NASA Tech Briefs

Official Publication of
National Aeronautics and
Space Administration
Volume 14 Number 6

Transferring Technology to
American Industry
and Government

June 1990

The Temperature Pill: Space Research Spawns Medical Breakthrough

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.

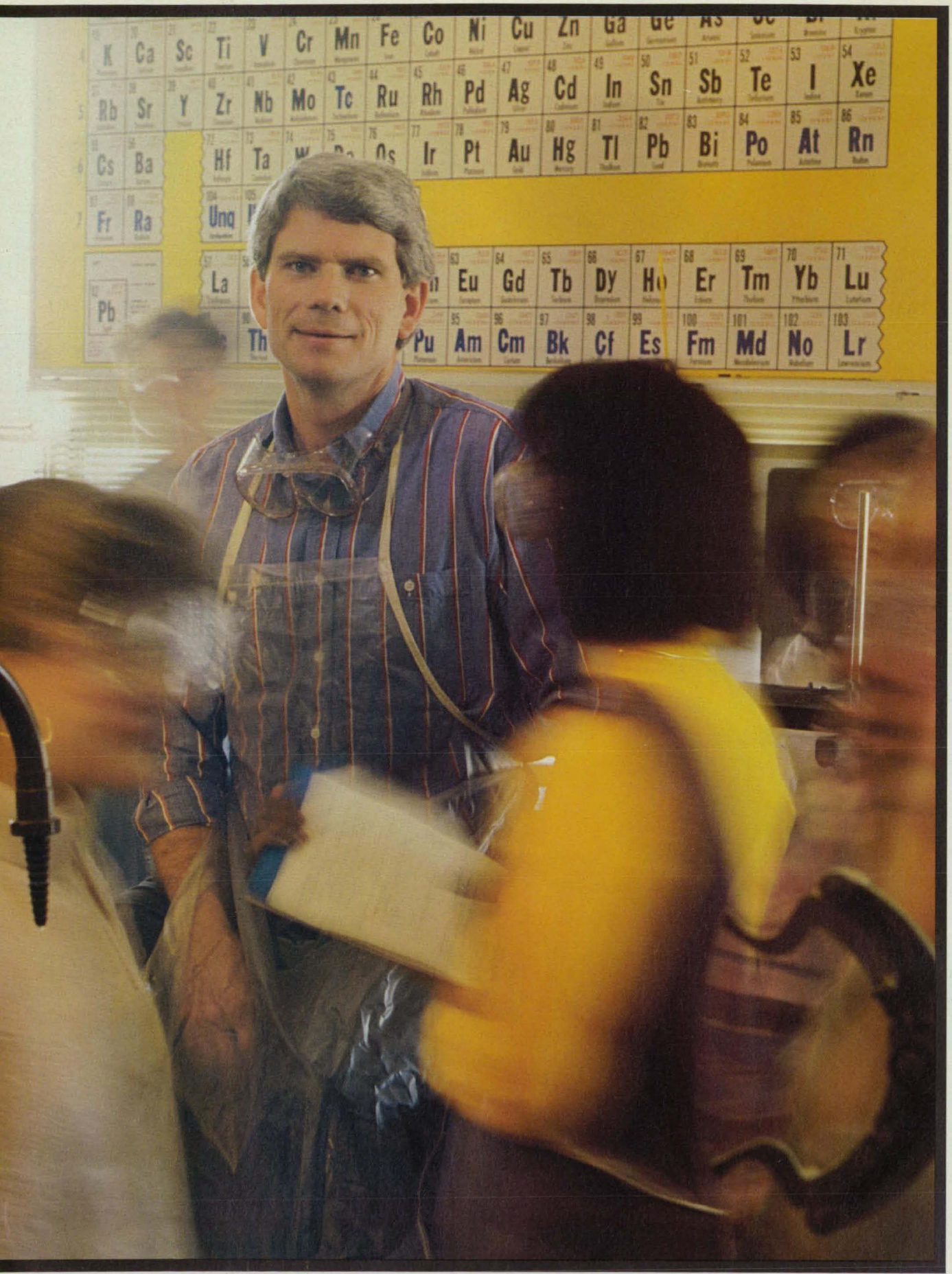
That's why Martin Marietta is helping to underwrite a new regional Academy for Teachers of Science and Math at the University of Tennessee. It's an intensive program of study and discussion for Martin Marietta Fellows; outstanding educators in all grade levels. Through the Academy, the private sector, 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



To some, 300 dots per inch may seem quite adequate.

To old Spot here, the 300 dpi of conventional laser printers is good enough. But to those with a big investment in high resolution imaging systems, the lack of truly superior hard copy output can be a doggone shame. Fortunately, the Lasertechnics 300D continuous tone printer provides the highest resolution, film or paper copy on the market today. Up to 2048 pixels per line with 256 levels of grey per pixel. Perfect for applications ranging from military reconnaissance to non-destructive testing and medical imaging workstations. Digital interfaces are available for most major computers. Finally an output system that matches your input in less than a minute for as little as 50 cents a page. Now, that's something to bark about!

