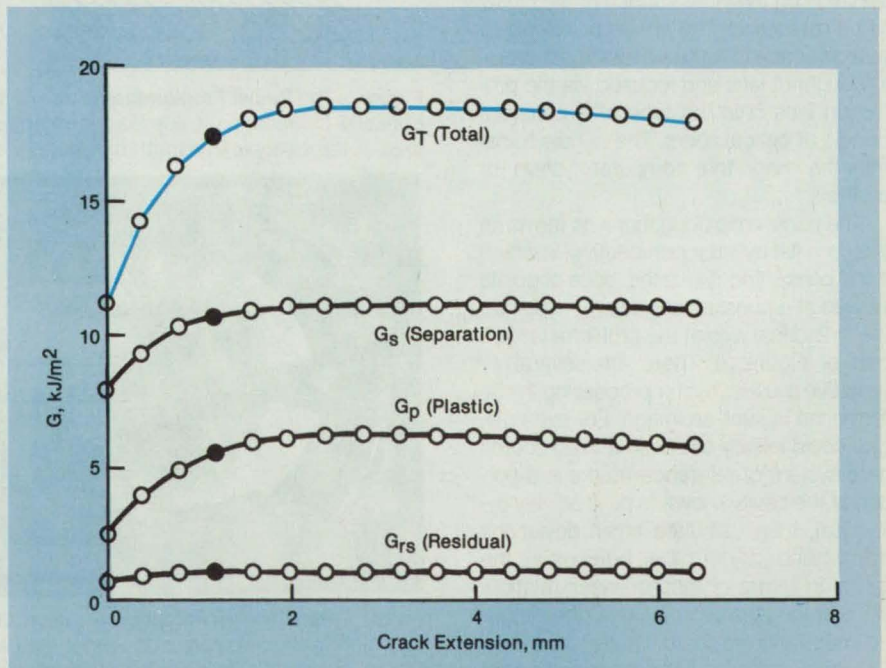
The extension of a crack in an elastic-plastic material involves the dissipation of energy through the creation of new crack surfaces and by yielding. An understanding of the energy-dissipation process in fracture may provide guidance for the development of tougher materials and could provide a basis for the prediction of the absorption of energy during failure. An analytical procedure has been developed to calculate the various components of the dissipation of energy during the extension of a crack and to relate them to the total dissipation of energy computed from the global load-displacement response.

A two-dimensional, elastic-plastic, finite-element analysis was used to implement the procedure. A standard compact specimen made of an elastic-plastic material was analyzed. The specimen was modeled mathematically by use of constant-strain triangular elements. Fracture was simulated analytically by use of the critical crack-tip-opening-displacement (CTOD) criterion. The crack was considered to be extended by release of the force at the tip of the crack in steps.

The analysis was repeated for three material toughnesses, which were simulated by using three different values for the critical CTOD. The magnitudes of the components of the dissipation of energy were

compared with the total dissipation of energy for the different material toughnesses. The effect of critical CTOD on separation of the crack and on the rate of plastic dissipation of energy were also examined.

Results from the analyses showed that the total rate of dissipation of energy, G_T , consisted of three components: (1) the crack-separation-energy rate, G_S , (2) the plastic-energy-dissipation rate, G_P , and (3)



The **Total Rate of Dissipation of Energy**, G_T , consists of three components.

the residual-strain-energy rate, G_{rs} (see figure). All three energy-dissipation components and the total rate of dissipation of energy initially increased with the extension of the crack and finally reached constant values. For ductile materials (larger CTOD), G_p became dominant (more than 70 percent of the total), whereas G_{rs} remained constant (about 6 percent). Furthermore, G_p appeared to vary linearly with the height of the plastic zone. G_s was found to be linearly proportional to the critical

CTOD.

The observations made in this study are valid for other elastic-plastic fracture situations. For instance, the observations could apply to a very wide range of practical situations, including the growth of cracks in pressure vessels in nuclear powerplants.

This work was done by Kunigal N. Shivakumar of Analytical Services and Materials, Inc., and John H. Crews, Jr., of Langley Research Center. Further information may be found in NASA TM-89032

[N87-17090], "Energy Dissipation Associated With Crack Extension in an Elastic-Plastic Material."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LAR-14025

Radial Profilometry

Inner surfaces of tubes and tubelike cavities are measured optoelectronically.

Marshall Space Flight Center, Alabama

Radial profilometry, now undergoing development, is a combination of optical and electronic techniques for the measurement of the inner surfaces of cylindrical or nearly cylindrical cavities. The main advantages of a radial profilometer are that it is relatively simple, inexpensive, and easy to use; it can be miniaturized; the profilometer probe contains no moving parts; the image is displayed continuously in the image plane; and measurements are automated. Potential applications include the inspection of pipes, tubes, and boreholes, and possibly the measurement of contours in blood vessels or other internal organs.

Figure 1 illustrates the optical configuration of a radial profilometer. A diverging laser beam launched from an optical fiber passes through a projection lens, then through a specially designed "panoramic doughnut" lens to a masked collimating lens, which shapes the beam into a thin cylinder. The cylindrical beam is reflected from a conical mirror to form a ring of illumination on the inner surface of the cavity to be measured. The image of the illuminated surface is captured by the panoramic doughnut lens and focused via the projection lens onto the face of a coherent bundle of optical fibers. The bundle transmits the image to a computer system for analysis.

The panoramic doughnut lens forms an image in flat cylinder perspective, in which each concentric ring is the locus of points viewed at a constant angle with respect to the cylindrical axis of the profilometer (left part of Figure 2). There are several alternative procedures for processing the information in such an image. For example, one could initially establish a fixed coordinate system of reference marks in a portion of the cavity known to be precisely cylindrical, then calculate small deviations from cylindricity in other portions of the cavity in terms of the nonlinear relationships among the coordinates in the distorted image and the coordinates in the cavity. The profilometer could be moved along the cavity to obtain a sequence of images that

could be processed collectively to yield the coordinates of the inner surface along a specified length.

Work continues to develop a more advanced version in which a known speckle pattern, instead of a homogeneous ring of light, is projected on the surface to be meas-

ured (right part of Figure 2) and in which the profilometer remains stationary. The speckle pattern in the resulting image would be digitally recorded and compared either with a reference standard or with other speckle patterns recorded as the shape of the cavity changes. The apparent shifts of

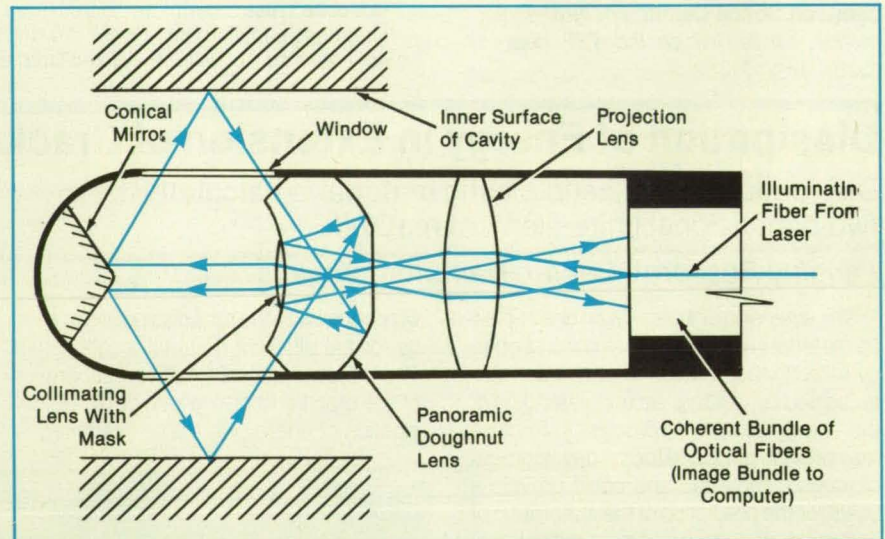


Figure 1. The **Radial Profilometer** is inserted in a pipe or other cavity to measure its shape optically. Illumination is supplied through an optical fiber, and the image of the inspected area of the cavity is transmitted through a bundle of optical fibers.

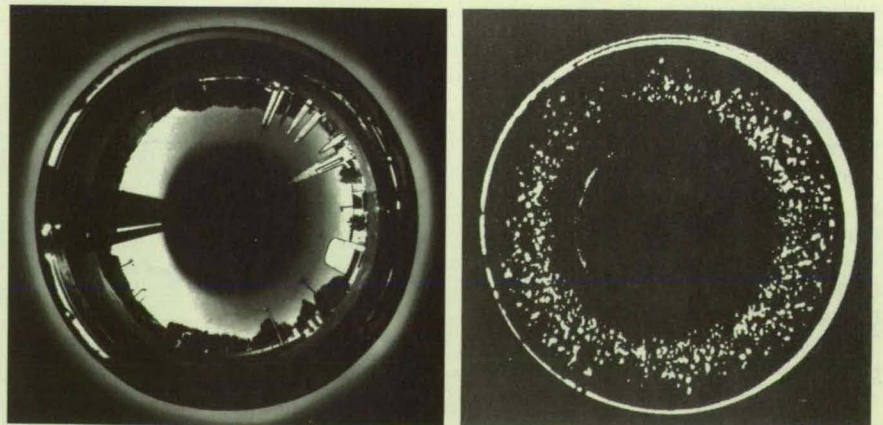


Figure 2. **Flat Cylinder Perspective** is illustrated by the image at the left, which was obtained by pointing the panoramic doughnut lens at the sky at Huntsville, Alabama's Space and Rocket Center. A speckle pattern like the one shown on the right image, also in flat cylinder perspective, can be compared to a reference pattern to measure the shape of a nearly cylindrical inner surface.

the speckle would be computed by numerical correlation of small portions of each pattern. These shifts would be used to compute the contour of the cavity with respect to the reference shape.

This work was done by J. A. Gilbert, P. Greguss, and D. R. Matthys of the University of Alabama for Marshall Space Flight Center. For further information, Circle 12 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 16]. Refer to MFS-26101

Redundant, Confined-Explosive Severance Device

A reliable, noncontaminating device separates structures along a line.

Langley Research Center, Hampton, Virginia

A noncontaminating, long, explosive joint with a highly reliable separation capability has been invented for such applications as the separation of rocket-motor stages of spacecraft from rockets or the Space Shuttle. Two explosive cords are housed in tubes that are held in place by two notched doublers and commercially available fasteners. When either cord is fired, its tube expands, bending the doublers and causing fracture at the adjacent notch.

The figure shows a cross section of the explosive joint with the length of the joint, into the plane of the paper. This design could be adapted to a curved structure; for example, by connecting its ends to form a cylinder. The prototype joint includes two 0.3125-in. (7.94-mm)-diameter, 0.035-in. (0.89-mm)-wall-thickness, 300-series stainless-steel alloy tubes, which contain rectangular-cross-section explosive cords. The structure around the tubes is made up of two endplates, two doublers with notched areas at which separation occurs, a center block, and fasteners.

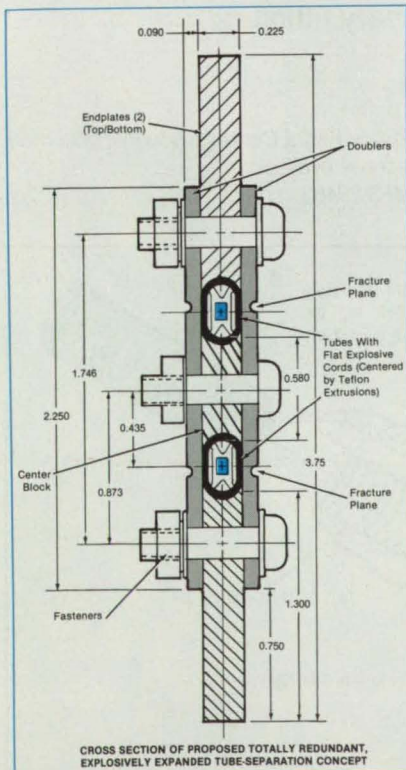
On firing of either of the explosive cords, the respective tube expands, bending the local areas of the doublers outward and causing the doublers to fail structurally in tension and shear at the respective notched area. Redundancy is achieved by this joint in that the firing of one cord does not affect the structure beyond the center fastener. Therefore, should one severance attempt fail, the other cord can be fired to achieve separation in the second plane. Containment of explosive products is achieved by the steel tube, which has welded end fittings that adapt to a commercially available detonator that initiates the explosion.

This joint can be fabricated from a variety of different metals, alloys, or composites. The joint can be scaled over a wide range of sizes and strengths for specific requirements, and it can be used in flat or curved panels. The shortest flat panel has a length of approximately 0.75 in. (19 mm), and there is no upper limit on length. The

minimum diameter of curvature of a panel would be approximately 3 in. (7.6 cm), and there would be no limit on the diameter of curvature. All materials for the endplates, center block, and doubler are symmetrical and interchangeable and are manufactured from sheet or extruded stock with highly predictable dimensional tolerances and material properties. The components are then shaped to the final configuration, drilled, and assembled with standard fasteners.

This work was done by Laurence J. Bement of Langley Research Center and Morry L. Schimmel of Schimmel Co. No further documentation is available.

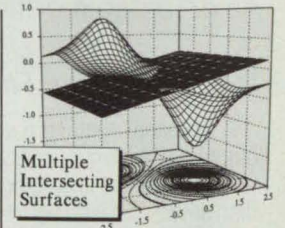
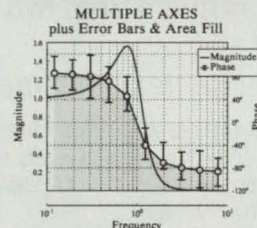
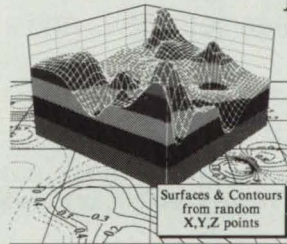
This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 16]. Refer to LAR-13582.



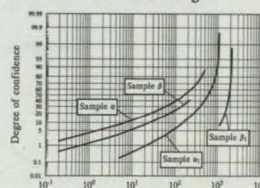
Upon firing of one explosive cord, fracture occurs at the nearest notch. If one severance attempt fails, the second cord can be fired.

NASA Tech Briefs, September 1990

CAN YOUR GRAPHICS SOFTWARE DO ALL THIS?



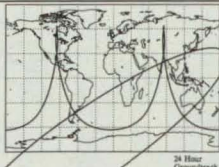
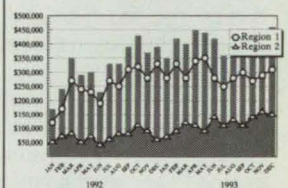
LOG & PROBABILITY Axes Scaling



"Graftool has the potential to be the ultimate graphics package, fulfilling everybody's needs."

-Ehud Kaplan
PC Magazine

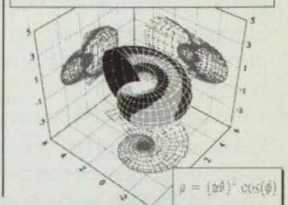
TECHNICAL BUSINESS GRAPHS



Experience the power & simplicity of the world's leading PC graphical analysis system.

- curve fitting, statistics, zooming, rotation, mouse support, scientific spreadsheet & more!

On-Screen Formula-Solver™



GRAFTOOL \$495 • Interactive Demo Available • Academic Discounts
Call 1 (800) SAY-GRAF • 1 (213) 540-8818 • FAX 1 (213) 540-3492

3-D VISIONS

412 S. Pacific Coast Highway, Second Floor, Redondo Beach, CA 90277
*Reprinted with permission from PC Magazine, March 14th, Copyright ©1989 Ziff Communications Co.

Circle Reader Action No. 669

Pressure-Measuring Diaphragm Transmits Optical Signals

A sapphire diaphragm would reduce the required number of instrumentation ports.

Marshall Space Flight Center, Alabama

A proposed sapphire diaphragm would perform two functions in an instrumented research engine or pressure vessel. It would serve both as a pressure sensor and as a window for observation, optical probing, or the optical transmission of other measurements.

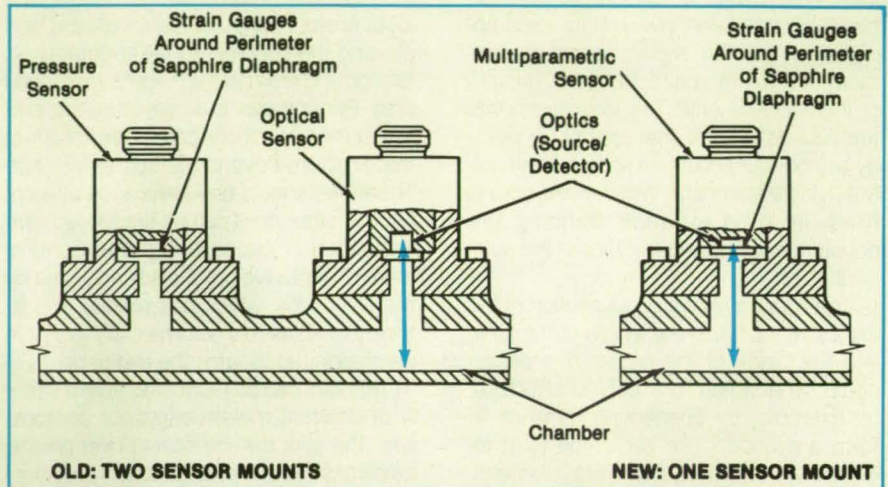
Strain gauges around the edge of the diaphragm would measure the deflection caused by pressure or vacuum in the vessel. As a window, the transparent diaphragm would transmit light from a source to the interior of the vessel and would carry light from the vessel to a light detector.

Increasingly, single-crystal sapphire is becoming the material of choice, replacing metal in pressure-sensor diaphragms because it offers high stability and a wide range of operating pressures. At the same time, sapphire is being used more and more as a transmission medium for pyrometers, spectrometers, and other instruments used to observe phenomena inside high-pressure (or high-vacuum) vessels. In the proposed application, the combined features of sapphire would be exploited so that only one window would be needed for both optical and pressure measurements

(see figure).

This work was done by Arthur J. Hill of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-29535



Deflections of the Sapphire Diaphragm would alter the resistances of strain gauges mounted around its periphery. At the same time, the transparent material would enable optical measurements of conditions in the chamber. Thus, additional information could be obtained about conditions in the chamber without the need for additional sensor mounts.

Simple, Internally Adjustable Valve

An adjustable orifice is made from two allen setscrews and an ordinary fitting.

Marshall Space Flight Center, Alabama

A valve that contains a simple in-line, adjustable, flow-control orifice can be made from an ordinary plumbing fitting and two allen setscrews (see figure). The construction of the valve requires only simple drilling, tapping, and grinding. Often, the orifice can be installed in an existing fitting, thus avoiding changes in the rest of the plumbing.

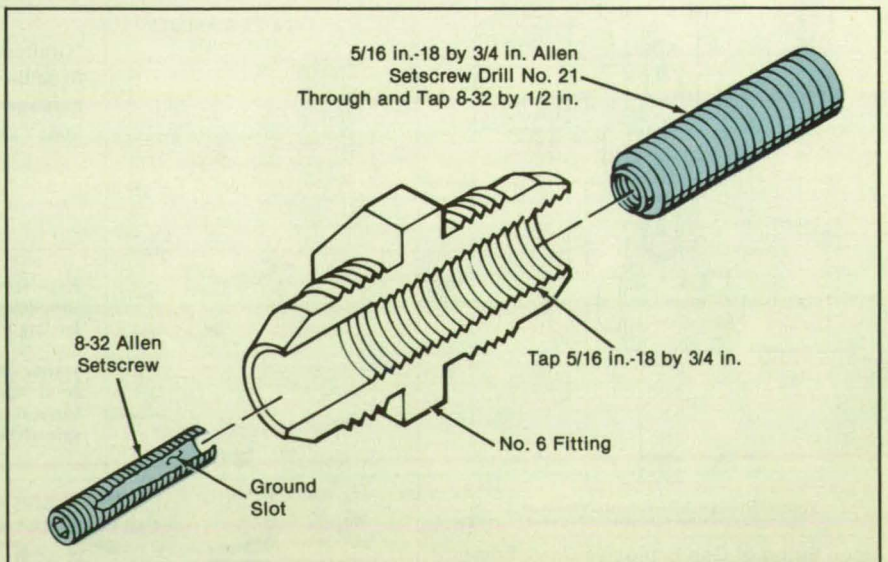
The interior of the fitting is tapped to accept the larger of two allen setscrews. The larger setscrew is drilled along its axis and tapped to accept the smaller setscrew. A tapered slot is ground into the side of the smaller setscrew. The size of the orifice is controlled by turning the smaller setscrew in or out to adjust the amount of slot exposed.

To reach the inner allen screw to adjust the orifice, one of the two lines connected to the fitting must be removed. This may be an advantage in some applications, a disadvantage in others. The hidden, internal placement of the orifice reduces the likelihood of accidental or mischievous adjustment but makes frequent adjustment im-

practical.

This work was done by Richard K. Burley of Rockwell International Corp. for Marshall

Space Flight Center. No further documentation is available. MFS-29463



The Adjustable Flow-Control Orifice can be installed in an ordinary plumbing fitting. The sizes and threads shown here are merely exemplary.

Predicting Unsteady Aeroelastic Behavior

The equations for the motion of the wing and the flow field are solved iteratively and simultaneously.

Langley Research Center, Hampton, Virginia

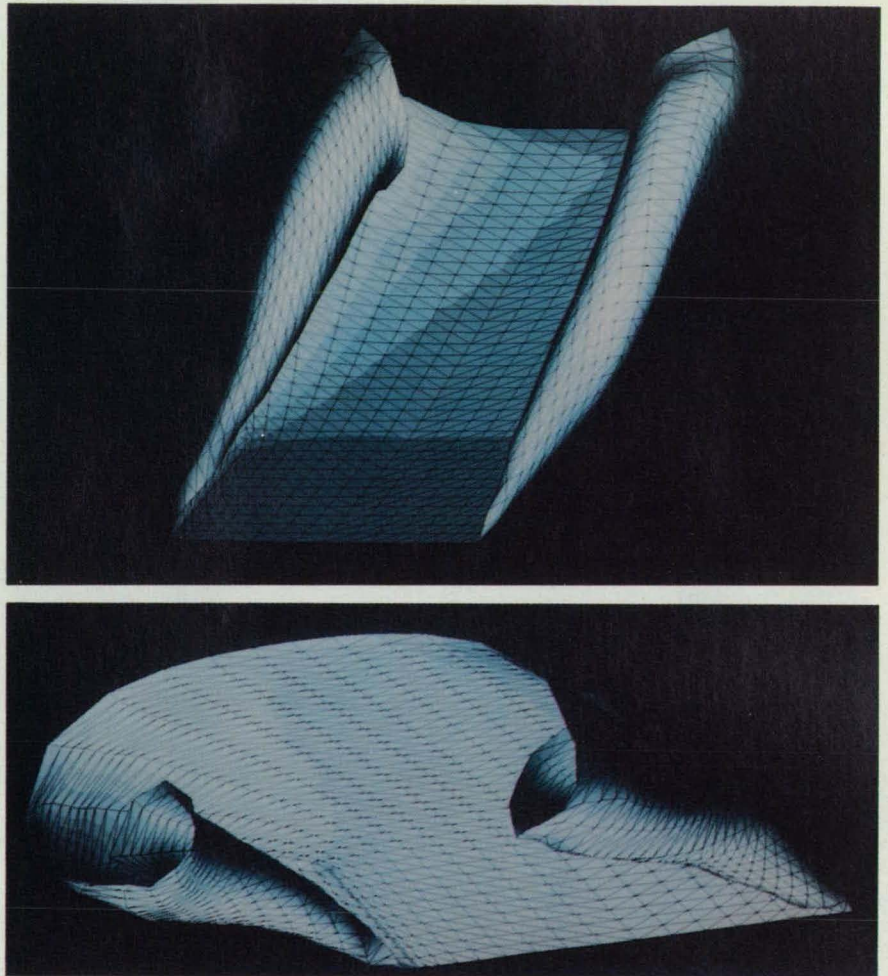
A new method for predicting subsonic flutter, static deflections, and aeroelastic divergence has been developed. The unsteady aerodynamic loads are determined by the unsteady-vortex-lattice method. The method accounts for the aspect ratio and the angle of attack. The angle of attack is limited only by the occurrence of stall or vortex bursting near the wing.

The method simultaneously and interactively integrates the equations of motion of the structure and the flow field. However, a complication arises in this approach: the aerodynamic loads cannot be predicted unless the motion of the wing is known, and the motion cannot be predicted unless the aerodynamic loads are known. Hence, an iterative scheme, based on the predictor-corrector method, provides the motion of the wing and the flow field simultaneously and interactively. The solution can predict aeroelastic divergence, flutter boundaries, transient motion, and deformations due to steady loads.

The differential equations of motion are developed for bending and torsion about a static angle of attack. The deflections (both rotation and translation) are expanded in terms of the free-vibration modes. The time-dependent coefficients in these expansions are then treated as generalized coordinates. The static problem, which is nonlinear in the aerodynamic loads, can be solved by iteration. The scheme provides the deflection due to static aerodynamic loads and weight; that is, the equilibrium solution.

The time-dependent displacements from the position are obtained in the analysis of flutter. The analysis of the static problem begins with the specification of a nominal angle of attack and the calculation of the corresponding distributed loads. Then these loads are used to calculate the bending and torsional deflections. At this point, the wing has a new shape, but the loads still correspond to the old shape. New loads, corresponding to the new shape, are obtained next; then another new shape is calculated. The procedure is repeated until either the shape and loads converge or aeroelastic divergence occurs. The method graphically animates the flow field and wing motion, as illustrated in the figure.

For the dynamic problem, the integration process is based upon Hamming's predictor-corrector technique. A typical time step begins when the current loads



The Wing and Flow Field Are Graphically Animated by use of this modeling technique.

and those at three previous time steps are used to predict the state variables (generalized coordinates and their derivatives) at the next time step. Then the new state variables are used to predict the loads at the next time step. These loads are then used to improve the predicted state variables, which in turn are used to improve the predicted loads. The iteration continues until convergence occurs. Then the procedure marches ahead to the next time step. When flutter does not occur, the dynamic solution converges to the static solution.

This technique was used to simulate flutter of a rigid wing mounted on an elastic support limited to two degrees of freedom (plunge and pitch about the elastic axis). The results simultaneously and interactively predict the motion of the structure and the motion of the fluid in the time domain.

Because the wake is generated as part of the solution, the history of the motion is included in the analysis.

The method can be used to predict the transient responses to initial disturbances. (Indeed, flutter boundaries are obtained by observing the character, growing or decaying, of such responses.) It can also be used to predict steady-state static and oscillatory responses. In addition to aerospace applications, this technique has potential for research in such unsteady structural/flow interactions as those in windmills, turbines, and compressors.

This work was done by Thomas W. Strganac of Langley Research Center and Dean T. Mook of Virginia Polytechnic Institute and State University. For further information, Circle 19 on the TSP Request Card.
LAR-14130

Polaroid's Ultrasonic Ranging System opens the door to new technology.

It can be found in "non-touch" screen computer monitors, AGV's, industrial robotics, electronic games, tape measures, aids for the disabled, loading docks, collision avoidance systems for cars, trucks and pleasure vehicles. And, yes, it even opens doors.

The Polaroid Ultrasonic Ranging System is an accurate, highly sensitive way to detect and measure the presence and distance of objects from 10.8 inches to 35 feet. What's more, accuracy, sensitivity and range can all be improved with circuit modifications.

Three of a kind. Polaroid offers three ultrasonic transducers for a wide variety of applications. You can choose the original instrument-grade transducer, proven in millions of SX-70 Sonar Autofocus cameras. Or our Environmental Transducer, available in a sturdy housing to withstand exposure to rain, heat, cold, salt spray, chemicals, shock and vibration. And now you can select our newest, smallest transducer, developed for Polaroid Spectra, the camera of the future. All use reliable, accurate and sensitive electrostatic transducer technology. All are backed by Polaroid.



Get a \$2 Million Head Start. Polaroid spent over \$2 million developing the Ultrasonic Ranging System. But now you can get this technology in our Designer's Kit for only \$165*. To order your Designer's Kit, please send a check or money order for \$165 for each kit, plus all applicable state and local taxes, to: Polaroid Corporation, Ultrasonic Components Group, 119 Windsor Street, Cambridge, MA 02139. Questions? Call Polaroid's Applications Engineers at 617-577-4681.

_____ Please send me _____ Designer's Kit(s).

_____ Please send more information.

Name _____

Title _____

Company _____

Address _____

City _____ State _____ Zip _____



Polaroid

"Polaroid", "SX-70" ® "Spectra"™

NTB 9/90

Books and Reports

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

Acoustic Reduction of Separation of Flow

The effect of sound is tested in flows about airfoils.

A report discusses experiments in the use of acoustic excitation to reduce the separation of two-dimensional laminar flow about airfoils at low angles of attack. The purpose of this investigation was to gain a better understanding of the effect of the excitation, the scaling of the parameters of the excitation, and the ranges of frequencies in which the excitation reduces separation effectively.

The experiments were performed in the NASA Lewis Low Speed Wind Tunnel, which has a 76-by-51-cm test cross section and an intensity of free-stream turbulence less than 0.1 percent. Airfoils of two different shapes and stalling characteristics were tested; for each shape there were two models with chords of 12.7 and 25.4 cm respectively. The airfoils were supported at midchord and spanned the test section. The acoustic excitation was provided by loudspeakers in the ceiling of the test section.

The experiments were conducted in the range of chord Reynolds numbers (R_c) from 25,000 to 100,000. A microphone was used to measure a reference level of sound pressure. A crossed hot-film probe was used to measure the fluctuations in velocity at a reference location. A single hot-wire probe on a computer-controlled traversing mechanism was used to measure the velocity field around each airfoil. The lift produced by the flow about each airfoil was measured, and the coefficient of lift computed. The effect on the coefficient of lift is a primary measure of the influence of the excitation.

The data from the experiments showed that sound of an appropriate frequency can reduce the separation of laminar flows on the suction sides of airfoils at low angles of attack and low R_c , resulting in significant increases in the coefficients of lift. It was found that when the amplitude of the perturbation in velocity induced by the sound is kept constant, the most effective frequency scales as $U_\infty^{3/2}$ (where U_∞ = the speed of the unperturbed flow in the test section). The optimum effect occurs at an excitation frequency f_0 that causes the parameter $f_0 c / U_\infty R_c^{1/2}$ (where c = the length of the chord of the airfoil) to have a value of 0.02 to 0.03. Detailed data on the flow field indicate that a separated region still exists

under the excitation and that the imposed perturbation is amplified primarily in the downstream shear layer rather than in the upstream boundary layer.

This work was done by K. B. M. Q. Zaman and D. J. McKinzie of **Lewis Research Center**. Further information may be found in NASA TM-101379 [N89-12552], "Control of 'Laminar Separation' Over Airfoils by Acoustic Excitation."

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-14876

Analysis of Stepped Labyrinth Seals

Rotordynamic coefficients are derived for compressible flow.

A report presents an analysis of compressible flow in a stepped labyrinth gas seal in a turbomachine. This analysis is part of a continuing effort to understand and suppress self-excited vibrations caused by stepped labyrinth seals. It is derived from a previous analysis of straight-through labyrinth seals.

The analysis is based on the following assumptions:

1. The fluid is an ideal gas.
2. Variations in pressure within a cavity of the seal are small compared with the differences in pressure across a seal strip.
3. The lowest frequency of acoustic resonance in the cavity is much higher than the speed of the rotor.
4. The eccentricity of the rotor is small compared to the radial seal clearance.
5. Although the shear stress is significant in the determination of the flow parameters (velocity, etc.), the shear-stress forces on the rotor are small when compared to the pressure forces.
6. The flow in the cavity is turbulent and isothermal.
7. Added mass terms are neglected.
8. The seal strips are midway between steps.

The equations of continuity and conservation of momentum are presented for a single-cavity control-volume model of each step of the seal. Axial leakage between steps is represented by a choked-flow model. The resulting governing equations are linearized by a perturbation treatment for small motion about a central position, taking zeroth- and first-order terms in an expansion in the eccentricity ratio.

The zeroth-order leakage equation is solved iteratively to obtain zeroth-order pressures in the cavities. The zeroth-order circumferential momentum equation is solved by a Newton root-finding technique to obtain zeroth-order circumferential components of velocities in the cavities. Under the assumption of an elliptical orbit

for the shaft and a corresponding harmonic response in the distributions of velocity and pressure, the first-order equations of continuity and conservation of momentum are reduced to linearly-independent, algebraic equations in a separation-of-variables approach. The resulting first-order distribution of pressure is integrated along and around the shaft to obtain the reaction force developed by flow through the seal and the corresponding rotordynamic coefficients.

The results of these calculations are presented in the form of a parametric study because there are no known experimental data for the rotordynamic coefficients of stepped labyrinth gas seals. The paramet-

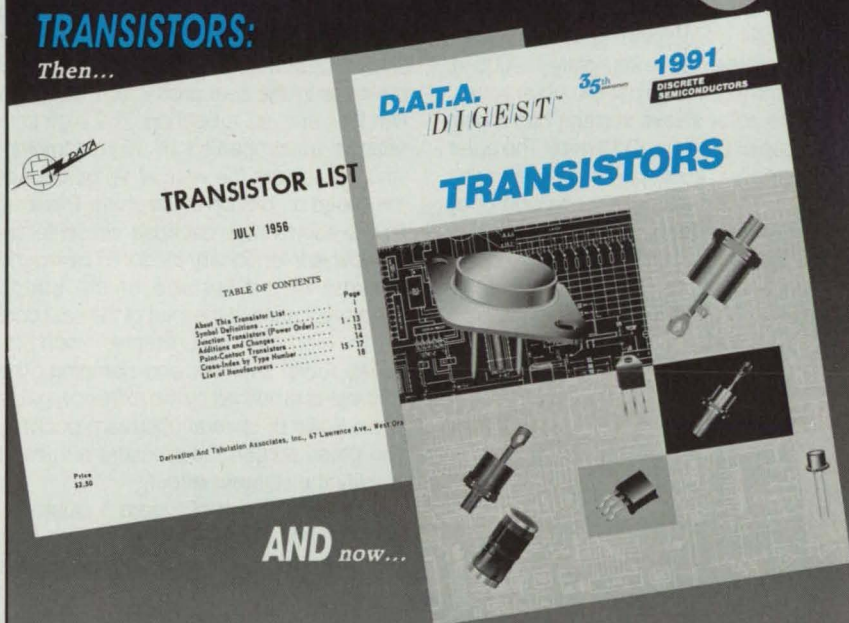
ric study investigates the relative rotordynamic stabilities of convergent, straight, and divergent stepped labyrinth gas seals. The results show that, generally, divergent seals are more stable, rotordynamically, than are straight or convergent seals. The results also show that, contrary to the conclusion drawn from a previous experiment on a 15-tooth seal, the teeth-on-stator seals are not always more-stable rotordynamically than are the teeth-on-rotor seals.

This work was done by Joseph K. Scharrer of Rockwell International Corp. for **Marshall Space Flight Center**. To obtain a copy of the report, "Stepped Labyrinth Gas Seal Program," Circle 31 on the TSP Request Card. MFS-29585

A technology comes of age

TRANSISTORS:

Then...



AND now...

Semiconductors have come a long way.

Back in 1956, **TRANSISTORS** was D.A.T.A.'s first book — with a whopping 297 parts from 28 manufacturers!

After 35 years, the new 1991 **TRANSISTORS DIGEST** can tell you everything you need to know for preliminary selection of **over 130,000 transistors from more than 150 manufacturers worldwide.**

New Surface-Mounted Discretes DIGEST available.

Other Discretes volumes available

- Diodes
- Thyristors
- Power Semiconductors
- Optoelectronics
- Direct Alternate Sources
- Suggested Replacements.

To order or for more information call toll-free 800-447-4666 (ask for Loretta) or FAX: 619-530-0637.

D.A.T.A. BUSINESS PUBLISHING™

A Division of Information Handling Services®

- 8977 Activity Road ■ San Diego, California 92126
- Telex: 530606 ■ Telephone: 619-578-7600

35th
anniversary

D.A.T.A.

Serving the electronics industry's information needs.
From vacuum tubes to Surface Mount Technology and beyond.



Machinery

Hardware, Techniques, and Processes

80 Damping Seals and Bearings for a Turbomachine

Books and Reports

81 Civil Applications for New V/STOL and STOL Aircraft

81 Thrust-Vector Deflectors for Spacecraft
82 Liquid-Ring Attitude-Control System for Spacecraft

Damping Seals and Bearings for a Turbomachine

Bearing loads are reduced to prolong service lives.

Marshall Space Flight Center, Alabama

An improved design for the support of a rotor in a turbopump integrates ball bearings with damping seals and damping bearings. The new design reduces the radial (side) loads on the ball bearings, making it possible to increase the contact angles to withstand increased transient axial loads. As a result, the service lives of the bearings are prolonged.

The top part of Figure 1 illustrates one of the duplex sets of ball bearings. The outer races of the bearings are packaged tightly in one sleeve. A flange or web in the middle of the sleeve between the outer races applies the axial preload and prevents the outer races from spinning in the sleeve. The bore of the sleeve fits tightly [0.0005-in. (0.0127-mm) gap] against the outer races, while the outer sleeve surface has a generous gap of 0.004 in. (0.10 mm). The outer gap normally is kept open by the centering function of the damping-seal support or by the damping bearing.

The damping seal and the damping bearing have rather stiff fluid films [e.g., 1,000,000 lb/in. (175 MN/m)] that center the

shaft, even under the high side loads at maximum operating speed. The floating sleeve radially unloads the duplex bearings, while the flexible suspension prevents the sleeve (and, therefore, the outer races) from spinning. These provisions help to prevent skidding of the balls and prolong the life of the bearing. The sleeves are attached to a soft [10,000 lb/in. (1.75 MN/m)] axial and radial spring. The soft spring centers the shaft during startup and shut-down, when the pressures are insufficient to maintain stiff fluid films in the damping-seal support and damping bearing.

Figure 2 illustrates one of the damping seals, which consists of an impeller rotor surface and a stator. The high differential pressure in the seal produces a stiff fluid film that acts as a bearing. The high stiffness is accompanied by high damping, which stabilizes the whirl at 90 percent of the speed of rotation of the shaft. The axial flow predominates because circumferential flow is intentionally hindered by isogrid pockets in the surface of the stator. Pressure losses at the inlet of the seal control the high seal-gap pressure, which produces radial stiffness and damping. The stiffness is amplified by the axial-flow gates in the walls of several upstream pockets. The gates spread the pressure surges to amplify the stiffness effect.

The bottom part of Figure 1 illustrates another set of ball bearings, between which the damping bearing discharges coolant directly into the inner races. The coolant follows the natural pumping of the

balls. Radial struts hold the damping-bearing stator to the housing. The damping bearing carries the side load, while the duplex bearing package floats in a large gap [e.g., 0.004 in. (0.10 mm)]. The stator of the damping bearing has isogrid pockets on the inside bordering a smooth center dam. The rotor of the damping bearing is smooth, except for backward slanted nozzles. The nozzles are individually fed through radial holes from the bore of the shaft.

Pressure is added by centrifugal pumping in the radial holes. The pressure drop in the holes is optimally half the supply pressure to maximize the stiffness of the fluid gap. Swirling of the fluid reduces stiffness. Therefore, swirl is reduced by backward nozzles and the rough surface of the stator. The roughness also reduces leakage.

Stiffness is increased further by the axial gates through the walls of the pockets near the smooth center dam. The stiff damping bearing prolongs the life of the ball bearing by floating it.

This work was done by George L. von Pragenau of Marshall Space Flight Center. For further information, Circle 125 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, Marshall Space Flight Center [see page 16]. Refer to MFS-28345

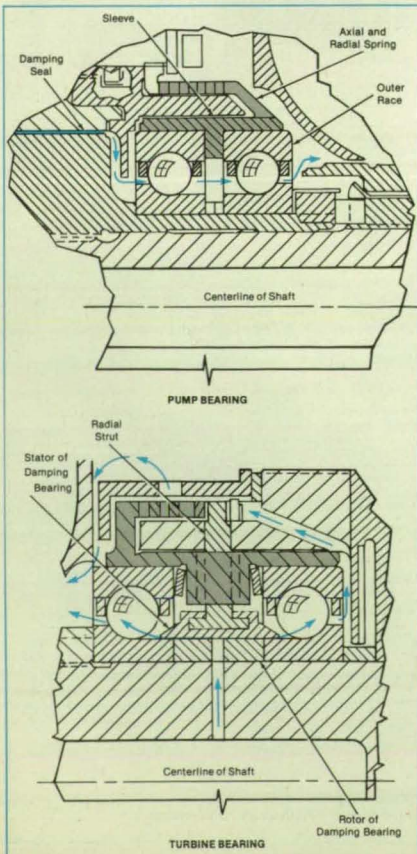
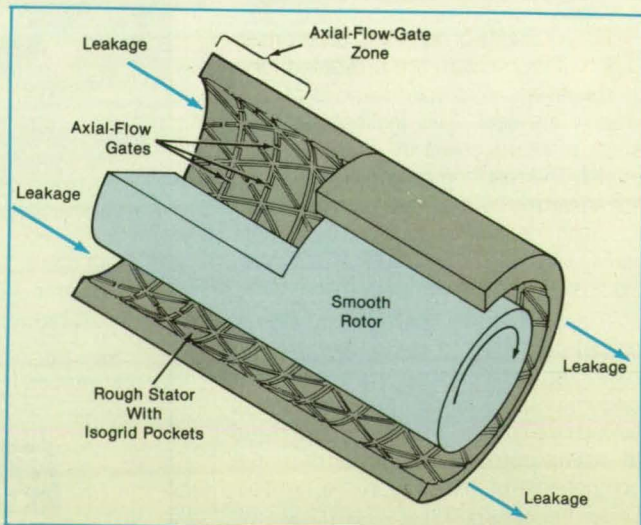


Figure 1. These Duplex Ball Bearings are designed for reduced side loading, and consequently, longer life.

Figure 2. The Film of Fluid between the rotor and stator acts as a stiff bearing.



Books and Reports

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

Civil Applications for New V/STOL and STOL Aircraft

New designs offer benefits in congested urban areas and remote regions.

A report explores the potential uses in civil aviation of advanced rotorcraft, vertical/short-takeoff-and-landing (V/STOL) aircraft, and short-takeoff-and-landing (STOL) aircraft. Future opportunities for such aircraft are enormous, the report concludes. They can overcome formidable geographic barriers and the lack of major airport facilities, bringing fast, flexible transportation to remote areas. At the same time, these aircraft can relieve congestion at airports in densely populated areas by utilizing pads and short runways without interfering with large-air-carrier traffic.

The report describes new aircraft configurations and compares their advantages. It considers such rotorcraft designs as the tilt rotor, folding tilt rotor, stowed rotor, compound advancing-blade concept (ABC) rotors, and stopped (X-wing) rotors. Among V/STOL aircraft, which combine hovering ability with extremely short takeoffs and landings, the report considers lift-cruise fan, tilting-wing, and vectored-thrust types. The report covers advanced STOL aircraft — which by definition can take off or land over a 50-ft (15-m) obstacle in a distance of 2,000 ft (600 m) — with augmentor wings, upper-surface-blowing wings, and externally blown flap systems.

The compound ABC rotor, tilt-rotor, tilt-wing, and X-wing aircraft are best suited to commuter airline service. Tourism appears to be an especially attractive application for compound ABC, tilt-rotor, and X-wing aircraft because they can land on surfaces that are not well prepared. Because they can also hover, they are well suited for public-safety, law-enforcement, air-ambulance, fire-fighting, and disaster-relief services. All configurations may be useful as utility vehicles in developing regions; the choice will depend on requirements for speed, range, and hovering.

This work was done by James A. Albers and John Zuk of Ames Research Center. Further information may be found in NASA TM-100035 [N88-11643], "Civil Applications of High-Speed Rotorcraft and Powered-Lift Aircraft Configurations."

Copies may be purchased [prepayment required] from the National Technical In-

formation Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12175

Thrust-Vector Deflectors for Spacecraft

A rotating shield would steer thrust in the desired direction.

A brief report proposes the use of thrust-vector deflectors (TVD's) to enhance con-

trollability and reduce the number of small rocket engines (thrusters) needed to control the attitudes of artificial satellites. Similar TVD's have already been developed in the aircraft industry for use in jet engines. The principal advantages to be gained by the use of TVD's are lower cost and greater simplicity.

A TVD of the type envisioned would include a deflector shield of approximately quarter-spherical shape. The shield would be mounted immediately downstream of the nozzle of a thruster to intercept and redirect the stream of gases emitted by

From one to a billion.

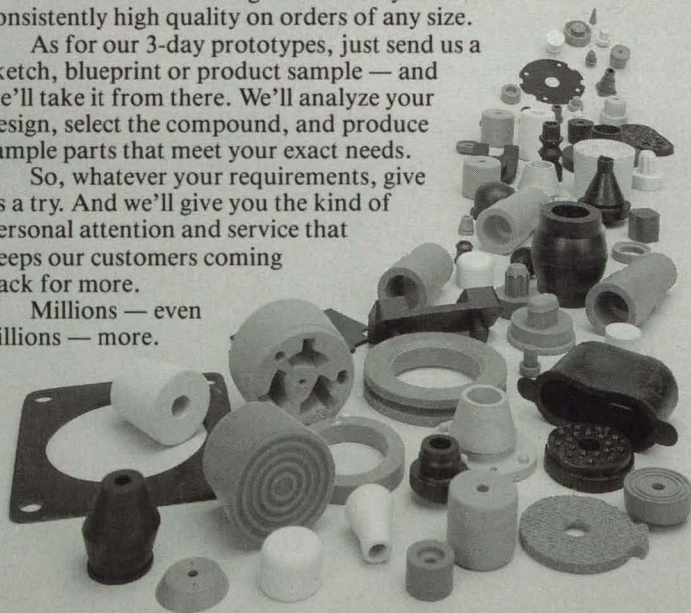
If we can give you 3-day delivery on one prototype rubber part — how long will it take for a billion parts?

Try us and see. You'll be surprised. Our modern manufacturing facilities ensure on-time delivery — on orders from 100 to 1 billion units at very competitive prices. And our SPC Program assures you of consistently high quality on orders of any size.

As for our 3-day prototypes, just send us a sketch, blueprint or product sample — and we'll take it from there. We'll analyze your design, select the compound, and produce sample parts that meet your exact needs.

So, whatever your requirements, give us a try. And we'll give you the kind of personal attention and service that keeps our customers coming back for more.

Millions — even billions — more.



SYNTEX
RUBBER CORPORATION

938 Crescent Avenue, P.O. Box 4006 8F9 Bridgeport, CT 06607
Tel (203) 367-8469 Fax (203) 367-6403

Circle Reader Action No. 515

the nozzle, thereby redirecting the thrust. In one version, the shield could be retracted out of the way to allow the gases to leave the nozzle undeflected and the thrust to point along the axis of the nozzle, or it could be extended part or all the way into the stream to deflect the stream and the resulting thrust to any desired angle up to 90° with respect to the axis of the nozzle. In a simpler version, the shield would be rotatable about the axis of the nozzle but, instead of being retractable, would be placed to deflect the stream 90° always.

The shield could also be rotated about the axis of the nozzle to any angular position within a range of 180°. Thus, altogether, the retractable version of the TVD could steer the thrust of a single small rocket motor to any direction within a solid angle represented by a quarter sphere, whereas the simpler, nonretractable TVD could steer thrust to any angle within a range of 180° in the plane perpendicular to the axis of the nozzle. The nonretractable version could be installed in place of the three coplanar thrusters in each set of four (three coplanar and one perpendicular to the plane) thrusters in a conventional eight-thruster attitude-control system on a satellite. The retractable version could be installed in place of all four thrusters in each set or could be installed with them

to augment the thrust of one or two of them.