The 300D Digital Image Recorder

Lasertechnics

5500 Wilshire Avenue NE
Albuquerque, NM 87113
800-227-9484
505-822-1123
FAX: 505-821-2213

Circle Reader Action No. 600

WHY BUY A NEW CAR WHEN YOU DON'T HAVE TO?

USE Tufoil® AND YOUR ENGINE WILL LAST... AND LAST...AND LAST!

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 Tufoil to the crankcase. 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 with a note describing the year and make of your car. We'll refund your $14.25 immediately.

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.
(in New Jersey, call 201-825-8110.)

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
- ☐ "Fun with Superconductors"—we're leading that field too!

See NASA Tech Briefs for technical details, 1986, 1987 and 1988.

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:

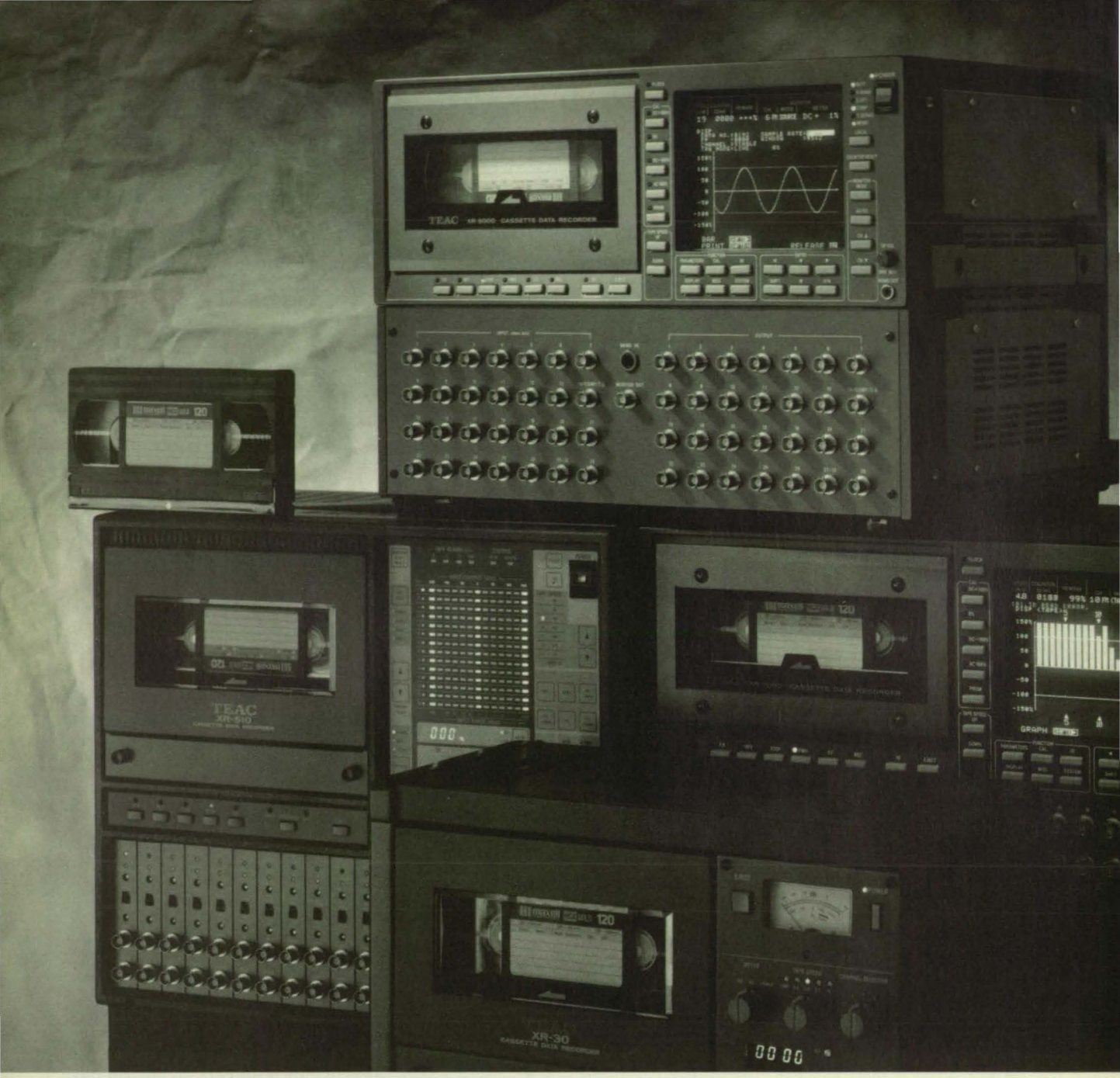
- ☐ ONE 8 oz. bottle . . . treat one car for $14.25 (plus $3.50 shipping and handling). See money back guarantee.
- ☐ TWO 8 oz. bottles . . . treat two cars for $25.00 (plus $4.00 shipping and handling) **SAVE $6.00**
- ☐ ONE Quart bottle . . . treat 4 cars for $34.95 (plus $4.00 shipping and handling)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

We ship within days!
MONEY BACK GUARANTEE ON 8-OZ.