This work was done by William C. Soong of McDonnell Douglas Corp. for Johnson Space Center. To obtain a copy of the report, "Thrust Vector Deflector," Circle 107 on the TSP Request Card. MSC-21672

Liquid-Ring Attitude-Control System for Spacecraft

Angular momentum would be transferred to liquid flowing in rings of tubing.

A proposed fluid-ring actuator described in a brief report would be used to orient a spacecraft. The actuator would be used instead of rotating inertia wheels. The actuator would include rings of tubing with liquid flowing inside.

Such an actuator would meet the need for a pointing system of low mass, low power, and high resolution. A combination of thrusters and a liquid-ring actuator could provide control of a base body during slews of scanning platforms, for example.

One or more pumps and appropriate valves would be used to transfer angular momentum to and from the liquid flowing in

the rings of tubing. Fluid pumps with no moving parts could be used if a liquid with the required electrical or magnetic properties were used.

Three fluid rings would provide control of the attitude of the spacecraft about the roll, pitch, and yaw axes. In the most-straightforward version of the actuator, each ring would be circular and would lie in a plane perpendicular to the axis it controls. However, the rings need not be strictly circular or planar. Nor is it essential that the three axes determined by the rings be exactly perpendicular to each other. All that is strictly required is that the three axes determined by the rings not be coplanar. Indeed, an important advantage of the proposed fluid-ring actuator is that the rings of tubing could be routed through existing structures, minimizing the required space and mass.

This work was done by Boris J. Lurie and J. Alan Schier of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Fluid Ring Actuator," Circle 23 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 16]. Refer to NPO-17485.

With an eye toward the future ...

Look to McGraw-Hill for the most authoritative and up-to-the-minute books on optical engineering and optoelectronics, including the eagerly awaited Second Edition of Warren J. Smith's classic book **Modern Optical Engineering** and John C. Stover's **Optical Scattering**.

Other books in McGraw-Hill's acclaimed Optical and Electro-Optical Engineering Series include **Fiber Optics Handbook**, **Optical Thin Films**, **Optical Integrated Circuits**, and **Optical Interference Coatings**. All new, all from McGraw-Hill, and all at better technical book-stores nationwide.

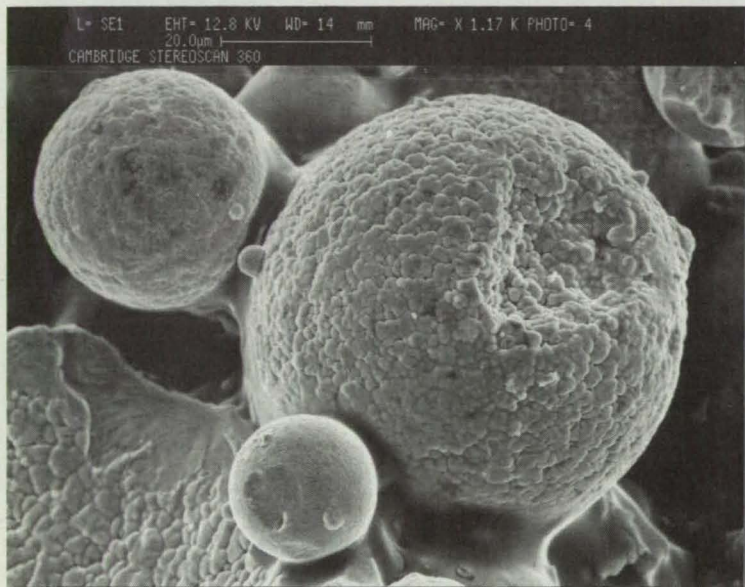
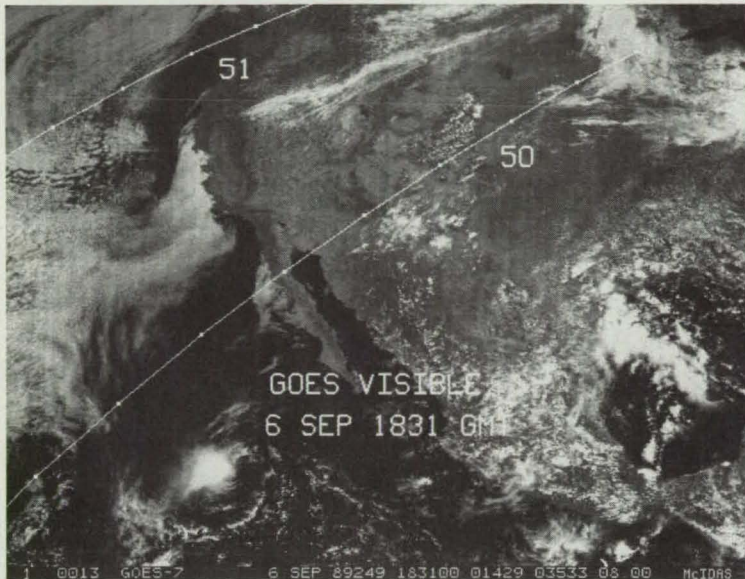
For a **free catalog** of all our books on optics and optoelectronics, please write to the address below.



McGraw-Hill, Inc.
Business and Computing Group
11 West 19th Street, New York, NY 10011



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



The high-resolution Seikosha VP-3500.

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

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

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

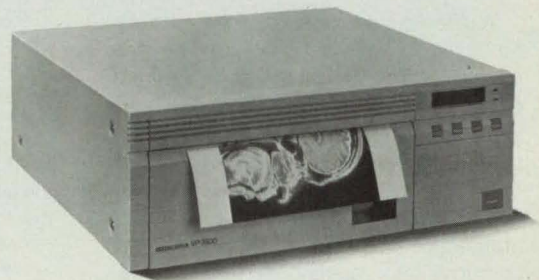
Our 1280-line, multi-format video printer can make things perfectly clear.

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

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

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

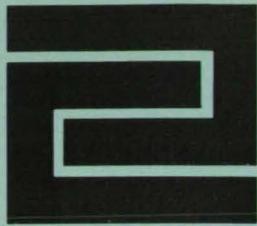
For a demonstration, or additional information on the Seikosha VP-3500, call 1 800-338-2609 or 1 201-327-7227.



SEIKOSHA
A SEIKO GROUP COMPANY

Serious printers for serious business.

Circle Reader Action No. 462



Fabrication Technology

Hardware, Techniques, and Processes

- 84 Monitoring Both Sides of a Weld in Progress
- 84 Monitoring Coating Thickness During Plasma Spraying

- 85 Vacuum-Gauge Connection for Shipping Container
- 85 Treating Nickel Alloy for Sonic Quality
- 86 Rolling Spot Welder
- 87 Controlled-Pinch Spot Welder

- 87 Dual-Head Robotic Welder
- 88 Removing Dross From Molten Solder
- 89 Holographic Reticle
- 90 Advanced Composite Pistons

Monitoring Both Sides of a Weld in Progress

Ultraviolet sources and cameras with image intensifiers would function despite brilliant arc light.

Marshall Space Flight Center, Alabama

A proposed remote vision system would provide for simultaneous viewing of the front and back of a workpiece while it is being welded. The system would thus enable a human or automatic controller to monitor both the weld pool on the front and the weld penetration on the back.

Because the intense light created by the welding arc makes viewing by visible light impractical, a nitrogen laser would generate ultraviolet light, which would be distributed to both sides of the workpiece through two optical-fiber cables (see figure). Image-intensifier tubes aimed at the weld on the front and back would convert the reflected ultraviolet light to visible light. Video cameras equipped with high-resolution charge-coupled devices would convert the visible outputs of the image intensifiers into images for viewing on video monitors.

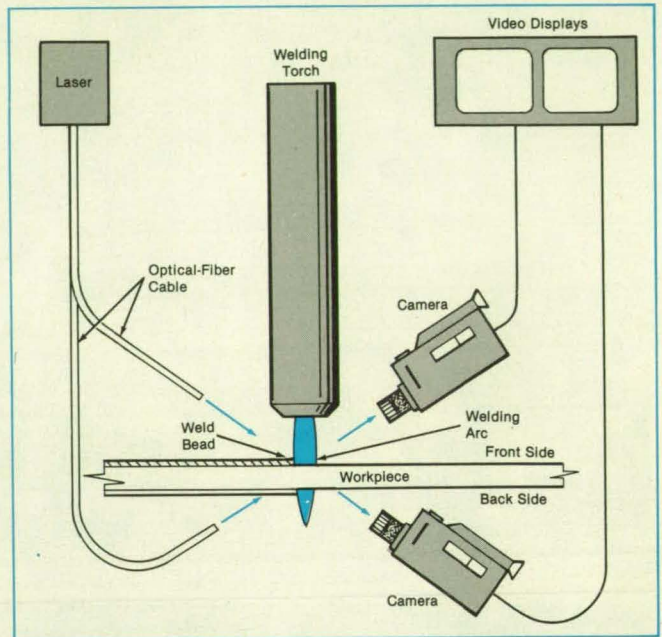
This work was done by C. B. Dickinson and J. B. Hunt of Martin Marietta Corp. for Marshall Space Flight Center. No further

The Dual-View Observation System would look at both sides of a workpiece while it is being welded. Image intensifiers in the cameras would be sensitive only to ultraviolet light provided by optical fibers and therefore, would not be saturated by the intense visible light of the welding arc.

documentation is available.

Inquiries concerning rights for the commercial use of this invention should be ad-

ressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28389



Monitoring Coating Thickness During Plasma Spraying

High-resolution video measures thickness accurately without interfering with the process.

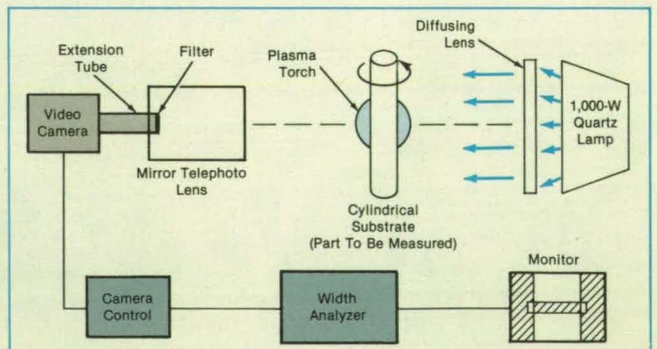
Lewis Research Center, Cleveland, Ohio

A video system monitors the thicknesses of plasma-sprayed coatings. The system measures the thickness after each pass of the spray gun with the coated part in place; it is not necessary to interrupt the process to remove the part for measurement.

The incremental layer-by-layer measurements ensure that an adequate coat is built up without danger of exceeding the required thickness. The measurements also furnish information about the status of the process. If the process is well adjusted, the thickness increases linearly with the number of passes. A deviation from linearity could mean that process conditions need correction.

The system works best with parts that have simple shapes, like cylinders and plates. It can also be used at selected loca-

The Camera Views the Cylindrical Part through a filter during plasma spraying. A lamp backlights the part, creating a high-contrast silhouette on the video monitor. The width analyzer counts the number of lines in the image of the part after each pass of the spray gun.



tions on more complex shapes. Its accuracy depends on the size of the part. It can measure the thickness of a coat on a 0.5-in. (1.27-cm)-diameter cylinder to within about 0.3 mil (0.008 mm).

The system (see figure) includes a commercial high-resolution video camera, a camera-control unit, and a width analyzer. The camera views the part from a distance

of about 5 to 7 ft (1½ to 2 m) through a telephoto lens that has a focal length of 500 to 700 mm. A 1,000-W quartz lamp backlights the part so that the camera sees it in silhouette. A diffusing lens between the lamp and the specimen distributes light to provide a more-uniform bright spot.

The lamp appears brighter to the camera than does the plasma. Therefore, it is

not necessary to use a shutter to protect the camera while the plasma flame is on, although a filter such as a number 6 welder's shade should cover the camera lens.

The field of view of the camera should encompass the entire thickness of the part. If the part is too large for this, then it must be held in position rigidly to prevent changes in position, which could give rise to errors in measurement.

The video monitor displays a negative, closeup image of the part. The width ana-

lyzer places the image of a bar over the image of the part and uses it to detect the number of white lines of the specimen contrasted against the black background. There are 1,024 lines available on the screen. For the 0.5-in. (1.27-cm)-diameter cylinder, magnified to cover about 75 percent of the width of the screen, one line represents about 0.33 mil (0.084 mm) of thickness. In practice, the resolution may be slightly better than this because fractional line widths can be estimated.

This work was done by Robert A. Miller

of **Lewis Research Center**. Further information may be found in NASA TM-101423 [N89-15218], "High Resolution Video Monitoring of Coating Thickness During Plasma Spraying."

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-14919

Vacuum-Gauge Connection for Shipping Container

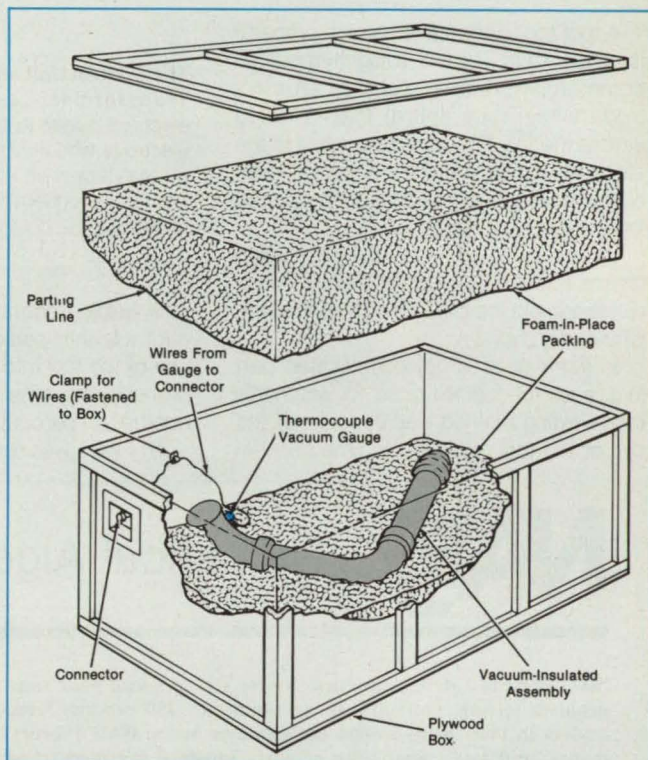
An external connector enables measurement of the vacuum in a stored part.

*Lyndon B. Johnson Space Center,
Houston, Texas*

The vacuums in stored vacuum-insulated parts like cryogenic feedlines must be monitored from time to time to ensure that the vacuums have not deteriorated during storage, because of leakage through defective welds or the like. While such parts often include thermocouple vacuum (that is, low-pressure-measuring) gauges for this purpose, the containers must be opened to gain access to the gauges. This nuisance can be eliminated by mounting a suitable electrical connector in the wall of each container and connecting the gauge to the connector before sealing the container (see figure). The readout meter can then be connected to the gauge without removing the container from storage and opening it. A part that has failed can be returned for repair with its original packing still intact.

The saving in time and money and reduced risk of handling can be considerable for a large part. This technique was used with 17-in. (0.43-m) diameter cryogenic lines that weigh 340 lb (154 kg) apiece. Previously, an overhead crane and special tools had been required to unpack the lines for vacuum checks.

A **Remote-Readout Connector** is added to a shipping container and connected to a thermo-couple vacuum gauge in a vacuum-insulated cryogenic line packed in the container. This simple provision enables the monitoring of the condition of the vacuum without opening the container.



This work was done by Robert H. Henry of Rockwell International Corp. for Johnson

Space Center. No further documentation is available. MSC-21523

Treating Nickel Alloy for Sonic Quality

Bars are processed to enable acoustic monitoring of stress.

Marshall Space Flight Center, Alabama

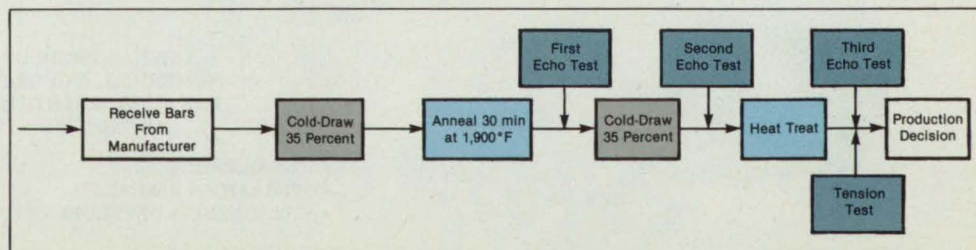
A treatment makes bars of Inconel* 718 alloy homogeneous so that acoustic waves can pass through the material at constant velocity. By thus assuring sonic quality, the

treatment makes possible accurate acoustic monitoring of preloads in fasteners made from the bars.

As received from the manufacturer, the

bars contain local regions in which the chemical composition is different from that of the bulk of the bar. The speed of sound in these regions may be 2 to 3 percent higher than that in the bulk. The difference causes confusing patterns of distorted or multiple echoes when parts are monitored acoustically for stress, making it impossible to interpret the monitoring display.

This **Combination of Thermal and Mechanical Treatments** provides Inconel* 718 bars of high sonic quality suitable for acoustic monitoring of preloads in fasteners made from the bars.



The treatment eliminates longitudinal inhomogeneous regions by recrystallizing the bars. It consists of the following steps (see figure):

- Cold-draw a bar to reduce its diameter by 35 ± 5 percent.
- Anneal the bar at $1,900^\circ\text{F}$ ($1,038^\circ\text{C}$) for 30 minutes in a protective atmosphere of hydrogen or argon. Keeping the bar in the protective atmosphere, cool the bar to $1,650^\circ\text{F}$ (899°C) in 10 ± 2 minutes, then

to $1,470^\circ\text{F}$ (799°C) in 20 ± 5 minutes, and finally to room temperature.

- Cold-draw the bar to reduce its diameter by another 35 ± 5 percent.
 - Prior to production, heat-treat the bar in hydrogen or argon for 8 h at $1,325^\circ\text{F}$ (718°C), then cool at 100°F (56°C) per hour to $1,150^\circ\text{F}$ (621°C). Hold the bar at this temperature for 8 h, then cool it in air.
- *"Inconel" is a registered trademark of the INCO family of companies.

This work was done by Donald E. Stuck, David Kramer, and Dan Q. Lam of Rockwell International Corp. for **Marshall Space Flight Center**. For further information, Circle 152 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 25]. Refer to MFS-29594

Rolling Spot Welder

A wheeled tool speeds tack-welding operations.

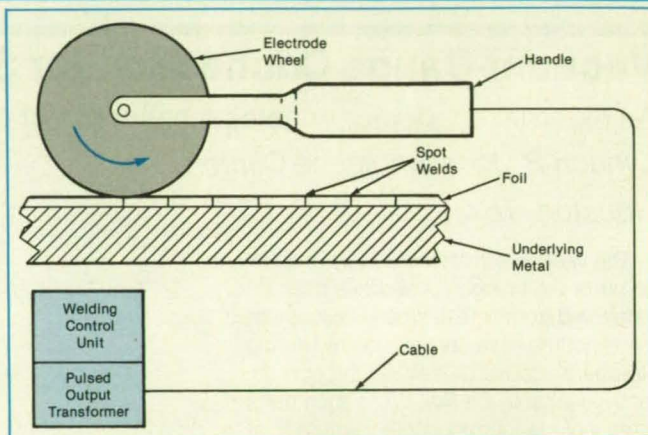
Marshall Space Flight Center, Alabama

A tool spotwelds foil to parts in preparation for brazing. The tool, a slightly modified commercial product, includes an electrode wheel (see figure) that is rolled across the foil. The welding current in the electrode is pulsed as the electrode moves along, making a series of uniformly-spaced low-current spot welds.

Before using the tool, the technician makes a few spot welds manually. These welds prevent the foil from sliding when the wheel rolls over it.

In work on a large, complicated part (e.g., a rocket-engine nozzle, for which this tack-welding method was conceived), the use of the tool reduces the time spent in

The **Control Unit and Transformer** send electrical pulses to the electrode wheel. The pulses tack-weld the foil to the underlying metal.



tack-welding operations by about 25 percent. It is anticipated that by integrating the use of the tool into a robotic tack-welding process, the time could be reduced by another 25 percent.

This work was done by Garret E. Wagner

and Steve L. Fonteyne of Rockwell International Corp. for **Marshall Space Flight Center**. No further documentation is available.

MFS-29580

NAG[®]

Numerical Algorithms Group

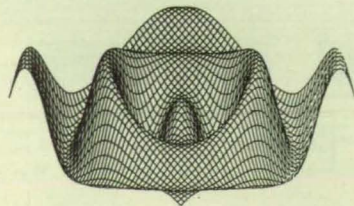
NAG Fortran Library products enable you to spend your time and talents on genuine problem solving, not software development. 200 experts, recognized worldwide as the leaders in their fields, create the solutions in the NAG Library. The accuracy, performance, and total capabilities of NAG software are unmatched in the industry. Take advantage of NAG's expertise in any of these fine products:

NAG FORTRAN LIBRARY

More than 700 user-level routines covering the principal areas of mathematics and statistics. Available on over 90 different computers from PC's to supercomputers.

NAG GRAPHICAL SUPPLEMENT

A convenient and versatile means for displaying numerical results generated by the Library. A facility not available with other libraries.



NAG ONLINE SUPPLEMENT

An interactive query system enabling the user to make maximum use of the NAG Library. The Online system provides hints on choice of routines, syntax assistance, and other forms of help.

NAG VECPAR_77

An interactive CASE tool for vectorizing and parallelizing Fortran programs. Attain performance improvements beyond what optimizing compilers may provide. Ideal for "rejuvenating" older applications.

NAG Ada Library

The first commercially available math library designed and written completely in Ada. Shortens the development cycle for embedded math operations in Ada programs.

GENSTAT and GLIM

Interactive statistical analysis systems used for data exploration, linear modelling, time series analysis...useful applications in statistical quality control and product survival analysis.

THE NAG PRODUCT LINE OFFERS
NUMERICAL AND GRAPHICAL ALGORITHMS
FOR MANY SCIENTIFIC AND ENGINEERING
APPLICATIONS INCLUDING:

- SIGNAL PROCESSING
- OPERATIONS RESEARCH
- APPLICATIONS DEVELOPMENT
- COMPUTATIONAL CHEMISTRY
- ECONOMETRIC MODELS
- STATISTICAL ANALYSIS

Controlled-Pinch Spot Welder

Compressed air furnishes repeatable clamping force.

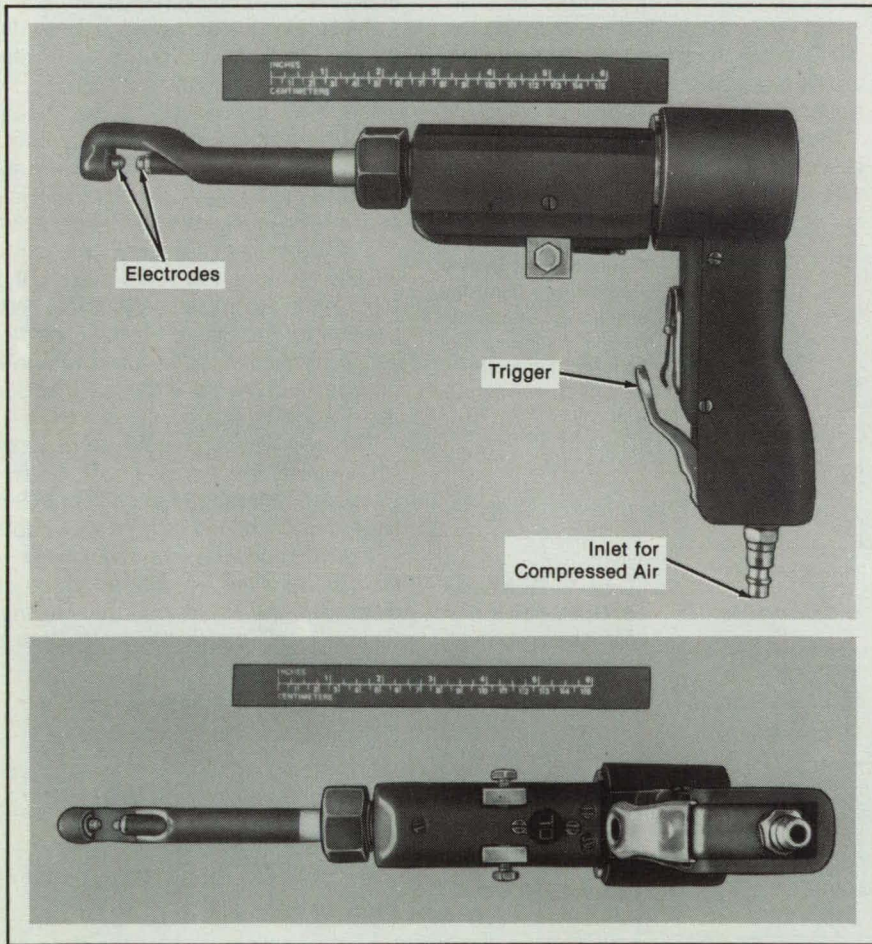
Marshall Space Flight Center, Alabama

A handheld spot-welding gun clamps the workpiece under air pressure instead of under the operator's hand pressure. It therefore makes spot welds that are more repeatable and reliable. It reduces the amount of manual labor required and enables welds to be made at a faster rate. Compact and light in weight, it can reach restricted areas that ordinary commercial welding guns cannot.

The spot-welding gun contains opposing pinching electrodes in a C-shaped tip (see figure). When the operator compresses the

trigger on the handgrip, the air pressure drives the electrodes together so that they pinch the workpiece between them. Simultaneously, current flows between the electrodes and welds the workpiece. Shop compressed air, connected through a line to the heel of the handgrip, produces a uniform pinching force from weld to weld.

This work was done by Gene E. Morgan of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available. MFS-29606



The Trigger on the Handgrip actuates both air pressure and welding current.

Dual-Head Robotic Welder

Distortion in welds is reduced.

Marshall Space Flight Center, Alabama

A robotic welder uses two welding heads simultaneously. The robot was developed for assembly of the "hot dog" shell on the main injector for the Space Shuttle main engine (see figure), and the concept is applicable to other, similarly rounded or contoured workpieces. The opposed heads

reduce the distortion and stress in opposed weld joints and speed up welding operations.

When only one welding head was used, small segments were welded on joints on alternating sides of the "hot dog" shell until the seams were complete. The welded



WE STILL ARE

Providing superior
indium solders.

Scientists around the world look to indium solders to solve their most difficult joining and bonding problems. Because unlike tin-lead solders, indium solders won't scavenge or leach metallizations of precious metals. Their strength is derived from outstanding ductility which also accommodates mismatches in thermal coefficients of expansion, severe thermal cycling and physical stresses. They'll even wet glass, quartz and glazed ceramics.

For free technical literature and consultation, call 800-448-9240.



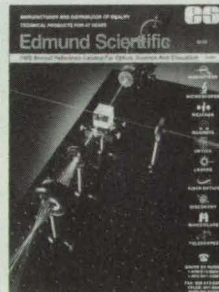
**INDIUM CORPORATION
OF AMERICA**

1676 Lincoln Avenue • Utica, NY 13502 • Telex
93-7363 Toll Free 1-800-448-9240 • In NY State
Call Collect 315-768-6400 • FAX 315-768-6362

Circle Reader Action No. 512



Write For Your Free Edmund Scientific 172 Page Catalog.



- LENSES
- PRISMS
- MIRRORS
- FIBER OPTICS
- OPTICS
- LASERS
- MAGNETS
- MAGNIFIERS
- MOTORS/PUMPS
- TELESCOPES
- MICROSCOPES
- POSITIONING EQUIPMENT
- COMPARATORS

Features over 7,000 products!

Our new, full color catalog describes one of the largest and most diversified lines in the nation of precision lenses, optics and optical instruments plus many hard-to-find scientific and technical products used in science, industry and by researchers.



Serving Industry Since 1942

Edmund Scientific Co.

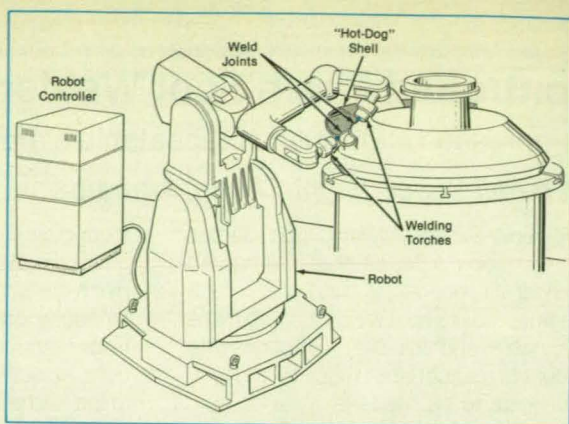
Dept. 10B1, N922 Edscorp Bldg., Barrington, NJ 08007
Tel. 1-609-573-6250 • Fax. 1-609-573-6295 • Telex 831-564

parts became mismatched, and uneven stresses built up.

With the opposed heads, welding proceeds continuously on both joints on opposite sides of the workpiece. The opposing welding forces tend to cancel each other, resulting in little or no distortion of the parts. Stresses are distributed more evenly.

This work was done by Gary S. Beard of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available. MFS-29610

One Controller Operates Two Welding Torches on a robot. The robot arms move the torches together along the contours of the two weld joints.



Removing Dross From Molten Solder

An automatic device helps to assure good solder connections.

Marshall Space Flight Center, Alabama

A machine wipes dross away from an area on the surface of molten solder in a pot. Intended for use in a robotic system for the fabrication of electronic circuits, the machine helps to provide the clean liquid-solder surface that is necessary for good soldered connections. The machine functions somewhat in the manner of a wind-

shield wiper, except that it moves in one direction only. An arm is rotated by a motor in a tilted plane on a mount attached to the solder pot (see Figure 1).

The arm normally remains at rest at a position determined by a parking switch, with which the arm makes mechanical contact at that position. A trigger pulse sup-

plied by an external robot causes a control circuit (see Figure 2) to turn the motor on, thereby causing the arm to start rotating away from the parking switch.

A blade on the arm sweeps down into, through, then up and out of the molten solder. With little splashing or rippling of the solder, the blade sweeps the dross to one side. The arm continues to rotate until it once again strikes the parking switch and stops. A new rotating/sweeping cycle begins upon receipt of a new trigger pulse.

The dross-removing equipment has worked well for a few years in use with a robot in the automated assembly of components for the Space Shuttle controller. The equipment could be used wherever precise, automated soldering must be done to military specifications.

This work was done by Winston S. Webb of Honeywell, Space and Strategic Avionics Division, for Marshall Space Flight Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28406.

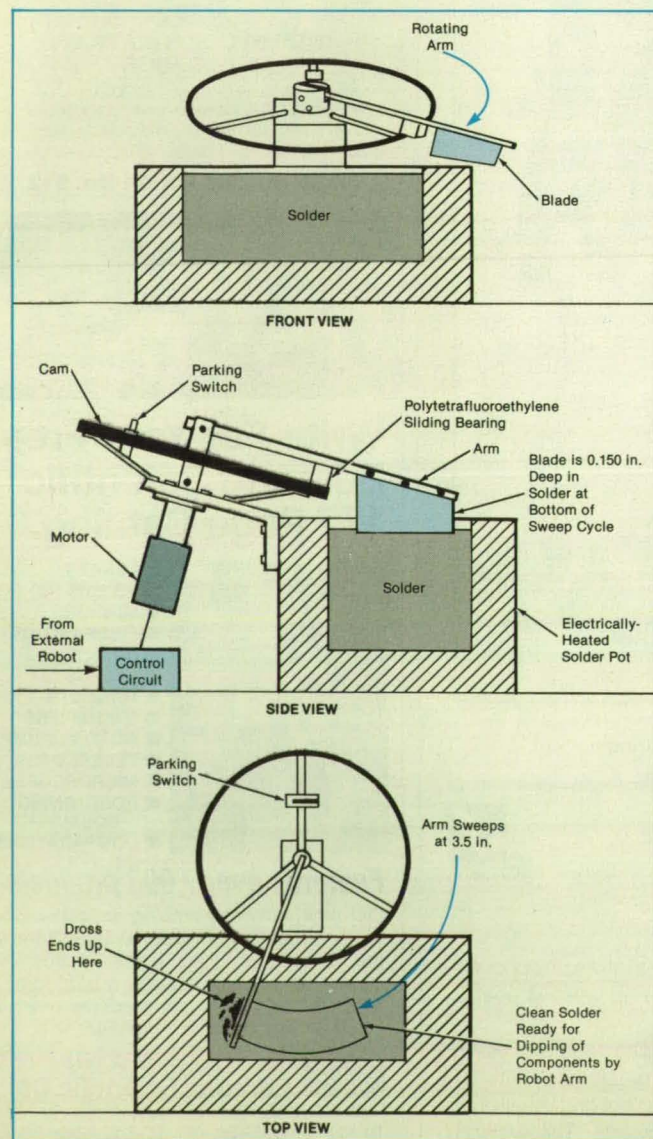
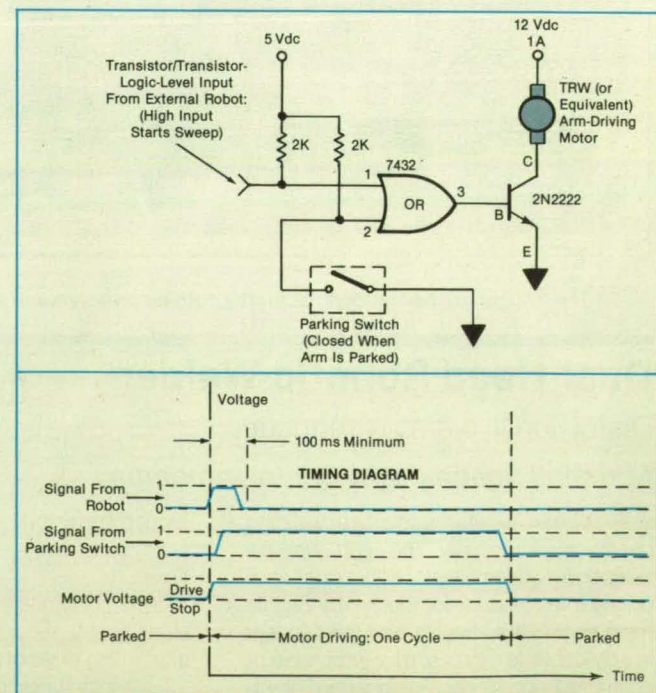


Figure 1. The **Dross-Removing Machine** sweeps across the surface of molten solder somewhat in the manner of a windshield wiper.

Figure 2. **Each Cycle of Operation** is triggered by a pulse from an external robot.



Holographic Reticle



This device could be used for noncontacting, nondestructive inspection of surfaces.

Marshall Space Flight Center, Alabama

A holographic reticle has been proposed for use in nondestructive evaluation of surface irregularities. Analogous to a common reticle used to measure the lengths and widths of surface features during visual inspection under a microscope, the holographic reticle would extend the inspection capability to include measurements of depth. Surfaces could be inspected without contamination, damage, or costly disassembly.

An inspector places a common reticle in the eyepiece of a microscope and views the surface to be inspected at a known magnification. A surface irregularity to be measured is aligned with a grid of calibrated lines on the reticle, and the inspector counts lines to determine the length and width of the irregularity.

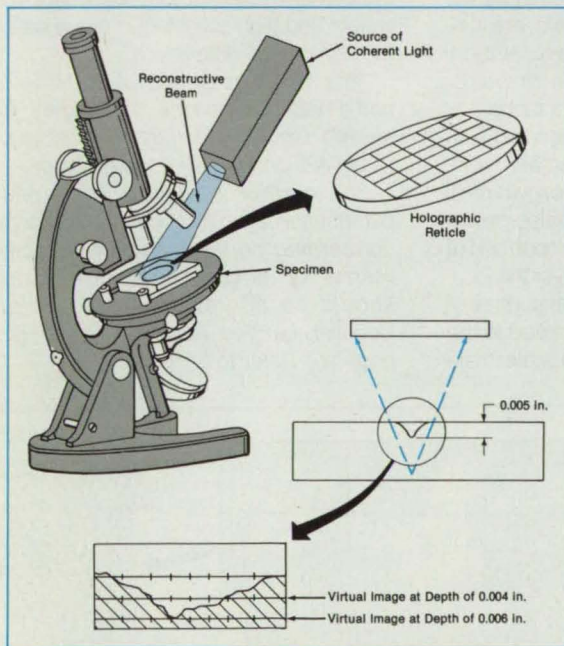
To provide information on depth, a holographic reticle would be made to contain multiple calibrated images. The images would be projected from a common point to indicate focal planes at specific distances through the surface to be inspected. The hologram would produce virtual images in the object field of the microscope. These virtual images would serve as reference points in the object field. As each such image was brought into

focus, a correlation would be made to the point at which the surface to be inspected came into focus. The surface to be inspected could then be said to lie at a depth between the depths of the holographic images above and below it.

An off-axis source of reconstructive light would be necessary for viewing of the hologram and the surface to be inspected under the microscope (see figure). The off-axis arrangement would allow for the projection of the hologram without reflection of the light into the microscope. (A hologram cannot be viewed with parallel light.) The holographic reticle would be calibrated by the use of known standards.

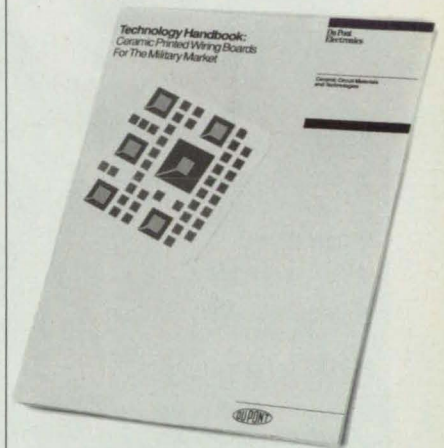
Holographic reticles would provide valuable information that is now difficult to obtain. For example, such surface defects as corrosion and porosity, as well as the propagation of cracks, could be measured accurately. Roughness, wear, and plating thickness could also be measured. Holographic reticles could also be used to determine the quality of microcircuits.

This work was done by Edward A. Henn and Marc M. Scribner of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available. MFS-29597



The **Holographic Reticle**, placed on the specimen, would produce virtual images of reticles of various depths into specimen.

The Reasons For Using Ceramic PWBs In High Performance Military Applications Could Fill A Book.



(Call 1-800-237-4357 And It's Yours Free.)

Call DuPont now and ask for our free Ceramic Printed Wiring Board Handbook for Military Applications.

DuPont Electronics

Share the power of our resources.



September 1990—Another Milestone for NASA Tech Briefs

With this issue, *NASA Tech Briefs* enters a new era. Over 200,000 copies of *NASA Tech Briefs* were printed, achieving a goal of expanding distribution of technical information and new ideas to engineers and scientists who design tomorrow's products.

Pure and Simple.

Introducing VAT's unique Mini Gate, an innovative new vacuum valve.



Starting at only \$695

Pure

- ▼ Virtually particle-free with no closing shock
- ▼ Low degassing
- ▼ Fully bakeable to 200°C
- ▼ Vacuum to UHV

Simple

- ▼ Patented sealing principle uses only one moving part
- ▼ Extremely compact and lightweight
- ▼ 1", 1 1/2", or 2" I.D.
- ▼ Visual indicator for open/closed position

See the Mini Gates and other innovative valves in our new 225 page catalog, 'Vacuum Valves 90'.

VAT
INCORPORATED

600 West Cummings Park
Woburn, MA 01801
Tel: (617) 935-1446
(800) 828-5625

Advanced Composite Pistons

Three-dimensional knitted fiber would yield improved mechanical properties.

Langley Research Center, Hampton, Virginia

A new concept involving an improved configuration of reinforcing fibers and an improved fabrication process is proposed to improve the thermal and mechanical properties of composite piston structures. The concept reduces the amount of labor necessary to manufacture piston structures, with attendant reductions in costs.

At present, composite piston structures are made with omnidirectional fiber mat to form the basic piston shapes, and unidirectional or woven two-dimensional fabrics to provide selective reinforcements where added strength is required. Two-dimensional layups and uniaxial fiber reinforcements are inherently weak in interlaminar properties and are difficult to fabricate. Additional woven plies to increase thicknesses and reduce the intensities of loads, or cross-stitches to improve interlaminar strength, are required to attain the desired mechanical properties.

The new design involves the enhanced configuration, shown in the figure, wherein a single knitted-carbon-fiber structure with one end closed (a sock) is used to form the external surfaces of the piston. The areas requiring additional strength, such as the wristpin bosses and piston crown, are reinforced as necessary with three-dimensional woven or braided monolithic shapes or precut plies of two-dimensional fabric.

The knitted sock (preimpregnated with phenolic resin) is laid in a female mold, closed-end first, then the crown and wristpin-boss reinforcements (also preimpregnated) are positioned. The open end of the sock is then draped back over the local reinforcements to form the inner surface of the piston. Pressure is then applied to the laminate by use of an expandable male

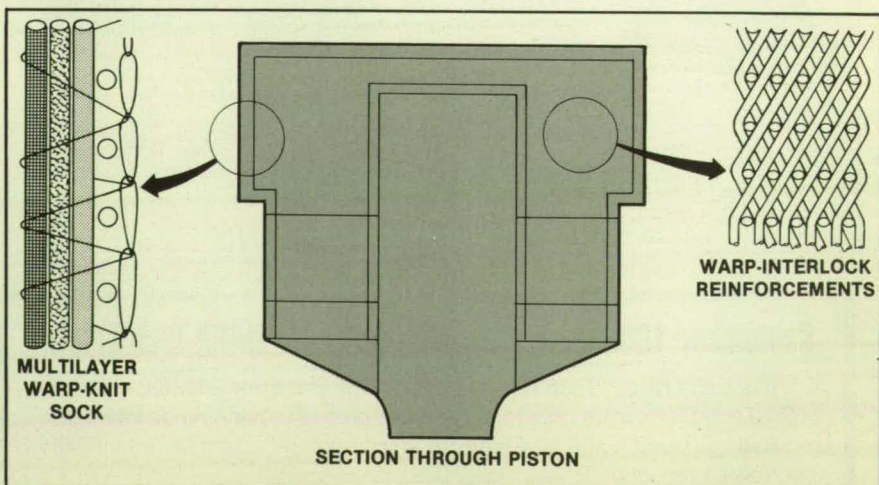
mold. While under pressure, the laminate is cured at 325 °F (163 °C) to form the desired piston shape. Alternatively, the layup can be placed over the expandable male mold and then inserted into the female mold to obtain the same result.

The preform is then subjected to an inert-gas pyrolysis treatment to carbonize the phenolic resin. It is then reimpregnated and repyrolyzed. The pyrolysis and infiltration steps are repeated to densify and strengthen the structure to attain the desired properties. These infiltration and pyrolysis steps are followed by a chemical-vapor deposition step, which provides an impervious carbon surface.

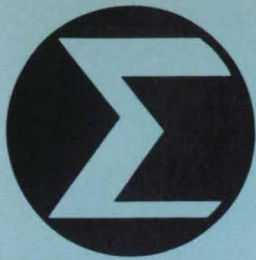
Among the advantages of this concept are improved mechanical properties of finished pistons and, especially, the elimination of heavy dependence on the inherently weak interlaminar properties of carbon-carbon; ease of automation to reduce fabrication costs; readily modifiable architecture to vary mechanical properties to desired values; and reduction in the number of elements required to fabricate pistons. The advantage of these piston structures lies in applications where light weight and high specific performance are the primary considerations.

This work was done by Allan H. Taylor and Philip O. Ransone of Langley Research Center. For further information, Circle 129 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 16]. Refer to LAR-13926.



A Single Knitted-Carbon-Fiber Sock is used to form the external surfaces of the piston.



Mathematics and Information Sciences

Hardware, Techniques, and Processes

- 91 Phase Calibration of Radar Polarimetric Data
- 95 Exponentially Stabilizing Robot Control Laws

- 95 Concurrent Algorithm for Particle-in-Cell Simulations

Books and Reports

- 97 Exact Linearization of Control of Robots

- 97 Non-Lipschitzian Dynamics for Modeling Neural Networks
- 98 Balancing Loads Among Robotic-Manipulator Arms

Phase Calibration of Radar Polarimetric Data

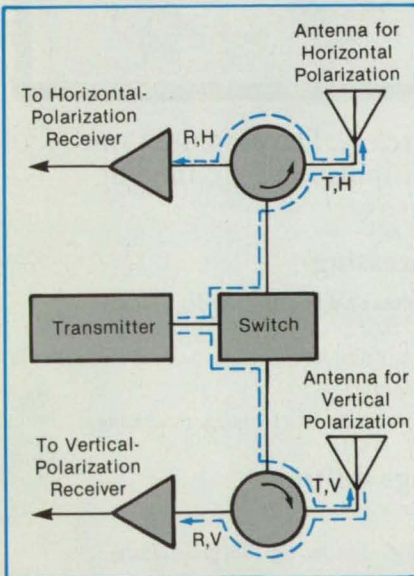
Calibration parameters are extracted from the data themselves.

NASA's Jet Propulsion Laboratory, Pasadena, California

A technique for the phase calibration of data acquired by an airborne imaging radar polarimeter is based on the extraction of the calibration parameters from the data themselves. It is not necessary to place calibration equipment on the ground or to have prior knowledge of conditions on the ground. The new phase-calibration technique enables the use of a data-compression technique to reduce the volume of data in a synthetic-aperture-radar correlator.

The phases of the radar return signals are essential elements of the radar polarimetric data. Therefore, phase calibration must be performed to correct for the phase delays along the transmitting and receiving paths of the radar equipment (see figure).

The new technique involves modifications of the Stokes matrices, which are 4×4 matrices, each element of which is a sum of products of elements of the scattering matrix. (The scattering matrix represents, in complex-number form, the relationship



A Typical Radar Polarimeter includes transmitting (T) and receiving (R) channels for horizontally (H) and vertically (V) polarized signals. The phase delay in each channel is usually known only approximately if at all. Consequently, it is necessary to phase-calibrate the radar return signals.

Advanced coating and laminating technology

Rexham custom coats and laminates flexible films, foils, and papers for use in electronics, aerospace materials, reprographics, and other high-performance applications.

You find resources developed during 30 years' work with high-precision projects—

- Coating accuracy capabilities in the millionths

- Clean room manufacturing
- Sophisticated on-line quality inspection
- Extensive analytical capabilities

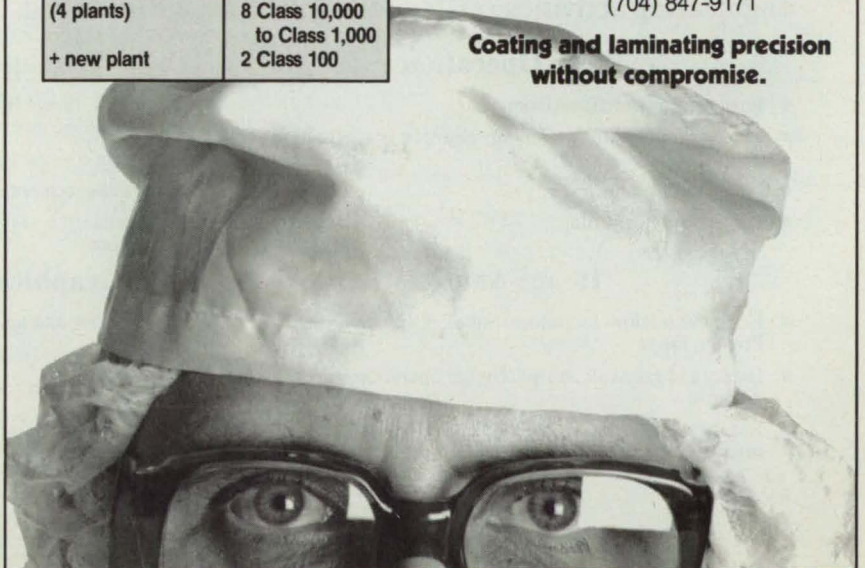
Call for our Credentials Package. Complete confidentiality guaranteed.