Fluoramics, Inc. NTB-69
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 6% sales tax).

Canadian Distributor: 1-800-363-7753



NOW TEAC'S XR SERIES IS 28-CHANNELS WIDE.

Introducing the world's first 28-channel VHS data recorder. The TEAC XR-9000. Now the performance and capacity of the larger open-reel decks are available with the convenience, economy and ease of operation of VHS cassettes. All within a lightweight, minimum foot print unit.

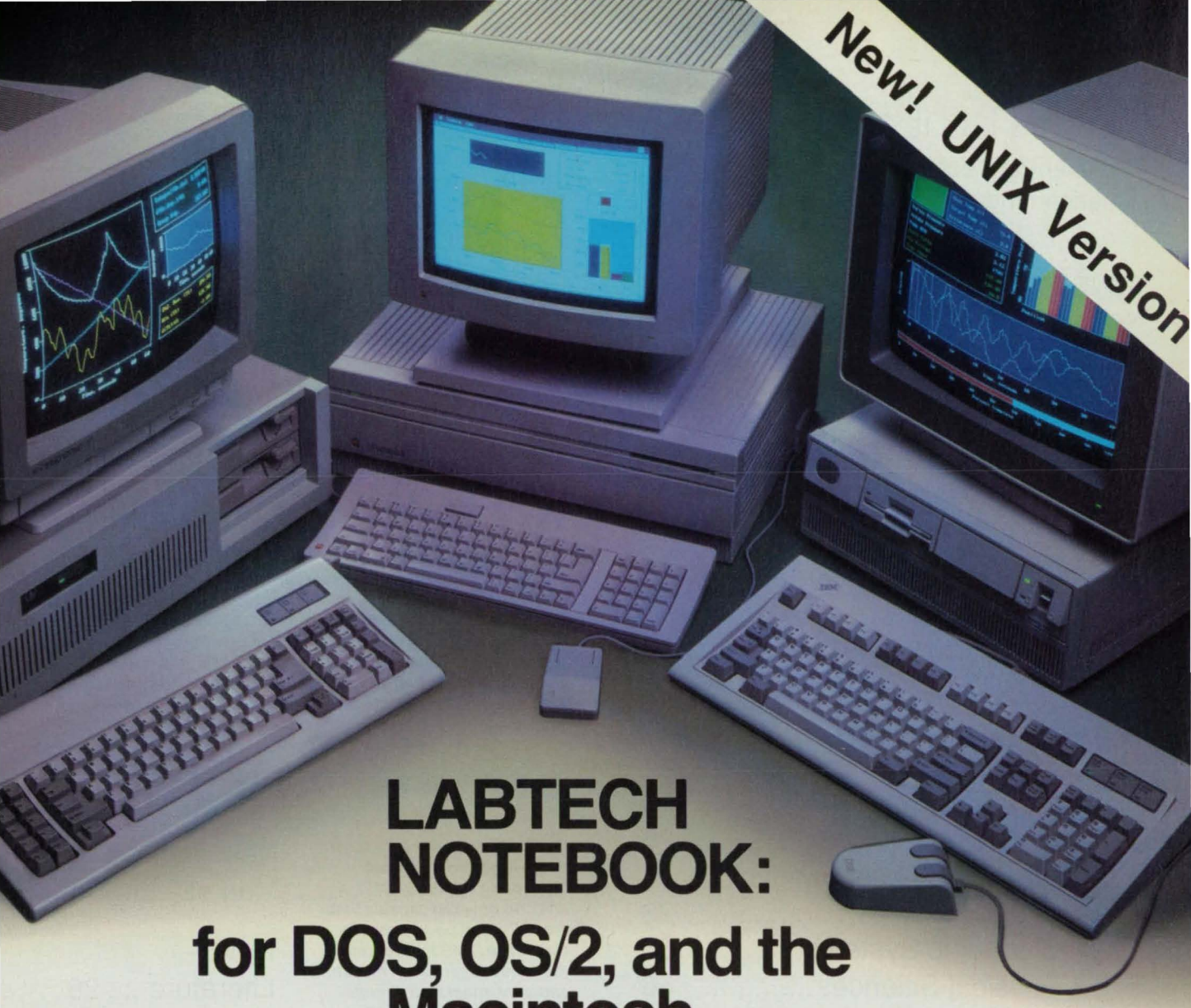
The XR-9000 offers TEAC's exclusive menu-driven on-screen display plus numerous auto-functions to provide a simple step-by-step setup procedure. You can use your computer to remotely control the XR-9000. And recorded data from the XR-9000 can be fed directly into a computer.