Rexham Industrial

P.O. Box 368
Matthews, NC 28106
(704) 847-9171

Coating and laminating precision without compromise.

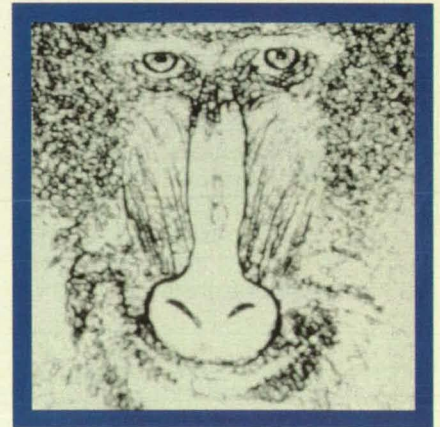
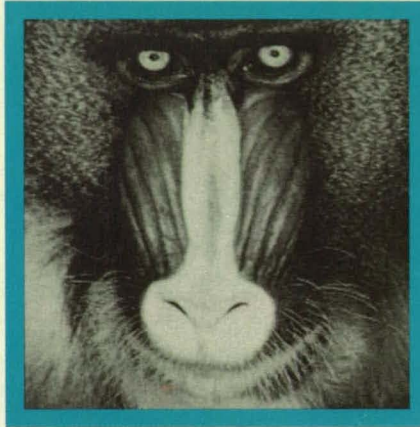
Coating/laminating lines (4 plants)	15
+ new plant (1990)	2
Clean rooms (4 plants)	8 Class 10,000 to Class 1,000
+ new plant	2 Class 100



Stop monkeying around and get serious about
Image Processing...

ImPro-Lab

-the new Digital Image Processing Package for Image Professionals



If you are an Image Processing Professional engaged in Research & Development or applications involving Image Processing, you will find this tool indispensable in your engineering activities related to Digital Image Processing.

Basic Operations

- Image storage/retrieval from disk
- Image thresholding, clipping, addition, subtraction, and/or/xor, etc.
- Image buffering
- Image display, printing

Image Analysis

- Edge Detection including Sobel, Laplace, Roberts, Prewitt, range
- Binary and grayscale morphological operations (erosion, dilation)
- Region segmentation, object counting, object area measurement

Image Processing

- Image FFT, Image filtering (linear 2-d filtering, moving average, order statistics, median)
- Histogram computation and equalization
- Image enhancement and sharpening
- Various image noise generators can be used for image processing simulations

Graphics/Image Editing

- Image mixing and halftoning
- Synthesis effects (using noise generators, e.g. film grain effect)
- Image scaling/rotation, thresholding and copying

Source Code Image Library Available!

9550 Skillman LB 125
Dallas, TX 75243
phone 214-343-8525
fax 214-343-2457

Hyperception

between the horizontal and vertical components of the radiation transmitted to, and returned from, the portion of the target in the designated picture element.) The first step is to compute the average, over all picture elements, of the phase difference contained in the cross-polarization terms of the receiving matrix, and to store this phase difference in a header that accompanies the full set of data. The step is to symmetrize the receiving matrix, which is similar to the scattering matrix except that it includes the unknown phase delays for which corrections have to be made. This

symmetrization avoids the duplication of cross-polarization terms. These two steps reduce the volume of data.

The symmetrized version of the receiving matrix is converted into Stokes-matrix format. The Stokes matrices can be averaged spatially to reduce the volume of data. In this case, the data are compressed further by quantization of the elements of the Stokes matrices. In the original application, the volume of data was reduced from 128 Mbytes to 10 Mbytes for each set.

The particular combination of phase-calibration and data-compression tech-

niques enables any amount of averaging to reduce the volume of data (at the expense of resolution), without loss of the fidelity of phase calibration. The phase-calibration algorithm is reversible in that if the data are phase-calibrated incorrectly, they can be recalibrated.

This work was done by Howard A. Zebker and Yunling Lou of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 135 on the TSP Request Card.
NPO-17844

Exponentially Stabilizing Robot Control Laws

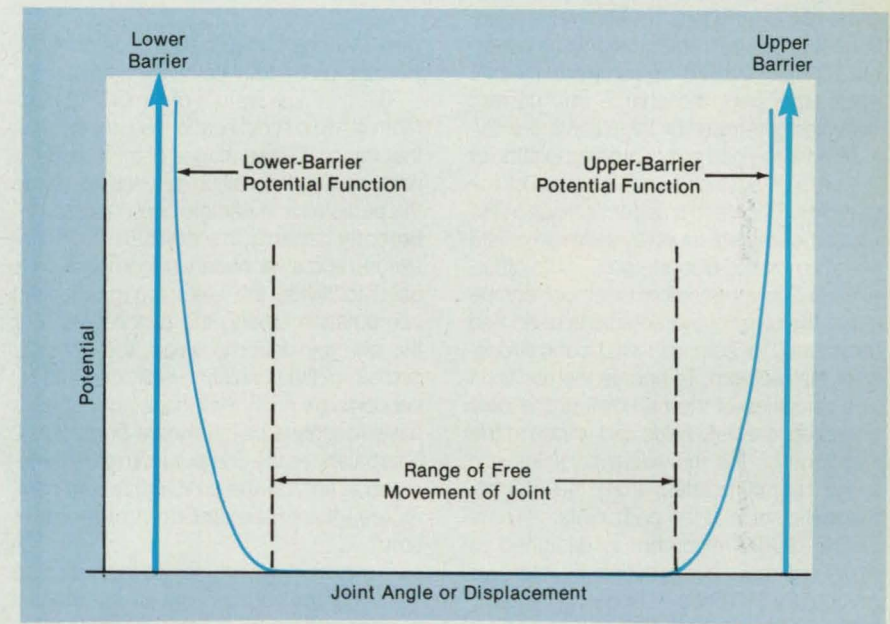
New control laws provide tradeoffs between computation and convergence.

NASA's Jet Propulsion Laboratory, Pasadena, California

A new class of exponentially stabilizing laws for the joint-level control of robotic manipulators has been introduced. In the case of set-point control, this approach offers the simplicity of a proportional/derivative control architecture. In the case of tracking control, this approach provides several important alternatives to the completed-torque method, as far as computational requirements and convergence. Finally, the new control laws can be modified in simple fashion to obtain asymptotically stable adaptive control, when the robot model and/or payload mass properties are unknown.

It has been recently recognized that the nonlinear dynamics associated with robotic manipulators have certain inherent passivity properties. More specifically, the derivation of the dynamical equations of robots from Hamilton's principle gives rise to natural Lyapunov functions for the design of controls, based on considerations of total energy. Through a slight modification of the energy Lyapunov function and the use of a convenient lemma to handle third-order terms in the derivatives of the Lyapunov function, closed-loop exponential stability can be achieved in both the set-point-control and tracking-control problems. By taking this approach, one avoids the need for generalization of the principle of invariance to time-varying systems, a need that has been a major source of difficulty in the past.

In the case of set-point control, one can derive exponentially stabilizing, proportional/derivative-plus-potential-shaping types of control laws by incorporating artificial potential fields into the Lyapunov function. Examples of simple control structures obtained through the use of potential fields



Upper- and Lower-Barrier Potential Functions can be incorporated into energylike Lyapunov functions to define joint stops.

include proportional/derivative alone, proportional/derivative plus bias, and proportional/derivative plus joint-stop barrier (see figure).

In the case of tracking control (that is, making the robot follow a prescribed trajectory), the modified Lyapunov function leads more directly to exponentially stable control laws. This class of control laws offers an alternative to control laws derived by the more-conventional computed-torque method, which compensates for nonlinear components of the dynamics of the robot. This class of control laws also provides tradeoffs between stability (or convergence) and the amount of on-line computa-

tion required, which is directly related to performance via the maximum rate of sampling. In the case of one such control law, the nonlinear structure is decoupled from the real-time measurements, completely eliminating the requirement for on-line nonlinear computation.

Asymptotically stable adaptive control is also possible with the same control architecture, and is discussed in a separate paper.

This work was done by John T. Wen and David S. Bayard of Caltech for NASA's Jet Propulsion Laboratory. For Further information, Circle 98 on the TSP Request Card.
NPO-17587

Concurrent Algorithm for Particle-in-Cell Simulations

Separate decompositions are used for the particle-motion and field calculations.

NASA's Jet Propulsion Laboratory, Pasadena, California

The General Concurrent Particle-in-Cell (GCPIC) algorithm is used to implement

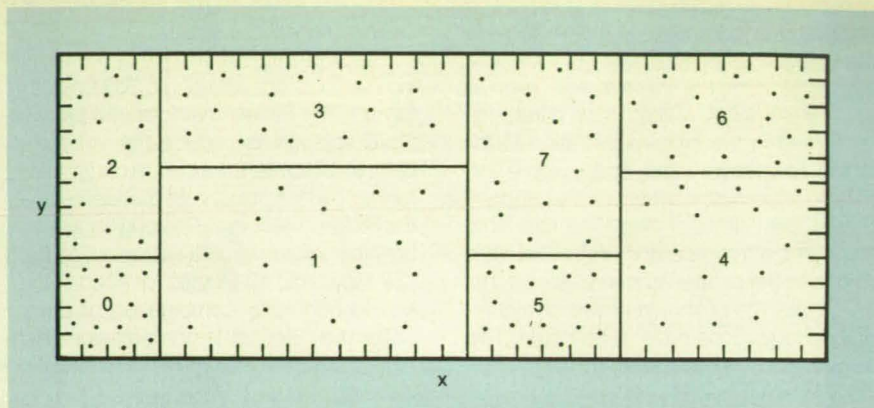
the motions of individual plasma particles (ions and electrons) under the influence of

particle-in-cell (PIC) computer codes on concurrent processors. PIC codes simulate

the motions of individual plasma particles (ions and electrons) under the influence of the electromagnetic fields generated by the particles themselves. Simulations are performed to study a variety of nonlinear problems in plasma physics, including magnetic and inertial fusion, plasmas in outer space, the propagation of electron and ion beams, free-electron lasers, and particle accelerators. Because the computation time in the PIC method is roughly proportional to the number of particles, it is desirable to use the GCPIC algorithm to take advantage of the speedup offered by concurrent processing for realistic simulations that require thousands to millions of particles.

To keep the amount of computation manageable, a PIC code provides for a discrete spatial grid to solve Maxwell's equations for the electromagnetic fields generated or modified by the plasma particles. At each time step, the charge and current densities generated by the plasma are calculated at the grid points by interpolation of the present positions and velocities of the particles. The electromagnetic fields at the next time step are found by solving the field equation on the discrete grid. Finite-difference or Fourier-transform methods can be used; the form of the equations used and the method for solving them depend strongly on the problem. To update the positions and velocities of the particles at the next time step, the new fields and forces at the locations of the individual particles are found by interpolating from the electromagnetic fields at the grid points.

The GCPIC algorithm is designed to make the most computationally intensive portion of a PIC code — updating the particles and the resulting charge and current densities — run efficiently on concurrent processors. The time to make these updates, termed the particle "push time," is defined to include the time to update the particle positions and velocities (including the interpolation to find the forces at the particle positions) and to "deposit" (interpolate) the contributions of the particles to the charge and current densities onto the



In a **Two-Dimensional Problem With Equally-Spaced Grid Points**, an equal number (15) of particles is assigned to each of 8 subdomains of different sizes. The computations for the particles in each subdomain are assigned to one of eight concurrent (parallel) processors.

grid. Generally, this push time is about 90 percent of the total computation time.

The principal feature of the GCPIC algorithm is two distinct spatial decompositions that mirror the two stages of a PIC code: a primary decomposition is used to divide the particles and particle computations efficiently among the concurrent processors, and a secondary decomposition is used to divide the electromagnetic-field computation among the processors. For the primary decomposition, the physical domain of the simulation is divided into N_p subdomains such that these subdomains have roughly equal numbers of particles. This balances the computation and memory loads among the processors and minimizes interprocessor communication time.

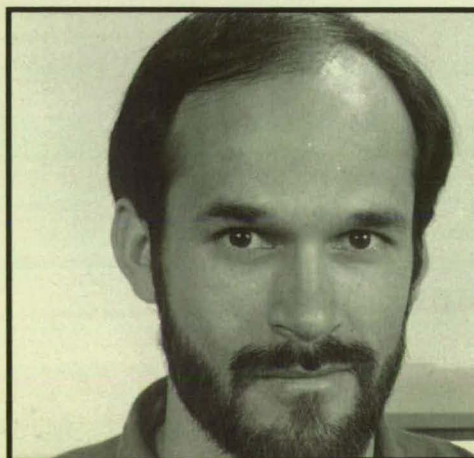
For problems with nonuniform particle densities, the subdomains are of unequal physical size, and, in general, contain unequal numbers of grid points (see figure). Each processor is assigned a subdomain and is responsible for storing and pushing the particles in this subdomain. Each processor is also responsible for storing the electromagnetic-field quantities for the grid points of its assigned subdomain. As a particle moves to a new subdomain, the particle is passed to the processor assigned that

subdomain in this primary decomposition.

The primary decomposition is not generally the optimum for solving the electromagnetic-field equations in parallel. Therefore, the secondary domain decomposition is chosen to make the concurrent field solution efficient and is used only for this and related diagnosis. The specific decomposition depends on which method of solution is used. In general, the most efficient decomposition for the field solution is likely to involve dividing the number of grid cells equally among the processors.

At each time step, prior to solving the field equations, the relevant charges and current densities at the grid points are passed among the processors and redistributed as needed in the secondary decomposition. After the field equations are solved, the electromagnetic-field quantities must be passed among the processors so that they are distributed as needed in the primary decomposition for the particle computation.

This work was done by Paulett C. Liewer of Caltech and Viktor K. Decyk of UCLA for NASA's Jet Propulsion Laboratory. For further information, Circle 50 on the TSP Request Card. NPO-17737



Eagle found the answer.

Actually, they started working on the answers to our stainless steel tubing problem before we had even started to formulate the questions.



EAGLE STAINLESS TUBE CORP.
10 Discovery Way • Franklin Industrial Park
P. O. Box 596 • Franklin, MA 02038

1-800-528-8650
FAX: 508-520-1954



Books and Reports

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

Exact Linearization for Control of Robots

The equivalence of several theoretical approaches is discussed.

A report comments on the application of geometric control theory (GCT), resolved-acceleration control (RAC), operational-space control (OSC), and nonlinear-decoupling theory (NDT) to a remote manipulator consisting of multiple rigid links. The principal concern in this and previous studies on these topics has been the search for a nonlinear feedback law that could make the end effector behave, for purposes of control, as though its dynamics were linear and decoupled.

The first chapter summarizes the aforementioned theoretical approaches. The second chapter describes the dynamics of manipulators and introduces the equations of motion. The third chapter continues the analysis with a view toward calculation of the kinematics of the end effector after linearization: It shows how the positional dynamics are decoupled and linearized, while the attitude dynamics remain nonlinear but controllable. This analysis provides for the linearization of the equations of the system without regard to a particular control-theory approach and thus helps in the comparison of the different approaches.

The fourth chapter compares the GCT, NDT, and OSC approaches on a manipulator of 6 degrees of freedom. The fifth chapter derives a feedback law for local exact decoupled external linearization and discusses its relationship to RAC and GCT. The sixth and final chapter presents conclusions.

The author shows that GCT, RAC, OSC, and NDT all lead to the same linearizing control law and decoupling of the motions of the end effector and that these approaches differ mainly in their implementation details and design philosophies. Exploiting the fact that the mass matrix of a rigid-link manipulator is positive definite, the author demonstrates that nonsingularity of the Jacobian matrix of the end effector is a necessary and sufficient condition for the existence of a locally output-decoupling feedback law. An understanding of the unity among the different control-theory approaches makes it relatively easy to specify this feedback law.

This work was done by Kenneth K.

Kreutz of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "On Manipulator Control by Exact Linearization," Circle 71 on the TSP Request Card. NPO-17363

Non-Lipschitzian Dynamics for Modeling Neural Networks

Failure of the Lipschitz condition leads to multiple possible outcomes.

A theoretical study explores the failure of the Lipschitz condition at points of unstable equilibrium in some dynamical systems. A function $f(x)$ is said to satisfy the Lipschitz condition at point b if

$$|f(x) - f(b)| \leq K|x - b|$$

for constant K and for all x in some neighborhood of b . The evolution of such dynamical systems is characterized by a special type of unpredictability characterized by unbounded Lyapunov exponents. The Lyapunov exponent σ , which characterizes the mean exponential rate of divergence of two initially close trajectories, is given by

$$\sigma = \lim_{t \rightarrow \infty} t^{-1} \ln(\epsilon/\epsilon_0)$$

where ϵ = the distance between trajectories at time t and ϵ_0 = the infinitesimal initial distance between trajectories.

The dynamical systems considered are the following:

1. $\dot{x} + \alpha x^k = 0$ (where x represents a spatial coordinate, α is a constant, and $k < 1$).
2. $\dot{x} - x^{1/2} \cos(\omega t) = 0$ (where t = time and ω = a constant angular frequency).
3. $\dot{x} - [2e^{-t} \cos(\omega t)] [\sin(x)]^{1/2} = 0$.

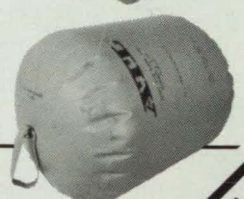
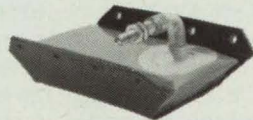
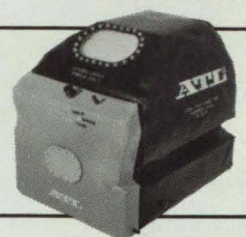
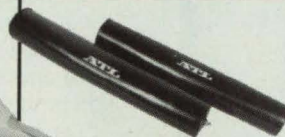
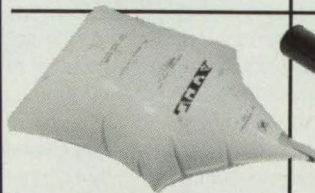
In each of these systems, the second term in the equation — the one that expresses the dynamics — is non-Lipschitzian at some point(s), and at these points the Lyapunov exponents go to infinity. In the first and second systems, this point is the equilibrium point $x = 0$. In the third system, it is the equilibrium points $x = \pm 2\pi m$, where m is an integer. Each such point is called a terminal attractor or a terminal repeller, depending on whether the system approaches it or escapes from it.

These represent two different kinds of instability or source of chaotic motion. Once the system goes into a terminal attractor, it stays there; that is, it loses the "memory" of its previous history. A terminal repeller also introduces chaos in the sense that when the system goes arbitrari-

ATL® Flexible Bladders

OUR DESIGN OR YOURS

- Actuators
- Dampers
- Bumpers
- Fuel Cells
- Collapsible Tanks
- Drums
- Plugs
- Inflatables
- Diaphragms
- Accumulators



Call our TOLL FREE Design Line **(800) 526-5330**

ATL® Aero Tec Laboratories, Inc.
Spear Road Industrial Park, Ramsey, NJ 07446
(in N.J. 201-825-1400) FAX: 201-825-1962 TLX: 642-730 ATL INC

IEEE-488... For Your PC



PC/XT/AT, 386, and PS/2

SOFTWARE for all your programming needs

- ★ Any popular language: BASIC, QuickBASIC, C, Pascal, FORTRAN, Assembly, 1-2-3, Quattro
- ★ High-speed, easy NI-488 functions: `ibwrt (scope, "curve?", 6)` ;
- ★ HP-Style commands:
`PRINT #1, "OUTPUT 1;F1S2"`
- ★ Automatic error and status window
- ★ ON SRQ subroutine branching
- ★ Interactive instrument control utility
- ★ Interactive configuration utility
- ★ Application Software:
LabWindows®, Measure, Asyst, Asystant GPIB, HTBasic, Labtech Notebook, WaveTest, TestCase

HARDWARE with the highest possible performance

- ★ Low-cost/high-speed choices
- ★ NI Turbo488™ ASIC for data rates up to 1 Mbytes/sec
- ★ SCSI, Serial, and Parallel Converters/Controllers
- ★ IEEE-488 Data Buffer with rates up to 900 kbytes/sec
- ★ Full-function Bus Analyzer
- ★ Extenders and Expander
- ★ FCC Certified

Free Support ★ 2-year warranty
30-day money back guarantee



6504 Bridge Point Parkway
Austin, TX 78730-5039

JAPAN (3) 788-1922 • UNITED KINGDOM (06) 355-23-545
FRANCE (1) 4865-3370 • WEST GERMANY (89) 80-7081
ITALY (2) 4830-1892 • THE NETHERLANDS (7) 399-6360

Call for **FREE** Catalog
(800) IEEE-488 • (512) 794-0100

ly close to it, it pushes the system away from it with an infinitesimally short but powerful force; in effect, it forces a "pulse of unpredictability" into the system.

In these non-Lipschitzian systems, unpredictability is caused by the nonuniqueness of the solutions to the dynamical equations at the mentioned equilibrium points. These systems can serve as idealized mathematical models of "creativity" because they respond to deterministic inputs with multiple-choice outputs. The "hidden logic" that makes the choices might be incorporated into a neural-network computing system: a neural network containing n terminal repellers would be able to make 2^n totally different decisions under slightly different external inputs, thereby demonstrating "intrinsic" logic. The most significant property of such neural networks would be the ability to be activated by internal rhythms that turn the terminal repellers on and off.

This work was done by Michail Zak of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Non-Lipschitzian Dynamics for Neural Net Modeling," Circle 157 on the TSP Request Card.
NPO-17814

Balancing Loads Among Robotic-Manipulator Arms

Improved controls would result in safer handling of delicate objects.

A paper presents a rigorous mathematical approach to the control of multiple robot arms simultaneously grasping one object. The mathematical development focuses on the relationship between the ability to control the degrees of freedom of the configuration (i.e., the angles of the rotary and/or extensions of the linear joints of the robot arms) and the ability to control the forces within the grasped object and robot arms. The understanding of this relationship should eventually lead to practical control schemes that would distribute the load more equitably among all the arms while grasping the object with the proper nondamaging forces.

The dynamical equations are given first in several joint-space forms that represent the constrained-joint-space dynamics and the abstract solution to the closed-chain forward dynamics problem. The dynamical equations are then placed in two alternative forms. The first gives insight into feedback linearization in the control of robots. The second shows that for nonredundant arms, the configuration space of the held object forms a good set of generalized coordinates.

It is shown that the loss of every degree of freedom of the free-arm configuration due to the imposition of the closed-chain

kinematic constraints results in the gain of a degree of freedom for the internal forces of the closed-chain system, which can be controlled simultaneously with the remaining degrees of freedom of the configuration. The subspace of controllable internal forces is shown to be isomorphic to the kernel of the force-transmission Jacobian (the "contact-force map"), which relates the contact forces to the net force acting on the held object. This subspace is also shown to depend only on the relative locations of the contact points. From this fact it is shown that the vectors that span this subspace and the projector into this subspace can be found solely from the locations of the tips of the arms. It is shown that the internal forces can be influenced independently of the degrees of freedom of the configuration and that this can be done in a feedforward manner, using only kinematic information about each arm: no knowledge of the object is required.

It is shown that master/slave multiarm control can be viewed as a special case of the foregoing. Because the subspace of the controllable internal forces is known to be the kernel of the contact-force map, a vector ξ in this subspace can be used to parameterize the controllable internal forces of the closed-chain system. It can be appreciated intuitively that if one takes one arm to be the "master" and controls the position of the tip of this arm, the forces on the tips of the remaining arms can be controlled to obtain desired behavior of the closed-chain system. It is shown that ξ is related in a one-to-one fashion with the contact forces on the slave arms, and an explicit form of the relationship is given.