It's been over a decade since TEAC introduced the world's first VHS cassette data recorder. Since then, we've helped develop every major improvement in VHS data recording technology. Today we're building VHS data recorders from 7- to 28-channels with models available in Wide Band Groups I and II, plus interchangeable FM, Super FM DR, and PCM modules. And in an industry with little tolerance for error, TEAC's enviable record of performance and reliability is unsurpassed.

So, if you're looking for greater capacity, with the most variety of options and models, at the most efficient cost-per-channel, TEAC XR series data recorders is the only place you'll find it.

TEAC®

Information Products Division.



LABTECH NOTEBOOK: for DOS, OS/2, and the Macintosh

LABTECH NOTEBOOK has been the accepted standard for data acquisition and control software since we introduced NOTEBOOK for MS-DOS. Now, we've taken the next step into the future with NOTEBOOK for OS/2 and the Macintosh.

LABTECH NOTEBOOK now gives you a choice of platforms — The IBM® PC/XT/AT, PS/2, compatibles, and the Apple® Macintosh. Setups and configurations are compatible — configure your system on one platform and run the same setup on another.

LABTECH NOTEBOOK collects data from multiple channels, displays the data graphically and stores it to disk in real-time. It features user defined acquisition, control and display setups; real-time mathematical, statistical and signal processing; sophisticated triggering; data replay; and continuous data collection while you work in other programs. Many input types, including analog, digital, thermocouple, RTD, strain and pressure gages, resistance, counters and frequency, are supported by NOTEBOOK.

The DOS version supports foreground/background operation and, as an option, expanded memory. The OS/2 version takes advantage of OS/2's multitasking capability and protected memory support. NOTEBOOK for the Macintosh works under Multifinder and follows the Macintosh menu and icon conventions.

LABTECH NOTEBOOK, with an installed base of 10,000 systems, supports hundreds of board-level data acquisition interfaces and distributed I/O systems from more than 30 manufacturers. NOTEBOOK can be found in most Fortune 500 companies, as well as in smaller enterprises.

New improved GPIB support

LABTECH

Laboratory Technologies Corporation • 400 Research Drive • Wilmington, MA 01887 • 508-657-5400 • FAX 508-658-9972

Circle Reader Action No. 423

NASA Tech Briefs
Transferring Technology to
American Industry and Government

JUNE 1990
Volume 14 Number 6

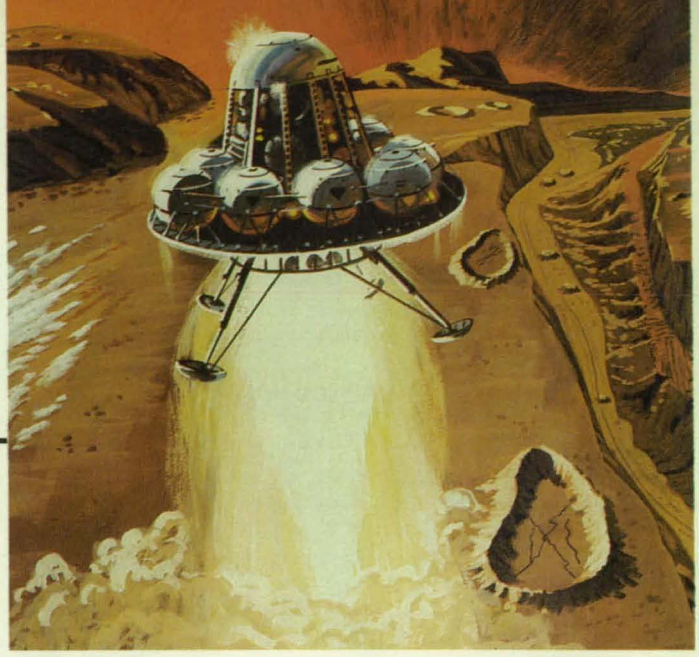


Photo courtesy NASA

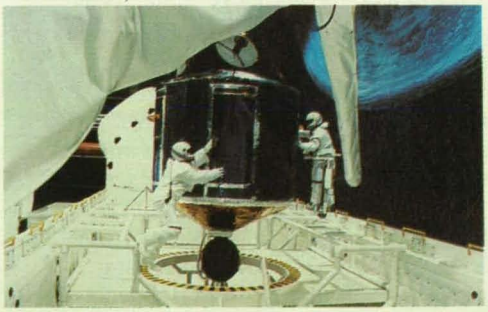
Last November, President Bush approved a national space plan (page 10) that would send humans to the moon, then on to Mars. In its Exploration Technology Program, NASA is developing the enabling technologies for these 21st century missions. One aim is to develop an autonomous planetary lander capable of avoiding surface hazards and landing at a precise spot without the help of Earth-based control. This requires advances in real-time image processing, onboard computing, and sensors for hazard detection.

SPECIAL FEATURES

TECHNICAL SECTION

DEPARTMENTS

On The Cover: The components of the Ingestible Thermal Monitoring System (ITMS), a silicone-covered capsule that "reads" deep body temperatures. The ITMS incorporates the latest advances in miniaturization of integrated circuits, batteries, and sensors. See page 106. (Photo concept and composition by Robert I. Johnson, director of advanced projects, Business Communications of America, Inc.)



Turn to page 10 for details on how to win a free stay at the United States Space Camp.

Photo courtesy U.S. Space Camp

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.

MODERNIZING INFORMATION PROCESSING.

We're integrating a significantly more efficient management information system for Air Force Pentagon operations. This Headquarters Systems Replacement Program will convert an installed base of 23 computer systems into one system using different hardware and software without interrupting service. HSRP will streamline budgeting, resource tracking, force structuring and administrative tasks. And its enhanced software will consolidate common system functions, provide easier access to information, and increase responsiveness. For more information, contact Grumman Data Systems, 6862 Elm Street, McLean VA, 22101. Or call (703) 556-7400.

GRUMMAN

GRUMMAN®
Data Systems

® A registered trademark of Grumman Corporation

Circle Reader Action No. 363

NASA Tech Briefs

Official Publication of
National Aeronautics and
Space Administration

ABP BPA

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**
Advertising Coordination Manager ..... **Maya V. Falek**
Telecommunications Specialist ..... **Evelyn Mars**
Reader Service Manager ..... **Sylvia Valentin**

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 Texeira**
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, Northwest) ..... **Paul Lesher, CBC** at (708) 501-4140
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 Haggett** 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 —**Thomas Stillman**
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**

PURE SIGNAL

LOW SSB PHASE NOISE OF −140dBc

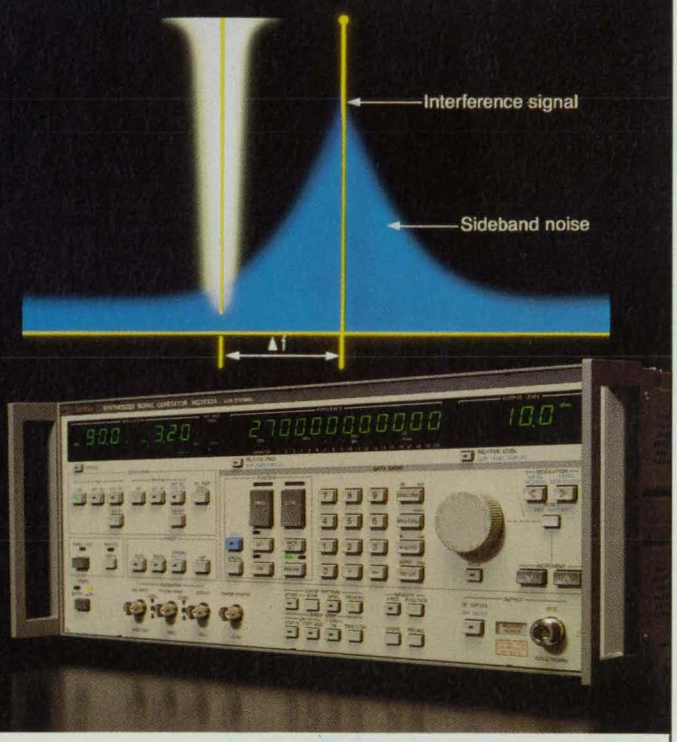
Anritsu's MG3633A Synthesized Signal Generator reduces sideband noise to −140dBc/Hz (20kHz offset from 1GHz signal), for the most precise performance and characteristics evaluation of all bands of radio communications equipment, even quasi-microwave.

Operating over the frequency range of 10kHz ~ 2.7GHz, the MG3633A provides AM, FM, and pulse (combined with the MA1610A) modulation, as well as simultaneous modulation in any combination. The DC mode enables simulations of digital transmissions, and provides FM stability of ±10Hz/H (typical).

The MG3633A also has an extremely accurate programmable attenuator to ensure ±1dB accuracy over the broad range of output levels from −123dBm to a powerful +20dBm. Output can be displayed in dBm, dBμ, V, mV, μV, or relative values.

From research to system maintenance, Anritsu gives you the best there is.

SYNTHESIZED SIGNAL GENERATOR MG3633A



Anritsu

ANRITSU AMERICA, INC. 15 Thornton Road, Oakland NJ 07436
800-255-7234 • (in NJ) 201-337-1111 • FAX 201-337-1033

Circle Reader Action No. 407

Editorial Notebook

NASA Tech Briefs/National Space Society 1990 Letter Writing Contest

At this time in 1988, we were in the backstretch of a presidential race. Did you know who was going to win? We didn't. Did you know about the impending cataclysmic changes in Eastern Europe? We didn't, not even in our wildest dreams.