The concept of feedback linearization is generalized somewhat, and it is shown that the closed-chain system can be represented in a form that allows for decoupled simultaneous control of the held object and the internal forces of the closed-chain system. It is shown that measurements of the contact forces (together with measurements of the states of the arms) make it possible to control position and orientation of a held object of unknown mass and shape while still maintaining control of the internal forces.

The last topic is the use of quadratic optimization to utilize the degrees of freedom represented by ξ to balance the load while regulating the contact forces imparted to the held object. An unconstrained quadratic optimization yields a solution that appears to shift the load to the arms that have more efficient actuators or are in better kinematical positions to support the object.

This work was done by Kenneth K. Kreutz and Anatole Lokshin of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Load Balancing and Closed Chain Multiple Arm Control," Circle 136 on the TSP Request Card.
NPO-17649



Life Sciences

Hardware, Techniques, and Processes

99 Emulsions Containing Perfluorocarbon Support Cell Cultures

Emulsions Containing Perfluorocarbon Support Cell Cultures

An additive reduces mechanical damage to cells, promoting denser growth.

Lyndon B. Johnson Space Center, Houston, Texas

The addition of an emulsion containing a perfluorocarbon liquid to an aqueous cell culture medium increases the capacity of the medium to support mammalian cells. The perfluorocarbon — FC-40 Fluorinert (or equivalent) — increases the average density of the medium so that it is approximately equal to that of the cells. The cells therefore stay suspended in the medium without mechanical stirring, which damages them. A volume fraction of 11.49 percent of the perfluorocarbon added to the aqueous medium increases the density enough to prevent the cells from settling.

In addition, the emulsion increases the viscosity of the medium so that oxygen can be bubbled through it and nutrients can be stirred in with less damage to the delicate cells. It has been hypothesized that droplets of the emulsion become attached to

the gas/liquid interfaces of bubbles, preventing the cells from becoming entrained in the circulation of liquid at the interfaces.

In experiments with hybridoma cells, bioreactors with the perfluorocarbon emulsion supported cells at densities as high as $2.5 \times 10^6 \text{ mL}^{-1}$. Without the emulsion, the densities of cells in the same bioreactors remained below $1 \times 10^5 \text{ mL}^{-1}$ because of the damage caused by the flow of gas needed to keep the cells in suspension in the medium.

Moreover, the emulsion enhances the transfer of cells: about 2.5 times as much oxygen gets to the cells in the presence of the emulsion as in its absence at the same rate of flow. The emulsion also enables cells to withstand higher rates of flow: in one case, hybridoma cells in columns without the emulsion were severely damaged,

but were not damaged appreciably even at a rate 27 percent higher when the emulsion was used.

This work was done by Lu-Kwang Ju, Jaw Fang Lee, and William B. Armiger of Johnson Space Center. For further information, Circle 101 on the TSP Request Card.

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

*President, Bio-Chem Technology, Inc.
66 Grant Valley Parkway
Malvern, PA 19355*

Refer to MSC-21480, volume and number of this NASA Tech Briefs issue, and the page number.

Instrument, Combination & Transit Cases

HIGH RELIABILITY MIL-SPEC CASES



- Designed to Meet Most Stringent Specifications.
- Reduces Lead Time, Engineering Costs.
- Thousands of Standard Sizes.
- Order by Catalog Number.

FREE LITERATURE
CALL TODAY:

818 846-4191
413 267-5561
Burbank, CA • Monson, MA

- Unequaled Range of Accessories & Options.
- Custom Designs & Modifications on Special Orders.



We Make You Look Good

Call Me, I'm Interested, Circle No. 610—Send Literature, Circle No. 613

Rack Mounted Equipment Cases

TOUGH, SAFE AND SECURE

- Shock- or Hard-Mounted Internal Chassis
- 12 Styles, Hundreds of Standard Sizes



- Waterproof Construction
- Front/Rear or Front Only Access
- Stackable For Field Operation

FREE DESIGN ASSISTANCE.

Meets applicable requirements of MIL-STD-108 and MIL-T-28800.



We Make You Look Good

CALL TODAY!
(818) 846-4191
(413) 267-5561

Burbank, CA • Monson, MA

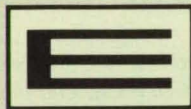
Call Me, I'm Interested, Circle No. 360—Send Literature, Circle No. 359

PATTERNED FOR PRECISION

Custom Foil Heaters Designed For Your Application.

Computer-generated for precision, uniformity, and fast turnaround, printed circuit heater patterns can be produced to most sizes, shapes, wattages, and voltage requirements. These heaters are available with variable power densities that yield higher temperatures in specifically designated areas. The variety of applications includes appliances, medical equipment, vending machines, photocopiers, and aerospace.

Our engineering staff can design a prototype for you from a simple sketch and a list of specifications. Contact us for engineering assistance. Write or call today.



ELECTRO-FLEX HEAT, INC.
Northwood Industrial Park, P.O. Box 88
Bloomfield, CT 06002-0088
(203) 242-6287

Circle Reader Action No. 322

THE RIGHT SEAL

Whatever the high-performance sealing application, we have the right seal. American Variseal is the only manufacturer of spring energized Turcite® seals to offer all of the most frequently specified types shown below. After analysis of your application, our design team will recommend a seal that combines the appropriate configuration and choice of materials for your specific needs. If you want quick response, efficient service and long-term solutions to your sealing problems, make us your source.

Variseal™ "W" Slant Coil Spring Energized Turcite® Seal

- Predictable, lighter spring load for a variety of critical applications.
- Extremely broad deflection range.
- Flat, consistent spring rate.
- Most flexible seal design for difficult installations.
- Unparalleled performance in small cross sections.

Variseal™ "M" Cantilever Spring Energized Turcite® Seal

- Medium spring load, versatile operating characteristics.
- Excellent in high and low temperatures.
- Good deflection range.
- Versatile in slow rotary and reciprocating applications.

Varilip® Rotary Shaft Seals

- Extremely wide temperature range (-200 to +500°F) and pressures to 500 psi.
- Low running friction and lowest breakout torque.
- Excellent high speed capabilities up to 12,000 SFPM.
- Self-lubricating. Undamaged by dry start-up or running periods.
- Turcite® sealing element is immune to swelling or corrosive attack.

- ### Variseal™ "H" Spring Energized Turcite® or Turcon®
- Excellent in cryogenics.
 - Very high unit loading.
 - Good static performance.
 - Broad range of corrosion resistant spring materials.

AMERICAN VARISEAL

We've got your seal.

Call (303) 465-1727 • Ask for Technical Support
P.O. Box 1479 • Broomfield, CO 80038 • Phone: 303-465-1727 • Fax: 303-469-4874

A DIVISION OF W.S. SHAMBAN AND COMPANY

Turcite®, Turcon® and Varilip® are registered trademarks of W.S. Shamban & Co.

New on the Market

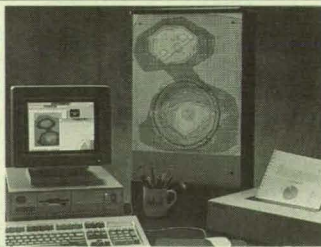


KeveX X-Ray Inc., Scotts Valley, CA, has developed a new 125 KV end window micro-focus x-ray tube offering two spot sizes: a 10-micron spot size for inspection of microelectronics and small components, and a 45-micron spot size for penetration of thicker, more massive materials. The end window allows the user to position the tube so that the distance is less than one inch. The product incorporates a permanently-sealed vacuum envelope in a hermetically-sealed steel cylinder for maintenance-free operation.

Circle Reader Action Number 798.

A new line of fiber optic position sensors from Computer Optical Products Inc., Chatsworth, CA, combines proprietary optical encoder technology and rugged multi-fiber bundles for rotary and linear sensing that outperforms resolvers, LVDTs, and conventional optical encoders, according to the manufacturer. Available in modular or housed configurations, the miniature units offer EMI/RFI immunity, high-temperature operation, and field-serviceable remote electronics. Applications include commutating motors, industrial controls, radar positioning, cockpit instrumentation, and missile guidance.

Circle Reader Action Number 800.

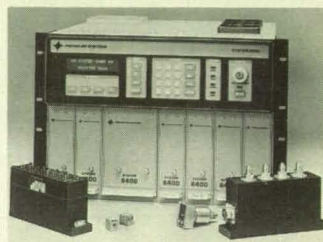


The intensity contours obtained from an acoustic intensity analysis of a speaker are displayed by the new STARAcoustics™ system from Structural Measurement Systems, Milpitas, CA. STARAcoustics is a complete data analysis and display package for analyzing acoustic intensity data. The PC-based system operating in Microsoft® Windows™ provides seamless integration from data acquisition and analysis through report generation.

Circle Reader Action Number 792.

Orpac's new boron nitride and aluminum nitride ceramic pastes offer high thermal conductivity, high electrical resistance, and high resistance to molten reactive metals. Nonaqueous and more malleable than solid shapes and thin-film coatings, the pastes can be troweled, packed, or hand-rubbed into place.

Circle Reader Action Number 796.



A new parallel processing data acquisition system from Pressure Systems Inc., Hampton, VA, provides high-speed measurement of pressure, temperature, force, flow, torque, vibration, and acceleration by accepting digital, analog, and frequency inputs. The modular, rack-mountable system consists of a mainframe chassis and one 4-channel input unit with 20,000 channels per second sampling capability. It can be expanded to as many as 64 input units for a maximum of 4096 channels, with data acquired at up to 400,000 channels per second. Its broad range of uses include wind tunnel testing, production and development testing, calibration, and process control applications.

Circle Reader Action Number 794.



The CI-3000 computer film recorder from Polaroid Corp., Cambridge, MA, offers 2000-line addressable spatial resolution, a choice of 16.7 million colors, and gray scale balance to meet both graphics and natural imaging applications. Designed for computers supporting the industry-standard Centronics parallel interface, the CI-3000 supports 18 film formats and can create a typical business slide entirely in-house in under ten minutes. The desktop recorder comes with Polaroid ImagePrint software providing CGM file compatibility with a wide range of application graphics packages.

Circle Reader Action Number 790.

New on the Market



Analogic Corp.'s new DP100 Data Precision **digital multimeter** measures frequency, temperature and resistance, as well as DC and true RMS AC voltage and current. Calibrated to the new worldwide voltage standards, the 5-1/2-digit instrument can be interfaced to almost any computer system or serial printer by means of a built-in, optically-isolated RS232 interface. The DP100 has a basic DC accuracy of 0.003%+2 counts, guaranteed for a full year without recalibration. The lightweight, portable instrument sells for \$595.

Circle Reader Action Number 778.



Metalsoft Inc., Santa Ana, CA, has introduced a **software package for unfolding sheet metal CAD files**. Three-dimensional IGES, DXF, and CADL files can be transferred from any CAD system and unfolded automatically. With just a few keystrokes, the user can add thickness to wire frame models, and automatically draw corner joints by selecting the desired type of joint.

Circle Reader Action Number 784.

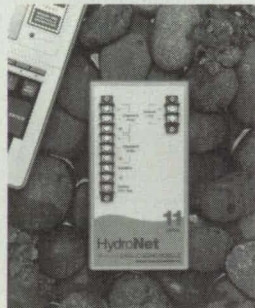


The TMA **μScan™ scatterometer system** from TMA Technologies Inc., Bozeman, MT, is lightweight, portable, and provides rapid and reliable measurements for optical fabrication, materials inspection, and quality control. From one measurement, the user can determine both the scattered light level and RMS roughness on either flat or curved surfaces, under any lighting conditions. Using one of the interchangeable heads, both reflective and transmissive measurements can be performed.

Circle Reader Action Number 788.

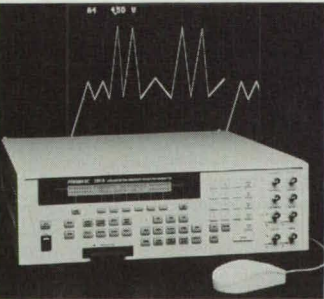
Design Analysis Associates Inc., Logan, UT, has introduced **HydroNet**, a low-cost battery-operated network of **data loggers**. HydroNet consists of independent one- to four-channel analog and digital logging modules that can be added or taken from a network. HydroNet accepts input from a variety of sensors and stores data in its 64k battery-backed CMOS RAM memory. Applications include remote data acquisition for environmental monitoring, meteorology, and scientific data acquisition.

Circle Reader Action Number 782.



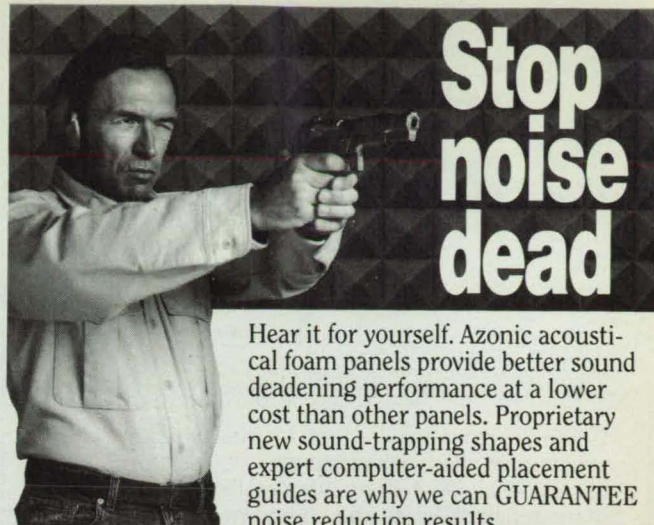
The first high-definition **arbitrary waveform generator**, the Model 2201A from Pragmatic Instruments Inc., San Diego, CA, is targeted at high-precision, low-frequency test and measurement applications. It features 16-bit precision at a 2 MHz sample rate; three phase-coherent output channels with 64k words of user memory per channel; and a built-in pseudo-random-sequence noise generator. A 32k-byte static RAM enables users to securely archive over 100 waveforms or instrument set-up configurations.

Circle Reader Action Number 780.



The 101SD sealed **Hall-effect keyboard** from Honeywell Inc., El Paso, TX, is designed for use in industrial applications where moisture, grime, dust and liquid contamination threaten the functionality of the keyboard. The 101SD meets water and moisture resistance standards as defined by a NEMA 13 rating and MIL-STD 202E Method 106D. It features a standard IBM 101 key layout and is compatible with IBM PC/XT/AT and PS/2 software.

Circle Reader Action Number 786.



Stop noise dead

Hear it for yourself. Azonic acoustical foam panels provide better sound deadening performance at a lower cost than other panels. Proprietary new sound-trapping shapes and expert computer-aided placement guides are why we can **GUARANTEE** noise reduction results.

- Noise Reduction Coefficient (NRC) values up to 1.25.
- New AZ-Fire Flex™ Heat Resistant to 482° F.
- Wide selection of materials, thicknesses and colors.
- OEM special applications and enclosures – call for quote.

If noise is a problem, call Azonic toll free at 1-800-842-9790. You'll like what you hear.



FREE SAMPLE



Noise Reduction From A to Z

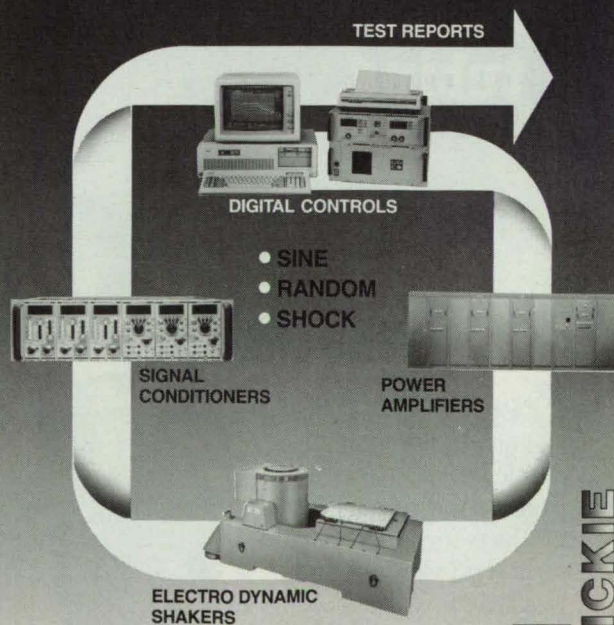
1610 E. Cliff Road
Burnsville, MN 55337
Phone 612-894-2230
FAX 612-894-2748

© 1990 AZONIC, Inc.

Circle Reader Action No. 477

VIBRATION TEST EQUIPMENT

Single Source Supplier



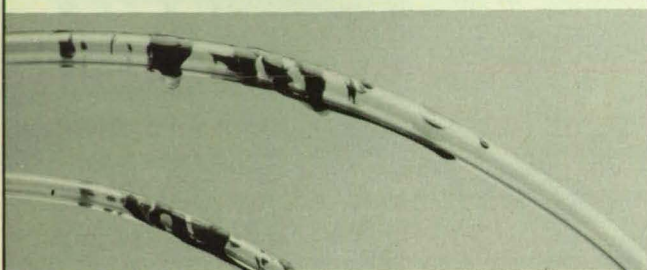
Telephone (203) 265-3929
Telex 643802 • Fax (203) 265-2690
West Coast Office (213) 316-0275
European Office 089/23 03 52 98

UNHOLTZ
6 BROOKSIDE DR., WALLINGFORD, CT 06492



DICKIE

Resistance.



When design engineers look for quality tubing with exceptional chemical resistance, they ask for Stevens Elastomers. And it's no wonder. Because our urethane tubing exhibits uncommon resistance to oils, gasoline, and other chemicals. It's also extremely resistant to abrasion. And it retains high flexibility down to -65°F .

We think you'll find it hard to resist Stevens Urethane Tubing. Write for a free brochure to JPS Elastomers Corp., Industrial Products Division, Northampton, MA 01061-0658, or call 413/586-8750 (FAX: 413/584-6348).

STEVENS
Elastomers

Stevens Urethane. High Performance Products.

Circle Reader Action No. 349

Thermoplastic Quick Couplings for plastic tubing.



One hand connect disconnect

Free guide to fittings and quick couplings for plastic tubing. New! 36 page catalog of quality products for flexible and semi rigid plastic tubing, $1/16''$ to $3/8''$ ID.



CPC COLDER PRODUCTS CO.

1001 Westgate Drive • St. Paul, MN 55114 • Call 612-645-0091

Circle Reader Action No. 517

New on the Market



The new **Densicell SPP Chip** from Densitron Corp., Torrance, CA, is designed specifically as a universal basic building block for massively parallel processors referred to as cellprocessors. Each chip has 64 identical computing cells in an 8×8 matrix. It is manufactured using 1.5 micron HCMOS technology and has a gate speed equivalent to ECL 10k—faster than 74 STTL. All inputs and outputs are TTL-compatible.

Circle Reader Action Number 776.

Digital Signals' new **SecLink voice and data encryption system** provides an integrated solution for secure communications over the public switched telephone network. By using Public Key technology, random keys are generated at the beginning of every secure communication and are electronically exchanged without user intervention, eliminating the need for crypto-key exchanges and improving system security. SecLink combines a digital voice compressor, data encryptor, and modem in a $1.5'' \times 7'' \times 9.5''$ package, and plugs into any standard tone (DTMF) telephone system.

Circle Reader Action Number 770.

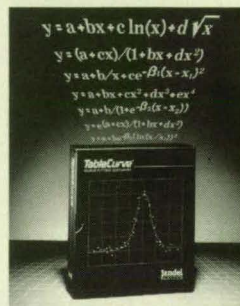


The **THERM 2280-8 programmable data acquisition system** from Metron Technology, Boulder, CO, is capable of monitoring four measuring channels, as well as storing or printing their values or evaluating them with the aid of a personal computer. It offers a wide variety of standard measuring ranges: five thermocouple types, capacitive humidity detectors, air velocity sensors, as well as four current and voltage signals. Two additional measuring channels are used for averaging and a seventh is used to monitor battery voltage. The system features a high degree of accuracy ($\pm 0.03\%$ of reading, ± 1 digit) and wide rangeability (temperature from -328° to $+3,200^{\circ}\text{F}$.)

Circle Reader Action Number 772.

TableCurve™ curve fitting software from Jandel Scientific, Corte Madera, CA, performs one-pass least squares curve fitting to 221 candidate equations in a single step. The processing step ranks the equations according to "goodness of fit" and then allows the user to graphically examine any equation and the corresponding coefficients by pressing a single key. A zoom in/out feature enables close-up and overview examinations of specific regions of the graph. Additional review features include listing of standard errors, F-statistic, residual graphs, and prediction/confidence tables for the data points.

Circle Reader Action Number 768.



The **1N6100 and 1N6101 diode arrays** jointly developed by Kopin Corp. and Silicon General Semiconductor Inc. are the first commercially-available silicon-on-insulator (SOI) integrated circuits and the first SOI-based circuits to meet DESC Joint Army-Navy (JAN) MIL-S-19500/474 qualification. The straight-through monolithic diode arrays provide a 75V minimum breakdown voltage, 100mA per diode current capability, switching speeds of less than 5ns, and leakage less than 25nA.

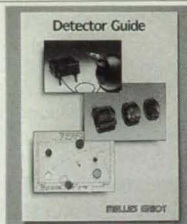
Circle Reader Action Number 766.



Cole-Parmer Instrument Co., Chicago, IL, has introduced the **Cleansphere benchtop mini-clean-room**, a Class 10 air quality personal workstation, measuring 21-5/8" high and 21-1/4" in diameter. Its spherical shape allows 360 degree viewability and ensures an air-pocket-free environment by rapid purging. The average air rate change is 415 changes per hour.

Circle Reader Action Number 774.

New Literature



Photodetectors and their associated electronics are detailed in a new detector guide from Melles Griot, Irvine, CA. The 24-page publication describes the parameters and uses of semiconductor detectors for measuring visible and near-infrared electromagnetic radiation and contains specifications for the company's line of modular components and systems, including detectors, amplifiers, lenses, optical filters, positioners, and mounts.

Circle Reader Action Number 702.



Lemo rF Inc., Huntingdon Valley, PA, has published a new catalog featuring data on SMA microwave connectors and cable assemblies. The catalog includes specifications for SMA connectors, interface mating dimensions, part number guidelines, and a connector finder for various SMA connector applications. It contains photographs and drawings of 60 popular SMA connectors for semi-rigid and flexible cable, as well as bulkhead and panel-mount connectors and strip transmission line types.

Circle Reader Action Number 712.

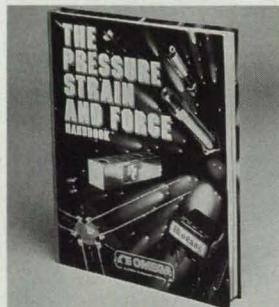


A free **motion control databook** from Sierracin/Magneddyne, Carlsbad, CA, provides detailed descriptions and drawings of the company's DC brushless, DC torque, and DC servo motors; tachometers; and electronic control systems. The 180-page publication includes application data and product design guides.

Circle Reader Action Number 706.

A new brochure from Renishaw Inc., Schaumburg, IL, spotlights the company's ML10 **laser measurement system** for verification/calibration of machine tools and CMMs. Designed for use in the field or lab, the ML10 offers resolution to ± 0.001 micron and can determine linear positional accuracy, velocity, pitch/yaw, straightness, squareness, parallelism, and flatness, in addition to dynamic measurements.

Circle Reader Action Number 708.

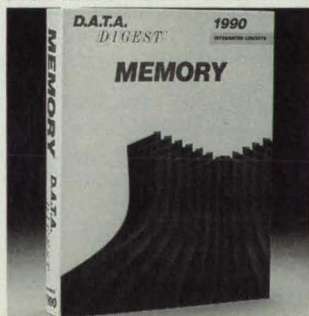


A 500-page **pressure, strain, and force measurement handbook** from Omega Inc., Stamford, CT, features a broad selection of thin film pressure transducers, solenoid valves, portable calibrators, load bolts and washers, beam load and "S" beam load cells, tank weighing assemblies, glycerine-filled dial gauges, and pressure switches. Product information includes technical standards, specifications, operating principles, and ordering information.