What we did know was that we were in an election year, and several congressmen had suggested that NASA contractors hire advertising agencies to generate support for NASA because they weren't hearing much from their constituents and thought that the American people didn't care about the space program. Dr. James C. Fletcher, then the administrator of NASA, warned, "...the nation's civil space program is facing extinction this year." We weren't thrilled with that prospect, and in this column in July 1988 I wrote:

I wondered what we at Associated Business Publications could do to help spread the word. I've long been a believer that a few determined people can make a difference, so I wrote to every representative, senator, and presidential aspirant, asking them to state whether they were for or against a strong national space program.

In total, I received 47 responses, all in favor of a strong space program. That leaves another 500 government decision-makers who did not respond. Which is why we need your help. From the thousands of feedback cards we read every month, we know that there are few Americans more aware of the benefits we have all obtained through the activity of NASA and its contractors than the readers of NTB. These feedback cards also attest that you're eloquent letter writers.

Therefore, we thought this would be an apt time to announce a writing contest in which everybody wins. In honor of Independence Day, and in the interest of continuing a long line of future Independence Days, we hereby announce a contest for the best letters in support of NASA and U.S. space exploration written to government leaders.

It worked so well that *NASA Tech Briefs'* editorial board was swamped with over 1000 letters. We had a difficult time determining the winner. Make that winners. We never dreamed that children would enter a contest in a highly technical magazine, but enter they did, and we decided to establish a children's category.

Since then we have seen President Bush commit the U.S. to landing astronauts on Mars by 2019. In establishing the Space Exploration Initiative, which aims to send humans to the moon and then on to Mars, the President has requested $1 billion in the fiscal year 1991 budget. That's fine...but congress has to appropriate the money. To help "raise the consciousness" of our representatives, we are initiating another contest, which we hope will be even more successful than the last.

One major improvement in this year's contest: We're not doing the judging. The National Space Society (NSS) is cosponsoring the contest with us, and will set up a blue-ribbon panel of judges. Letters will be judged on strength of argument and creativity.

Here's how the contest works: Write a letter of 500 words or less to the politician(s) of your choice, outlining your reasons for asking him or her to support the President's Space Exploration Initiative. Then send a copy of your letter(s) to the National Space Society at the address listed on page 12. All letters received by August 15, 1990 will be judged by the NSS panel, and the winning letters in the adults' and children's categories will be published in the October issues of both *NASA Tech Briefs* and *Ad Astra*, an official NSS magazine. All letter writers will be listed on an honor roll appearing in the October editions of both publications. Further, we plan to send copies of the letters to every congressman on the Hill.

The grand prize winners will receive a tuition-free stay at the United States Space Camp, an educational camp that simulates an astronaut's training program. Second prize in the adults' category is a VIP invitation to a space shuttle launch. Five merit winners will each receive one free category from the NTB:BASE software library, a PC-compatible database covering over 25 years of NASA technology.

Gentlepeople, we are all responsible for what will or will not happen to our space program. We can't afford to wait for the other guy to do it for us. So please, start those letters flowing to the politicians. This is a contest in which every American will prove ultimately to be a winner. Thanks for your support. ❑

America's Next Steps In Space

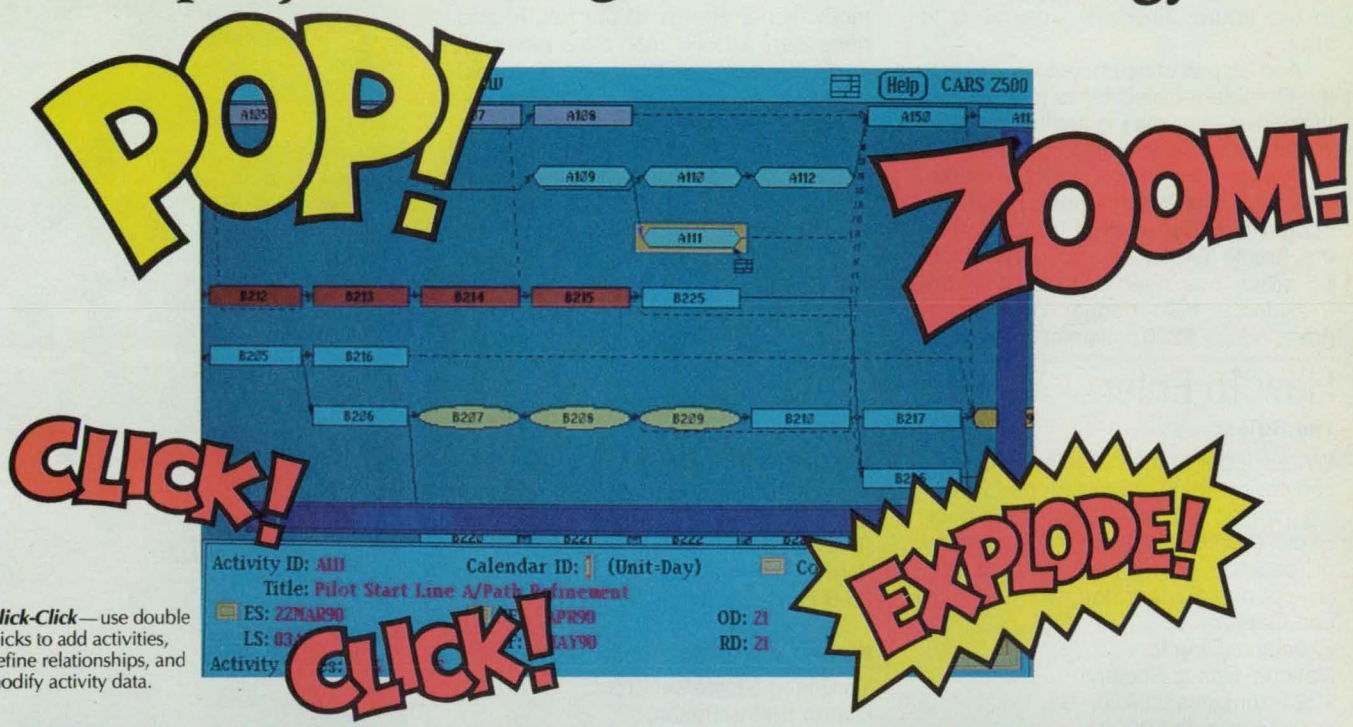
Charles Walker
National Space Society President

It is part of the human psyche to thirst for new frontiers. We are a pioneering species, continually on the move to expand the horizons of our knowledge and to satisfy our curiosity about the unknown.

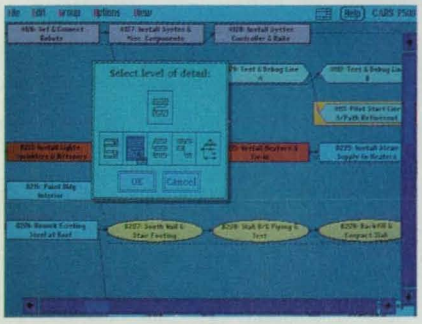
Today we see a trailway just as clear as the path taken by Lewis and Clark or that seen by settlers moving along the Oregon trail. It is a rocket trail...arching skyward into the new frontier of space.

Last July, in celebration of human-

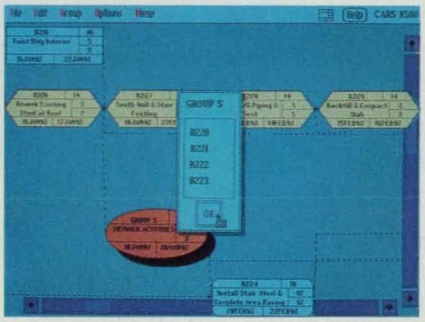
Primavera introduces some important new project management terminology.



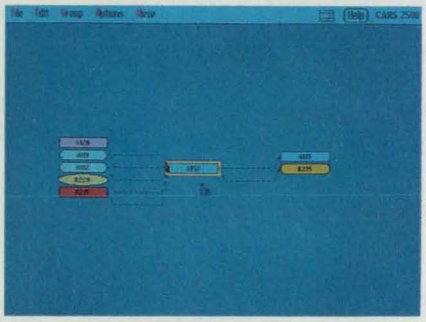
Click-Click—use double clicks to add activities, define relationships, and modify activity data.



Zoom — five levels of detail for your network, from bird's-eye to close-up.



Explode—The Collapse command compresses several activities into one; Explode redisplays activities in their original positions.



Pop — highlights all predecessor-successor relationships and lets you click your way along any activity path.

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.

Plus, you can output the schedule to your plotter or laser printer with a few quick keystrokes. This is *what-you-see-is-what-you-get* schedule building. No sweat, no strain.

Now, the world's best high-performance project management software is even easier to access. And it's available today, running under DOS in 640K.

Circle Reader Action No. 663

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

Please rush me my FREE video demo.

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ ST _____ ZIP _____
PHONE _____
NTB

kind's first step on the moon's surface, President Bush established a set of spacefaring goals for the 21st century America. "First, for the coming decade—for the 1990s—space station Freedom—our critical next step in all our space endeavors. And next—for the new century—back to the moon. Back to the future. And this time, back to stay."

And, as part of his challenging speech, the President called for "a journey into tomorrow—a journey to another planet—a manned mission to Mars."