Circle Reader Action Number 710.

The 1990 **Memory ICs D.A.T.A. DIGEST™** from D.A.T.A. Business Publishing, San Diego, CA, features preliminary selection data for over 46,000 memory ICs, compiled from manufacturer data sheets and cross-referenced by function, generic number, part number, discontinued part number, electrical parameters, and suggested replacements. Also included are sections covering physical characteristics, connection data pinouts from manufacturer schematic drawings, and manufacturers' names, addresses, and phone numbers.

Circle Reader Action Number 704.



ROTOCON HIGH PERFORMANCE ROTARY CONTACTS

**THERMOCOUPLES,
RTD's, LVDT's
STRAIN GAUGES,
1 to 100 contacts!**



Unlike conventional slipping designs, the unique ROTOCON Sealed Mercury Rotary Contacts are low noise, low resistance, zero maintenance links between stationary and rotating components.

"Try Before You Buy"

**Call:
800-234-4322 then dial 4721,
or 608-836-7571 (FAX 608-831-0300 TELEX 754381)**



meridian laboratory

2415 Evergreen Road, P.O. Box 156, Middleton, WI 53562-0156

Circle Reader Action No. 327

- Zero Electrical Noise
- Low And Stable Resistance
- Compact Size
- Zero Maintenance
- Environmentally Sealed
- Rugged And Reliable
- Unaffected By Vibration
- Mount In Any Orientation

A variety of standard and custom ROTOCON models are available to fit your mounting configuration, rotation speed, and current requirements (up to 2000 Amps!).

Hazardous Location Work Lights

**13 & 26 Watt
FM Approved Cord, Ballast &
Lamp Unit. Furnished without
plug attached and suitable
for Class I, Division I, Groups C
& D; Class II, Division I, Groups
E, F & G;* Class III, Division I.**

*Group G does not apply to 26 watt model

Designed to aircraft specifications, this ruggedly constructed work light provides ultimate safety and dependability in high-hazard areas. All aluminum body with specially-compounded bumper guards withstands damage from falling objects, bumping or dropping, while patented shock absorbers protect high-output fluorescent tube.

- Compact 3 1/2" x 14 3/4" size
- Lightweight (3 3/4 lbs.)
- NEMA 4-Watertight



INDUSTRIES, INC.

P.O. Box 312, Angola, NY 14006
716-549-0135 • FAX: 716-549-2725



Noncontact measurement with submicron resolution

With resolution better than .000001 inch, our fiber-optic and capacitive displacement measurement systems provide repeatability and accuracy for:

- Vibration and modal analyses
- Runout and bearing studies
- Gap and positioning control
- Thickness measurement

MTI noncontact measurement systems give you design flexibility:

- No mass loading or target damage
- Frequency response from dc to 500 kHz
- Linearity $\pm 0.1\%$ of full scale
- Range to 0.5 in.

MTI Instruments

Pioneers in Sensor Technology

1-800-342-2203

968 Albany-Shaker Road
Latham, NY 12110
(518) 785-2211



Circle Reader Action No. 365

INTRODUCING THE OMNI-WRIST™*

- Singularity-free motion
- 180 degrees pitch and yaw
- 360 degrees roll
- High precision
- 25 pound load capacity
- 3/4 inch through hole
- 5.5 inch diameter

For telerobots, aerospace and aviation inspection, welding robots, research and development

For a free brochure, call or write.

Ross-Hime designs inc.

1313 Fifth Street SE Minneapolis, Minnesota 55414
(612) 379-3808 FAX (612) 379-3875

*U.S. Patents 4,729,253; 4,723,460; 4,686,866



The OMNI-WRIST™ is being applied to NASA space applications. Ross-Hime designs, inc.

Circle Reader Action No. 329

New Literature



Airpax, Cheshire, CT, has released a new bulletin describing their Series 2024 **hybrid thermal sensor**, which combines the switching of a snap-acting bimetal thermostat with the constant sensing of a negative temperature coefficient thermistor. Standard temperature range is from 35° to 300 ° F. Dimensional drawings of six standard body sizes, terminals and tube lengths are included.

Circle Reader Action Number 720.

Power General, Canton, MA, has published a new catalog containing electrical and mechanical specifications for their line of **AC/DC switching power supplies and DC/DC converters**. Switching power supplies range from 25 to 200 watts in output power, and include features such as universal input voltage range and VDE/FCC class "B" input filtering. Over 200 DC/DC models range from 1 to 100 watts and offer six-sided continuous shielded copper cases, short-circuit protection, input filtering, and industry-standard footprints. Also included is a new line of switching power supplies approved per UL 544 for use in medical, dental, and laboratory equipment.

Circle Reader Action Number 718.

Bulletin SY-003 from Krautkramer Branson, Lewistown, PA, describes the Aerotech® **MultiScanner** for use with ultrasonic nondestructive flaw detectors. When interfaced with a single-channel flaw detector, the MultiScanner can read the input of eight transducers. It can test with multi-element array transducers or multiple single-element or dual-element transducers. For hard copy documentation, the MultiScanner can be interfaced with a C-Scan recorder.

Circle Reader Action Number 716.

A new brochure from Burr-Brown Corp., Tucson, AZ, describes applications of the company's **data collection systems**, ranging from simple time and attendance monitoring to on-line MRP and shop floor control. Also highlighted is a broad line of hardware and software that can be configured to provide a customized system solution. Complete solutions include a wide range of terminals, transaction processors, input devices, accessories, and application interface software.

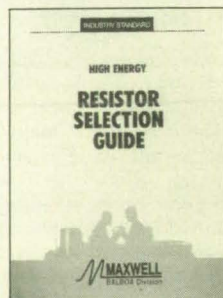
Circle Reader Action Number 714.

Indium Corporation of America, Utica, NY, has created a new catalog designed to keep the electronics industry abreast of the rapid changes in **Surface Mount Technology (SMT)**. The publication describes how Indium develops products for unique or standard SMT applications, flex circuits, injection-molded boards, hybrids, and special metallizations. Also explained is the company's free technical advisory service and extensive reference library.

Circle Reader Action Number 722.

A new product selection guide from Maxwell Laboratories, San Diego, CA, describes criteria for specifying **high-energy resistors** in a variety of industrial high-voltage applications. These fixed, linear resistors can be used for average power dissipation beyond the capability of conventional organic resistors. Standard models are rated up to 500 kV in air, with resistances from 10 milliohms to 100,000 ohms. The guide also provides information on attachment hardware and design configuration advantages.

Circle Reader Action Number 724.



Electro-Science Laboratories, King of Prussia, PA, has introduced a materials catalog that describes hundreds of **thick film, solder paste, and polymer thick film products**. Product groupings include silver and gold cermet conductors, solderable gold bearing materials, multi-layer and crossover dielectrics, capacitor dielectrics, overglazes, and underglazes. The catalog lists technical papers and data sheets available upon request.

Circle Reader Action Number 726.



CONCURRENT ENGINEERING: WESCON STYLE



November 13-15, 1990 • Anaheim Convention Center • Anaheim, Calif. USA

Gone are the days when you worked alone, developing your bit of a design. Wondering how to test this thing from the design department. Trying to figure out how to manufacture this whatsit that looked great on paper, but can't be produced.

Today the team works together. Simultaneously. In parallel. To shorten development time. And raise product quality. And increase profitability.

That's what concurrent engineering is all about.

And that's what WESCON is all about, too.

R&D. Design. Test. Manufacturing. Only WESCON covers them all. Advances in new technologies and appli-

cations. Real world solutions for real world problems. The latest products and best of proven products.

Semiconductors. Bus products. Special VME Future Bus+ Extended Architecture issues seminar and product demonstrations. RF components. Passive components. Instrumentation. Electronic design automation tools.

Production materials and services. WESCON has what you, and all of the members of your team, need.

Plan now to attend



Wescon

**For More Information
call 800-877-2668.**



**Send me a Preview Program with full information about
WESCON/90 (available August, 1990)**

Name _____ Title _____

Company _____

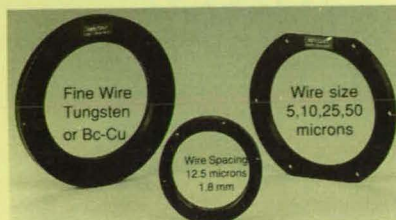
Street Address _____

City _____ State _____ Zip Code _____

Mail to: Wescon Preview, 8110 Airport Blvd.
Los Angeles, CA 90045 or Fax to 213/641-5117

Circle Reader Action No. 630

Free Standing Wire Grid Polarizers For Spectroscopy at Millimeter and Sub-millimeter wavelength



Applications

- FAR-IR Wavelength Polarization
- Interferometer Beam Divider
- Variable Reflector
- Coupling Device for Long Wavelength Lasers
- Suitable for High Vacuum and Cryogenic Conditions

Custom design available

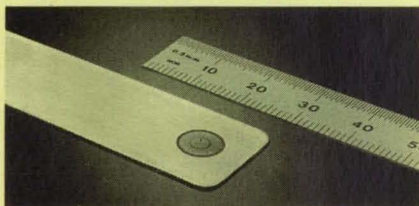


Another quality product from

SPECAC

SPECAC ANALYTICAL INC.
301 Commerce Drive Tel (203) 366-5112
Fairfield, CT 06430 Fax (203) 384-1524
A Cambridge Electronics Industries (CEI) Company
Circle Reader Action No. 388

ARE YOU STILL TRYING TO MEASURE VERY THIN GAPS THE HARD WAY?



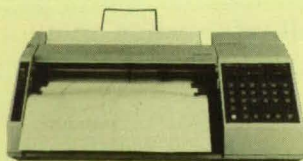
Capacitec HPS Series of thin (back to back) sensors can measure gaps as small as 0.025" (.635mm) inboard 84" (2133.6mm) with accuracies of 0.0003" (7.6µm), without scratching delicate surfaces.

Capacitec

P.O. Box 819, 87 Fitchburg Rd., Ayer, MA 01432 U.S.A.
Tel. (508) 772-6033 • Fax (508) 772-6036

Circle Reader Action No. 385

Combined XY + Strip Chart Recorders from Fluke



- Multi-format XY + Xt analog recorders, single or dual channel, plus digital enhancements for easy chart annotation and control.
- Fast dynamic response, wide sensitivity range, and IEEE-488/RS-232.

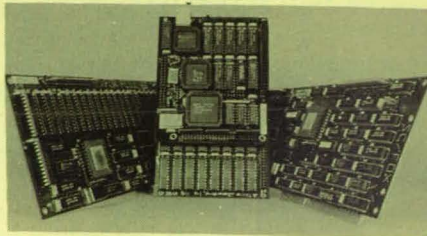
For more information on the PM 8278 Series of XY and Strip Chart Recorders from Fluke, call 1-800-44-FLUKE, ext. 77 today.

FLUKE

Circle Reader Action No. 440

1291-P8278

SC/FOXtm High Performance Embedded System Computers



SC/FOX PCS32 (Parallel Coprocessor System 32) 15 MIPS to 70 MIPS, uses 32-bit SC32 RISC microprocessor, general purpose PC/XT/AT/386 32-bit plug-in board, 64K-1M byte O-wait-state static memory.

SC/FOX SBC (Single Board Computer) 18 MIPS, 60 MIPS burst, uses 16-bit Harris RTX 2000, for stand-alone operation. Eurocard size, 1 serial, 1 printer port, 64K-512K byte O-wait-state static memory.

SC/FOX PCS (Parallel Coprocessor System) 15 MIPS, 50 MIPS burst, uses 16-bit Harris RTX 2000, PC/XT/AT/386 plug-in board, up to 1M byte O-wait-state static memory, multiple board operation.

SC/FOX SCSI I/O plug-on daughter board for PCS or SBC with SCSI controller, parallel, floppy, serial ports, and software drivers.

Ideal for embedded real-time control, signal processing, and data acquisition. Forth development software included. OEM pricing.

SILICON COMPOSERS INC (415) 322-8763
208 California Avenue, Palo Alto, CA 94306
Circle Reader Action No. 679



FREE!
130
Page
Catalog

"Optics
for
Industry"

Free 130 page product catalog from Rolyn, world's largest supplier of "Off-the-Shelf" optics. 24-hour delivery of simple or compound lenses, filters, prisms, mirrors, beamsplitters, reticles, objectives, eyepieces plus thousands of other stock items. Rolyn also supplies custom products and coatings in prototype or production quantities. **ROLYN OPTICS Co.**, 706 Arrowgrand Circle, Covina, CA 91722-2199, (818)915-5707, FAX (818)915-1379

Circle Reader Action No. 551

Wave Form 20MHz - 32K \$1290

The WSB-100 Wave Form Synthesizer Board from Quatech has the best set of numbers in the market. With speed to 20MHz and a 32K memory at \$1290, it's making waves in more ways than one. The WSB-100 is also a star performer as a digital pulse/word generator with the optional digital module.

Call for our free
PC Interface Handbook
1-800-553-1170

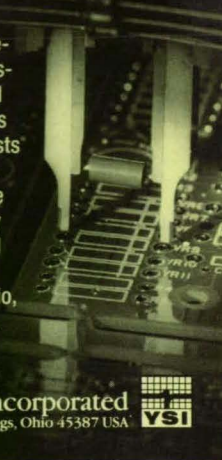
QUATECH

662 Wolf Ledges Parkway
Akron, OH 44311

Circle Reader Action No. 599

Now, you can afford the high precision you really need.

With new YSI Precision Machine-Insertable Thermistors. Tape and reel packaging reduces manufacturing costs and YSI precision gives you the edge in circuit accuracy and reliability. Call 800 343-4357 for information. In Ohio, call 513 767-7241.



YSI Incorporated
Yellow Springs, Ohio 45387 USA

Circle Reader Action No. 596

Electrodeposited Bellows CONTACTS

Insure Electrical Continuity!

Servometers gold plated contact springs insure adequate electrical continuity where tolerance build-up could become a problem.

Nine different configurations are available from stock in OD's from .037 to .245 in. • spring forces from .018 oz./0.01 in. to .27 oz./0.01 inch • self inductances as low as 3.1 x 10⁻¹⁰ Henrys • DC resistances as low as .005 ohms.



FREE
Sample and
Product Guide

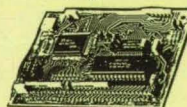
Call us today.
Special designs will be promptly quoted.

The Specialists in Miniature Bellows-Couplings-Contacts
501 Little Falls Road
Cedar Grove, NJ 07009
SERVOMETER (201) 785-4630 • Telex: 384233
Fax: (201) 785-0756

Circle Reader Action No. 490

Go FORTH and multiply....or divide, control, log data, etc....

TDS9090
FORTH
control
computer



Powerful 4" x 3" single-board computer, based on the CMOS HD6303Y. High-level easy Forth language on board - vital for fast control. 30K RAM, 16K RAM/PROM, 2K EEPROM. Attach keyboard, lcd, I2C peripherals. Built-in interrupts, multi-tasking, watchdog timer, editor and assembler. 35 I/O lines, two RS-232 ports. 6 - 16 volts operating at 3ma. Optional data-logging module : 10-channel, 10-bit or 8-channel, 12-bit A/D, 256K RAM, D/A, date/time clock -- low-power mode lasts one year on 9v battery !. Includes lots of ready-made software solutions. Program with PC. Over 4000 are in use world-wide for machine control, data-logging, inspection, factory automation, robotics, remote monitoring, etc... 30-day free trial.

\$219 (25 qty)



SAELIG Company
1193 Moseley Road, Victor, NY 14564
(716) 425-3753 • fax -3835

Circle Reader Action No. 399



Build Your Own Space Shuttle

This 1/72 scale model of the space shuttle Discovery features a huge 13" wingspan and includes engraved tile detail, movable rudder and flap, authentic NASA decals, adjustable manipulator arm, opening cargo bay doors, and detailed Spacelab payload. Molded in white. Kits are \$22.95 each + \$3.50 postage and handling. (NY residents add sales tax.) **Send check or money order to: NASA Tech Briefs, Dept. F, 41 East 42nd St., New York, NY 10017. For credit card orders, call (800) 258-0201 (NY state: 212-490-3999).**



Climb aboard the world's best fighter aircraft—the F-16 Falcon, F-15 Eagle, and F-111—for high flying adventure! This action-packed VHS videotape features real combat footage. \$19.95 each plus \$3.00 postage. NY residents add sales tax.

Name _____
 Address _____
 City _____
 State _____ Zip _____
 Total enclosed: _____
 for _____ Jet videos.

Send check or money order to:
NASA Tech Briefs, Dept. F
41 East 42nd St.,
New York, NY 10017



Coating removal or surface preparation problems?
Call 1-800-634-9185.



79 Connecticut Mills Ave., Danielson, CT 06239
 (203) 779-1401 Fax: 779-1403

Circle Reader Action No. 582



Subject Index

A

ACOUSTIC EXCITATION

Acoustic reduction of separation of flow page 78 LEW-14876

ADAPTIVE CONTROL
 Exponentially stabilizing robot control laws page 95 NPO-17587

Robust, high-performance control for robotic manipulators page 36 NPO-17785

ADSORPTION
 Concentrating gaseous contaminants for monitoring page 45 MSC-21424

AERODYNAMIC LOADS
 Predicting unsteady aerolelastic behavior page 77 LAR-14130

AEROELASTICITY
 Predicting unsteady aeroelastic behavior page 77 LAR-14130

AIRCRAFT TIRES
 Measurement of water sprays generated by airplane tires page 70 LAR-14030

AIRFOILS
 Acoustic reduction of separation of flow page 78 LEW-14876

ALLOYS
 Directional solidification of monotectic alloys page 61 MFS-26080
 Making self-lubricating parts by powder metallurgy page 63 LEW-14902

B

ANIMATION

Flexible animation computer program page 68 LAR-14102

ANTENNA ARRAYS

More about lens antenna for mobile/satellite communication page 33 NPO-17680

ANTENNAS

Dielectric-filled paraboloidal front ends page 24 NPO-17802

Planar microstrip Yagi antennas page 18 NPO-17873

ARC WELDING

Monitoring both sides of a weld in progress page 84 MFS-28389

ATOMIC CLOCKS

Linear ion trap for atomic clock page 44 NPO-17758

ATTITUDE CONTROL

Liquid-ring attitude-control system for spacecraft page 82 NPO-17485

Thrust-vector defectors for spacecraft page 81 MSC-21672

AUTOCLAVING

Process for autoclaving HMW PMR-II composites page 64 LEW-14839

BACKSCATTERING

Viewing integrated-circuit interconnections by SEM page 18 NPO-17635

BEARINGS

Damping seals and bearings for a turbomachine page 80 MFS-28345

BOUNDARY LAYER SEPARATION

Acoustic reduction of separation of flow page 78 LEW-14876

C

CELLS (BIOLOGY)

Emulsions containing perfluorocarbon support cell cultures page 99 MSC-21480

CIRCUITS

Removing dross from molten solder page 88 MFS-28406

CIRCULAR WAVEGUIDES

Directional couplers for detecting circular waveguide modes page 33 NPO-17175

CMOS

Effects of dose rates on radiation damage in CMOS parts page 32 NPO-17344

COATINGS

Monitoring coating thickness during plasma spraying page 84 LEW-14919

COLOR TELEVISION

Real-time digital compression of television image data page 40 LEW-14945

COMBUSTION CHAMBERS

High-pressure promoted-combustion chamber page 46 MSC-21470

COMPOSITE STRUCTURES

Advanced composite pistons page 90 LAR-13926

COMPRESSED GAS

High-pressure promoted-combustion chamber page 46 MSC-21470

COMPRESSIBLE FLOW

Analysis of stepped labyrinth seals page 79 MFS-29585

COMPUTER ANIMATION

Flexible animation computer program page 68 LAR-14102

COMPUTER DESIGN

Bus-programmable slave card page 34 MSC-21387

CONCENTRATORS

Concentrating gaseous contaminants for monitoring page 45 MSC-21424

CONCURRENT PROCESSING

Concurrent algorithm for particle-in-cell simulations page 95 NPO-17737

CONTAINERS

Vacuum-gauge connection for shipping container page 85 MSC-21523

CONTAMINANTS

Concentrating gaseous contaminants for monitoring page 45 MSC-21424

COUPLINGS

Redundant, confined-explosive severance device page 75 LAR-13582

CRACK PROPAGATION

Dissipation of energy in extension of cracks page 73 LAR-14025

CRYOGENICS

Vacuum-gauge connection for shipping container page 85 MSC-21523

CULTURE TECHNIQUES

Emulsions containing perfluorocarbon support cell cultures page 99 MSC-21480

D

DAMPING

Damping seals and bearings for a turbomachine page 80 MFS-28345

DATA COMPRESSION

Real-time digital compression of television image data page 40 LEW-14945

DATA PROCESSING EQUIPMENT

Bus-programmable slave card page 34 MSC-21387

DECONTAMINATION

Catalytic destruction of toxic organic compounds page 46 NPO-17669

DEFLECTORS

Thrust-vector defectors for spacecraft page 81 MSC-21672

DEFORMATION

Computing deformations of rubbery materials page 47 NPO-17670

DIAPHRAGMS (MECHANICS)

Pressure-measuring diaphragm transmits optical signals page 76 MFS-29535

DIFFERENTIAL EQUATIONS

SINDA '85/FLUENT, Version 2.2 page 68 MSC-21528

DIFFRACTION

Diffraction analysis of distorted reflector antennas page 66 NPO-16818

DIRECTIONAL COUPLERS

Directional couplers for detecting circular waveguide modes page 33 NPO-17175

DIRECTIONAL SOLIDIFICATION (CRYSTALS)

Directional solidification of monotectic alloys page 61 MFS-26080

DOPPLER EFFECT

Linear ion trap for atomic clock page 44 NPO-17758

DROPS (LIQUIDS)

Behavior of evaporating liquid drops in clusters page 61 NPO-17843

DYNAMIC STRUCTURAL ANALYSIS

Flexible animation computer program page 68 LAR-14102

DYNAMICAL SYSTEMS

Non-Lipshitzian dynamics for modeling neural networks page 97 NPO-17814

E

ELASTOPLASTICITY

Dissipation of energy in extension of cracks page 73 LAR-14025

ELECTRIC WELDING

Controlled-pinch spot welder page 87 MFS-29606

Rolling spot welder page 86 MFS-29580

ELECTRON BEAM WELDING

Checking automated-welder programs by computer page 41 MFS-29006

ELECTRON MICROSCOPY

Viewing integrated-circuit interconnections by SEM page 18 NPO-17635

ELEVATION

Differential radar interferometry maps changes in elevation page 36 NPO-17831

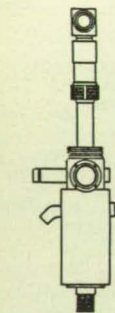
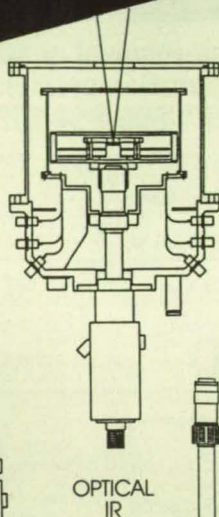
EMULSIONS

Emulsions containing perfluorocarbon support cell cultures page 99 MSC-21480

ENERGY DISSIPATION

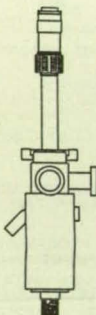
Dissipation of energy in extension of cracks page 73 LAR-14025

CRYOGENIC RESEARCH SYSTEMS



UV-VIS-IR SPECTROSCOPY

SUPERCONDUCTOR RESEARCH



UHV

Liquid Transfer Systems
 Closed Cycle Refrigerators
 Multiple Pin Leadless Carrier Dewars
 Pourfill Dewars
 Custom Systems
 Engineering/Design Support
 Equipment Rental
 Temperature Cycling
 Cryogenic Instrumentation and Sensors

R.G. HANSEN & ASSOCIATES
 631 Chapala Street
 Santa Barbara, CA 93101
 (805) 564-3388 FAX (805) 963-0733

ETALON
 Calculating performances of Fabry-Perot etalons
 page 66 LAR-14055

ETCHANTS
 Milder etchant for penetrant inspection
 page 63 MFS-29645

EVAPORATION
 Behavior of evaporating liquid drops in clusters
 page 61 NPO-17843

EXPLOSIVE DEVICES
 Redundant, confined-explosive severance device
 page 75 LAR-13582

F

FABRY-PEROT INTERFEROMETERS
 Calculating performances of Fabry-Perot etalons
 page 66 LAR-14055

FIBER COMPOSITES
 Advanced composite pistons
 page 90 LAR-13926

FIELD EFFECT TRANSISTORS
 MCI/MOSFET switch
 page 26 NPO-18001

FINITE ELEMENT METHOD
 Computing deformations of rubbery materials
 page 47 NPO-17670

FITTINGS
 Simple, internally adjustable valve
 page 76 MFS-29463

FLOODS
 Making topographical maps from SAR and flood-gauge data
 page 44 GSC-13212

FLOW EQUATIONS
 SINDA '85/FLUJIT, Version 2.2
 page 68 MSC-21528

FLUX (RATE)
 Simplified calculation of solar fluxes in solar receivers
 page 68 NPO-17732

FREQUENCY MULTIPLIERS
 Millimeter-wave quantum-well frequency multipliers
 page 28 NPO-17584

G

GAS ANALYSIS
 Concentrating gaseous contaminants for monitoring
 page 45 MSC-21424

GRAPHITE-POLYIMIDE COMPOSITES
 Process for autoclaving HMW PMR-II composites
 page 64 LEW-14839

H

HIGH PRESSURE OXYGEN
 High-pressure promoted-combustion chamber
 page 46 MSC-21470

HINGES
 Precise hinge has low friction
 page 71 NPO-17749

HOLOGRAPHY
 Holographic reticle
 page 89 MFS-29597

IMAGING RADAR
 Phase calibration of radar polarimetric data
 page 91 NPO-17844

IMPINGEMENT
 Computing impingements of rocket exhausts
 page 67 MSC-21419

INCONEL (TRADEMARK)
 Milder etchant for penetrant inspection
 page 63 MFS-29645

Treating nickel alloy for sonic quality
 page 85 MFS-29594

INSPECTION
 Milder etchant for penetrant inspection
 page 63 MFS-29645

INTEGRATED CIRCUITS
 Viewing integrated-circuit interconnections by SEM
 page 18 NPO-17635

INTERFEROMETRY
 Differential radar interferometry maps changes in elevation
 page 36 NPO-17831

ION TRAPS (INSTRUMENTATION)
 Linear ion trap for atomic clock
 page 44 NPO-17758

IONIZING RADIATION
 Effects of dose rates on radiation damage in CMOS parts
 page 32 NPO-17344

J

JOINTS (JUNCTIONS)
 Offset joint for segmented pressure vessel
 page 70 MFS-28365

Redundant, confined-explosive severance device
 page 75 LAR-13582
 Removing dross from molten solder
 page 88 MFS-28406

K

KLYSTRONS
 High-efficiency klystron for television transmitters
 page 30 LEW-14926

L

LABYRINTH SEALS
 Analysis of stepped labyrinth seals
 page 79 MFS-29585

LAMINATES
 Process for autoclaving HMW PMR-II composites
 page 64 LEW-14839

LAND MOBILE SATELLITE SERVICE
 More about lens antenna for mobile/satellite communication
 page 33 NPO-17680

LASER DOPPLER VELOCIMETERS
 Laser velocimetry in low-speed wind tunnels
 page 42 ARC-11564

LATCHES
 Simulating a massive, mobile structure
 page 72 MSC-21482

LENS ANTENNAS
 More about lens antenna for mobile/satellite communication
 page 33 NPO-17680

LINEARIZATION
 Exact linearization for control of robots
 page 97 NPO-17363

LIPSCHITZ CONDITIONS
 Non-Lipshitzian dynamics for modeling neural networks
 page 97 NPO-17814

LOADS (FORCES)
 Balancing loads among robotic-manipulator arms
 page 98 NPO-17649

LOW SPEED WIND TUNNELS
 Laser velocimetry in low-speed wind tunnels
 page 42 ARC-11564

M

MANIPULATORS
 Robust, high-performance control for robotic manipulators
 page 36 NPO-17785

MAPPING
 Differential radar interferometry maps changes in elevation
 page 36 NPO-17831

MATRICES (CIRCUITS)
 Switching matrix for optical signals
 page 22 KSC-11392

MEASURING INSTRUMENTS
 Radial profilometry
 page 74 MFS-26101

MICROPROCESSORS
 Bus-programmable slave card
 page 34 MSC-21387

MICROSTRIP ANTENNAS
 Planar microstrip Yagi antennas
 page 18 NPO-17873

MICROWAVE ANTENNAS
 Planar microstrip Yagi antennas
 page 18 NPO-17873

MILLIMETER WAVES
 Millimeter-wave quantum-well frequency multipliers
 page 28 NPO-17584

MOBILE COMMUNICATION SYSTEMS
 More about lens antenna for mobile/satellite communication
 page 33 NPO-17680

MONITORS
 Monitoring both sides of a weld in progress
 page 84 MFS-28389

MONOTECTIC ALLOYS
 Directional solidification of monotectic alloys
 page 61 MFS-26080

N

NEURAL NETS
 Non-Lipshitzian dynamics for modeling neural networks
 page 97 NPO-17814

NICKEL ALLOYS
 Treating nickel alloy for sonic quality
 page 85 MFS-29594

O

OPTICAL COMMUNICATION
 Switching matrix for optical signals
 page 22 KSC-11392

OPTICAL FILTERS
 Calculating performances of Fabry-Perot etalons
 page 66 LAR-14055

OPTOELECTRONIC DEVICES
 Active limiters for photodetectors
 page 38 NPO-17654
 Radial profilometry
 page 74 MFS-26101

ORIFICES
 Simple, internally adjustable valve
 page 76 MFS-29463

OXIDATION
 Catalytic destruction of toxic organic compounds
 page 46 NPO-17669

P

PARABOLIC ANTENNAS
 Dielectric-filled paraboloidal front ends
 page 24 NPO-17802

PARTICLE IN CELL TECHNIQUE
 Concurrent algorithm for particle-in-cell simulations
 page 95 NPO-17737

PENETRANTS
 Milder etchant for penetrant inspection
 page 63 MFS-29645

PERFLUORO COMPOUNDS
 Emulsions containing perfluorocarbon support cell cultures
 page 99 MSC-21480

PHASE ERROR
 Phase calibration of radar polarimetric data
 page 91 NPO-17844

PHOTOMETERS
 Active limiters for photodetectors
 page 38 NPO-17654

PISTONS
 Advanced composite pistons
 page 90 LAR-13926

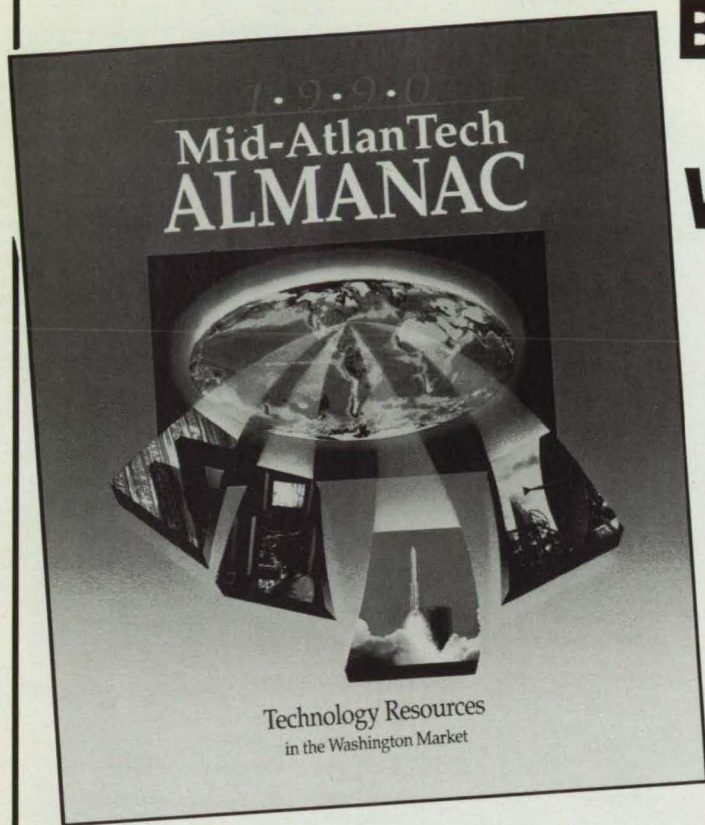
PLASMA PHYSICS
 Concurrent algorithm for particle-in-cell simulations
 page 95 NPO-17737

PLASMA SPRAYING
 Monitoring coating thickness during plasma spraying
 page 84 LEW-14919

PLUMES
 Computing impingements of rocket exhausts
 page 67 MSC-21419

POLARIMETRY
 Phase calibration of radar polarimetric data
 page 91 NPO-17844

The Essential Business Reference for the Washington Market



WASHINGTON TECHNOLOGY is proud to publish the 1990 Mid-AtlanTech Almanac featuring profiles of hundreds of the leading technology companies doing business in the Washington Market.

216 pages, including directories of Technology Venture Capital, High Tech Networking and Support Organizations, International Resources, Associations and Federal Laboratories.

You'll find the 1990 Mid-AtlanTech Almanac is the most valuable resource for doing business in America's fastest growing Technology Market.

Fourth Edition now available!

PRICE: \$30 per copy, postpaid
(plus applicable sales tax)

WASHINGTON TECHNOLOGY is a biweekly newspaper presenting the business news of technology for management in corporations and government.

WASHINGTON TECHNOLOGY

The Newspaper for Technology-Intensive Business

1953 Gallows Road - Suite 130
Vienna, VA 22182

(703) 848-2800 Fax: (703) 848-2353

- Please Send ____ copy(s) of the 1990 Mid-AtlanTech Almanac at a cost of \$30 per copy, postpaid (plus sales tax).
- Enter my subscription to WASHINGTON TECHNOLOGY at a cost of \$30 per year.

Total Amount Due \$ _____

Check Enclosed Visa/MC — info. below

Name _____ Title _____

Company _____ Phone (____) _____

Address _____ Fax (____) _____

City _____ State _____ Zip Code _____

Visa/MC# _____ Exp. Date _____

Signature _____ Date _____

POWDER METALLURGY
Making self-lubricating parts by powder metallurgy
page 63 LEW-14902

PRESSURE MEASUREMENT
Pressure-measuring diaphragm transmits optical signals
page 76 MFS-29535

PRESSURE VESSELS
Offset joint for segmented pressure vessel
page 70 MFS-28365

PROFILOMETERS
Radial profilometry
page 74 MFS-26101

Q

QUANTUM WELLS
Millimeter-wave quantum-well frequency multipliers
page 28 NPO-17584

R

RADAR ANTENNAS
Diffraction analysis of distorted reflector antennas
page 66 NPO-16818

RADAR IMAGERY
Differential radar interferometry maps changes in elevation
page 36 NPO-17831

RADIANT FLUX DENSITY
Simplified calculation of solar fluxes in solar receivers
page 68 NPO-17732

RADIATION DAMAGE
Effects of dose rates on radiation damage in CMOS parts
page 32 NPO-17344

REFLECTOR ANTENNAS
Diffraction analysis of distorted reflector antennas
page 66 NPO-16818

RELIEF MAPS
Making topographical maps from SAR and flood-gauge data
page 44 GSC-13212

REMOTE MANIPULATOR SYSTEM
Balancing loads among robotic-manipulator arms
page 98 NPO-17649

Exact linearization for control of robots
page 97 NPO-17363

Exponentially stabilizing robot control laws
page 95 NPO-17587

Robust, high-performance control for robotic manipulators
page 36 NPO-17785

RETICLES
Holographic reticle
page 89 MFS-29597

ROBOTICS
Balancing loads among robotic-manipulator arms
page 98 NPO-17649

Checking automated-welder programs by computer
page 41 MFS-29006

Exponentially stabilizing robot control laws
page 95 NPO-17587

ROBOTS
Dual-head robotic welder
page 87 MFS-29610

Exact linearization for control of robots
page 97 NPO-17363

ROCKET EXHAUST
Computing impingements of rocket exhausts
page 67 MSC-21419

ROTARY WING AIRCRAFT
Civil applications for new V/STOL and STOL aircraft
page 81 ARC-12175

ROTORS
Precise hinge has low friction
page 71 NPO-17749

RUBBER
Computing deformations of rubbery materials
page 47 NPO-17670

S

S MATRIX THEORY
Computing scattering matrices for circular waveguides
page 65 NPO-17245

SAPPHIRE
Pressure-measuring diaphragm transmits optical signals
page 76 MFS-29535

SATELLITE ATTITUDE CONTROL
Liquid-ring attitude-control system for spacecraft
page 82 NPO-17485

SCATTERING
Computing scattering matrices for circular waveguides
page 65 NPO-17245

SELF LUBRICATING MATERIALS
Making self-lubricating parts by powder metallurgy
page 63 LEW-14902

SHELLS (STRUCTURAL FORMS)
Dual-head robotic welder
page 87 MFS-29610

SHORT TAKEOFF AIRCRAFT
Civil applications for new V/STOL and STOL aircraft
page 81 ARC-12175

SHUTTERS
Active limiters for photodetectors
page 38 NPO-17654

SIMULATION
Simulating a massive, mobile structure
page 72 MSC-21482

SOLAR COLLECTORS
Simplified calculation of solar fluxes in solar receivers
page 68 NPO-17732

SOLDERING
Removing dross from molten solder
page 88 MFS-28406

SOLID PROPELLANT ROCKET ENGINES
Offset joint for segmented pressure vessel
page 70 MFS-28365

SPACECRAFT CONTROL
Liquid-ring attitude-control system for spacecraft
page 82 NPO-17485

SPACECRAFT STRUCTURES
Simulating a massive, mobile structure
page 72 MSC-21482

SPOT WELDS
Controlled-pinch spot welder
page 87 MFS-29606

Rolling spot welder
page 86 MFS-29580

SPRAY CHARACTERISTICS
Behavior of evaporating liquid drops in clusters
page 61 NPO-17843

SPRAY INGESTION
Measurement of water sprays generated by airplane tires
page 70 LAR-14030

STATORS
Precise hinge has low friction
page 71 NPO-17749

STRESS MEASUREMENT
Treating nickel alloy for sonic quality
page 85 MFS-29594

SUBMILLIMETER WAVES
Dielectric-filled paraboloidal front ends
page 24 NPO-17802

SUBSONIC FLUTTER
Predicting unsteady aeroelastic behavior
page 77 LAR-14130

SURFACE PROPERTIES
Holographic reticle
page 89 MFS-29597

SWITCHING CIRCUITS
MCI/MOSFET switch
page 26 NPO-18001

Switching matrix for optical signals
page 22 KSC-11392

SYNTHETIC APERTURE RADAR
Differential radar interferometry maps changes in elevation
page 36 NPO-17831

Making topographical maps from SAR and flood-gauge data
page 44 GSC-13212

T

TELEVISION TRANSMISSION
High-efficiency klystron for television transmitters
page 30 LEW-14926

Real-time digital compression of television image data
page 40 LEW-14945

THERMAL ANALYSIS
SINDA '85/FLUINT, Version 2.2
page 68 MSC-21528

THICKNESS
Monitoring coating thickness during plasma spraying
page 84 LEW-14919

THRUST VECTOR CONTROL
Thrust-vector deflectors for spacecraft
page 81 MSC-21672

THYRISTORS
MCI/MOSFET switch
page 26 NPO-18001

TIRES
Measurement of water sprays generated by airplane tires
page 70 LAR-14030

TURBOMACHINERY
Analysis of stepped labyrinth seals
page 79 MFS-29585

Damping seals and bearings for a turbomachine
page 80 MFS-28345

U

ULTRAHIGH FREQUENCIES
High-efficiency klystron for television transmitters
page 30 LEW-14926

V

VACUUM GAGES
Vacuum-gauge connection for shipping container
page 85 MSC-21523

VALVES
Simple, internally adjustable valve
page 76 MFS-29463

VERTICAL TAKEOFF AIRCRAFT
Civil applications for new V/STOL and STOL aircraft
page 81 ARC-12175

W

WASTE DISPOSAL
Catalytic destruction of toxic organic compounds
page 46 NPO-17669

WAVEGUIDES
Computing scattering matrices for circular waveguides
page 65 NPO-17245

Directional couplers for detecting circular waveguide modes
page 33 NPO-17175

WELDED JOINTS
Controlled-pinch spot welder
page 87 MFS-29606

WELDING
Checking automated-welder programs by computer
page 41 MFS-29006

Dual-head robotic welder
page 87 MFS-29610

Monitoring both sides of a weld in progress
page 84 MFS-28389

Rolling spot welder
page 86 MFS-29580

WING TUNNELS
Laser velocimetry in low-speed wind tunnels
page 42 ARC-11564

Advertiser's Index

3-D Visions	(RAC 669)	75
AT&T Federal Systems	(RAC 655)	29
Aero Tec Laboratories, Inc.	(RAC 480)	97
Aerospatiale	(RAC 339)	20-21
Algor Interactive Systems, Inc.	(RAC 361)	69
Allied Engineered Plastics	(RAC 606)	37
Allied Signal	(RAC 415)	13
Amco Engineering Co.	(RAC 500)	COV IV
American Variseal	(RAC 322)	100
Amoco Performance Products	(RAC 336)	4-5
Atlantis Sweatshirts		43
Azonic, Inc.	(RAC 477)	101
Burr-Brown Corporation	(RAC 313)	32
Capacitec	(RAC 385)	106
Colder Products Co.	(RAC 517)	102
DATA Business Publishing	(RAC 629)	79
Digital Technology, Inc.	(RAC 685)	72
Dolphin Scientific	(RAC 510, 511)	41, 43
DuPont Electronics		89
Eagle Stainless Tube Corp.	(RAC 386)	96
Edmund Scientific Co.	(RAC 641)	87
Eighteen Eight Laboratories	(RAC 675)	109
Electro-Flex Heat, Inc.	(RAC 486)	60
Fluoramics, Inc.	(RAC 364)	15
Gould Electronics		7, 35
Hardigg Industries, Inc.	(RAC 492)	43
Howmet Corporation	(RAC 335)	62
Hyperception Inc.	(RAC 445)	92
IBM Corporation		25
Inco Alloys International	(RAC 569)	9
Indium Corporation of America	(RAC 512)	87
Information Handling Services	(RAC 478)	23
Integrated Inference Machines	(RAC 307)	14
JPS Elastometrics Corp.	(RAC 349)	102
John Fluke Mfg. Co. Inc.	(RAC 668, 440)	106
KH Industries, Inc.	(RAC 563)	103
MTI Instruments	(RAC 365)	104
Magnetic Shield Corp., Perfection Mica Co.	(RAC 370)	61
Martin Marietta		COV II
MathSoft, Inc.	(RAC 682)	17
McGraw Hill, Inc.		82
Measurement Systems, Inc.	(RAC 435)	66
Meridian Laboratory	(RAC 327)	103
Micro Way		COV IV
Molecu Wire	(RAC 331)	2
NUPRO Company	(RAC 378)	42
Naval Instruments	(RAC 681)	98
Naval Underwater Systems Center	(RAC 324)	31
Nicolet Instruments	(RAC 696, 697)	3, 19
Numerical Algorithms Group	(RAC 377)	86
Omaton, Inc.	(RAC 338)	65
Polaroid Corporation	(RAC 557)	78
Primavera Systems, Inc.	(RAC 663)	67
Quatech	(RAC 599)	106
R.G. Hansen & Associates	(RAC 688)	106
RGB Spectrum	(RAC 467)	8
RemGrit Corporation	(RAC 320)	27
Rexham Industrial	(RAC 369)	91
Rolyn Optics Co.	(RAC 551)	106
Ross-Hime designs, Inc.	(RAC 329)	104
Saelig Company	(RAC 399)	106
Science Applications International Corporation	(RAC 692)	30
Servometer Corporation	(RAC 490)	106
Silicon Composers, Inc.	(RAC 679)	106
Software Spectra, Inc.	(RAC 509)	67
Specac Analytical, Inc.	(RAC 388)	106
Structural Research and Analysis Corporation	(RAC 676)	40
Syntax Rubber Corporation	(RAC 515)	81
Technology 2000		49-60
Teledyne Microwave	(RAC 373)	48
Teledyne Solid State	(RAC 537)	39
Tiodize	(RAC 422)	64
US Technology Corporation	(RAC 582)	107
Unholtz-Dickie Corporation	(RAC 318)	101
VAT Incorporated	(RAC 518)	90
Wardwell Braiding Machine Co.	(RAC 396)	64
Washington Technology	(RAC 333)	109
Westcon/90	(RAC 630)	105
YSI Incorporated	(RAC 408, 596)	12, 106
Zero West Division	(RAC 359, 360, 610, 613)	99

*RAC stands for Reader Action Card. For further information on these advertisers, please circle the RAC number on the Reader Action Card elsewhere in this issue. This index has been compiled as a service to our readers and advertisers. Every precaution is taken to ensure its accuracy, but the publisher assumes no liability for errors or omissions.

Five Centuries Ago, Shielded Enclosures Were Custom Made.

Some Still Are.



The crusading spirit is alive and well at AMCO. We have the proven capability, experience, and willingness to work with you on the more difficult shielding applications encountered today.

In 1962 AMCO designed and built the first Modular Shielded Enclosure System. Used by NASA on the Saturn Booster Program it remains today one of the most reliable on the market.

AMCO has made many advancements since then:

- Modular Shielded Enclosure Systems for FCC & Commercial Applications.
- Shielded Cabinets compatible to Tempest NACSIM-5100A.
- Custom or Modified Standard Shielded Enclosures for those very special needs – including Siesmic, Environmental, Drip Proof, Shock & Vibration.

For free catalogs call **1-800-833-3156**.

In Illinois call **708-671-6670**.

Ask for Commercial Catalog 650 and/or Heavy Duty Catalog 204.

For free initial consultation call **708-671-6670** and ask for The Performance Evaluation Lab-Extension 232.



AMCO

AMCO Engineering Co.

3801 N. Rose Street

Schiller Park, Illinois 60176

Circle Reader Action No. 500

Discover Parallel Processing

Quadputer™

The Microway Quadputer is the world's most popular PC Transputer development environment. It can be purchased with two to four Transputers and one to four megabytes of RAM per processor. The Quadputer runs all the popular Transputer development software, all of which is available from Microway. It is compatible with our Monoputer™ which provides 1 to 16 megabytes of RAM and a single T800, our Videoputer™ which comes in VGA and higher resolution versions and is powered by a memory mapped pair (T800 and 34010), and our Linkputer™ whose cross bar switching network can dynamically link up to 32 Transputers. Finally, all Microway Transputer products can be used with our Number Smasher-860 to provide out-of-this-world numeric performance!

For more information, please call 508-746-7341.

Microway

The World Leader in PC Numerics

Corporate Headquarters, Research Park, Box 79, Kingston, MA 02364
Tel 508-746-7341 • FAX 508-746-4678
U.K. - 32 High St., Kingston-Upon-Thames, 081-541-5466 • Italy 02-74.90.749
Ireland 40 836455 • Germany 069-75 2022 • Japan 01-6 333 157

Number Smasher® 860

The highest performance coprocessor card to ever run in a PC, Number Smasher-860 delivers up to 80 million single precision floating point operations per second at 40 MHz and produces over 10 Linkpack megaflops. The board comes standard with an ISA interface, two Transputer Link Adaptors that allow it to interface with a Microway Quadputer or Videoputer, your choice of our NDP Fortran, C or Pascal for the 80860, plus 8 megabytes of high speed memory.

NDP Fortran-860, C-860 and C++860

Microway NDP 860 Compilers make it easy to recompile your favorite mainframe, 80386 or PC application for the 80860. The resulting code runs on our XTEND-860™ environment under DOS, UNIX or XENIX.