Rhetoric does not a rocket make, however. The White House has since sought funding for what is now called the Space Exploration Initiative. Over $1 billion has been requested in the President's 1991 budget for this program, nearly $200 million of which is for new projects directly supporting a return to the moon and the exploration of Mars.

There are those who question placing a down payment on America's future in space. We at the National Space Society believe that such a down payment is crutial to the nation's technological leadership, key to rekindling the motivational energy of our youth, and necessary to build upon our space sprit de corps—earned after 30 years of spectacular achievement.

The Space Exploration Initiative has not caught Capitol Hill's imagination, yet. Has it caught yours? Tell us—and your elected representatives—why. With your help, we can truly reach for the stars...Ad Astra! ❑

For information on joining the National Space Society, call (202) 543-1900

How To Enter

The Rules:

Write a letter to the politician(s) of your choice, outlining your reasons for asking him or her to support the Space Exploration Initiative. Then send a copy of the letter, listing your age and daytime phone number, to:
Lori Garver
Executive Director
National Space Society
922 Pennsylvania Ave., SE
Washington, DC 20003

Deadline: August 15, 1990

Prizes:

Children's category (ages 16 and under): One grand prize winner will have the choice of a week-long stay at the United States Space Camp in either Huntsville, Alabama or in the Space Coast area of Florida. The winner must provide his or her own transportation.
Adults' category: One grand prize winner will attend the three-day adult session at the U.S. Space Camp in Huntsville. The second prize winner will attend a space shuttle launch at the Kennedy Space Center in Florida. This prize includes a guided tour of the launch area. (Prizes do not include transportation.) Five merit winners will each receive one NTB:BASE software category.

Where To Write:

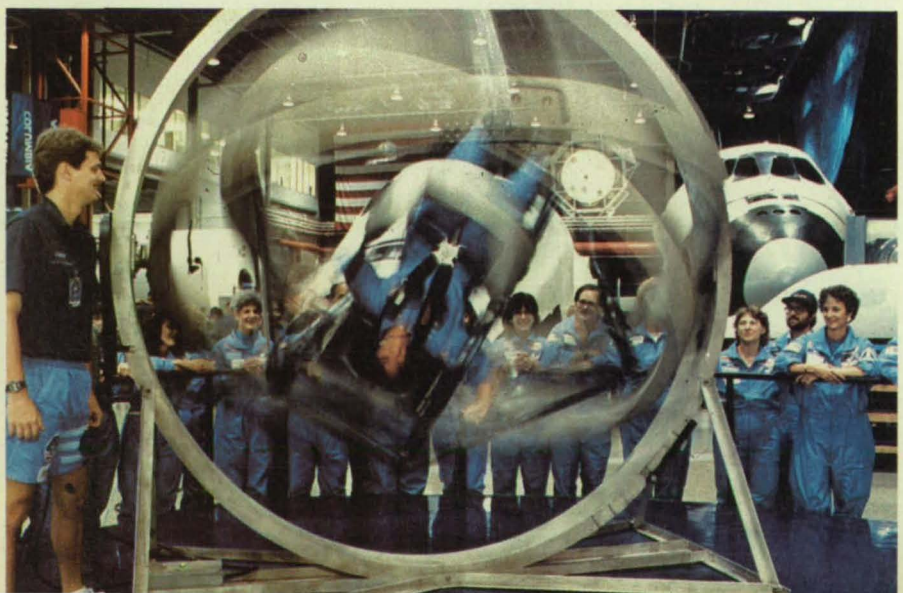
To United States senators:
United States Senate
Washington, DC 20510

To members of the House of Representatives:
U.S. House of Representatives
Washington, DC 20515

When addressing a congressman, the title "Honorable" should precede the name, as in the Honorable John Smith. For the letter's salutation, "Mr." or "Ms." is acceptable.

Remember: Send the original letter to the politician of your choice, and a copy to Lori Garver at the National Space Society.

Grand prize winners earn a free stay at the United States Space Camp, an educational camp that simulates an astronaut's training program. Photo courtesy U. S. Space Camp



THERE'S ONLY ONE THING TO SAY ABOUT INFORMATION SECURITY.

ORACLE

The term "state-of-the-art database security" can be written more concisely:

Oracle.

That's because Oracle's commitment to providing leading edge information security solutions to numerous federal agencies and military branches is well established and growing.

Already, Oracle's relational DBMS software provides high-level data integrity and security on everything from micros and minis to workstations and mainframes.

Add Oracle's reputation for exceptional quality, service and support and you'll arrive at a winning combination for high-security software.

To learn more about how Oracle can help you manage information with security and integrity, register for an Oracle seminar, or call **1-800-345-DBMS, ext. 6764** for a free brochure.

Incidentally, there's one more thing to say about information security: Authorized ADP Schedule Price List Contract No. GS00K 88 AGS 5937.

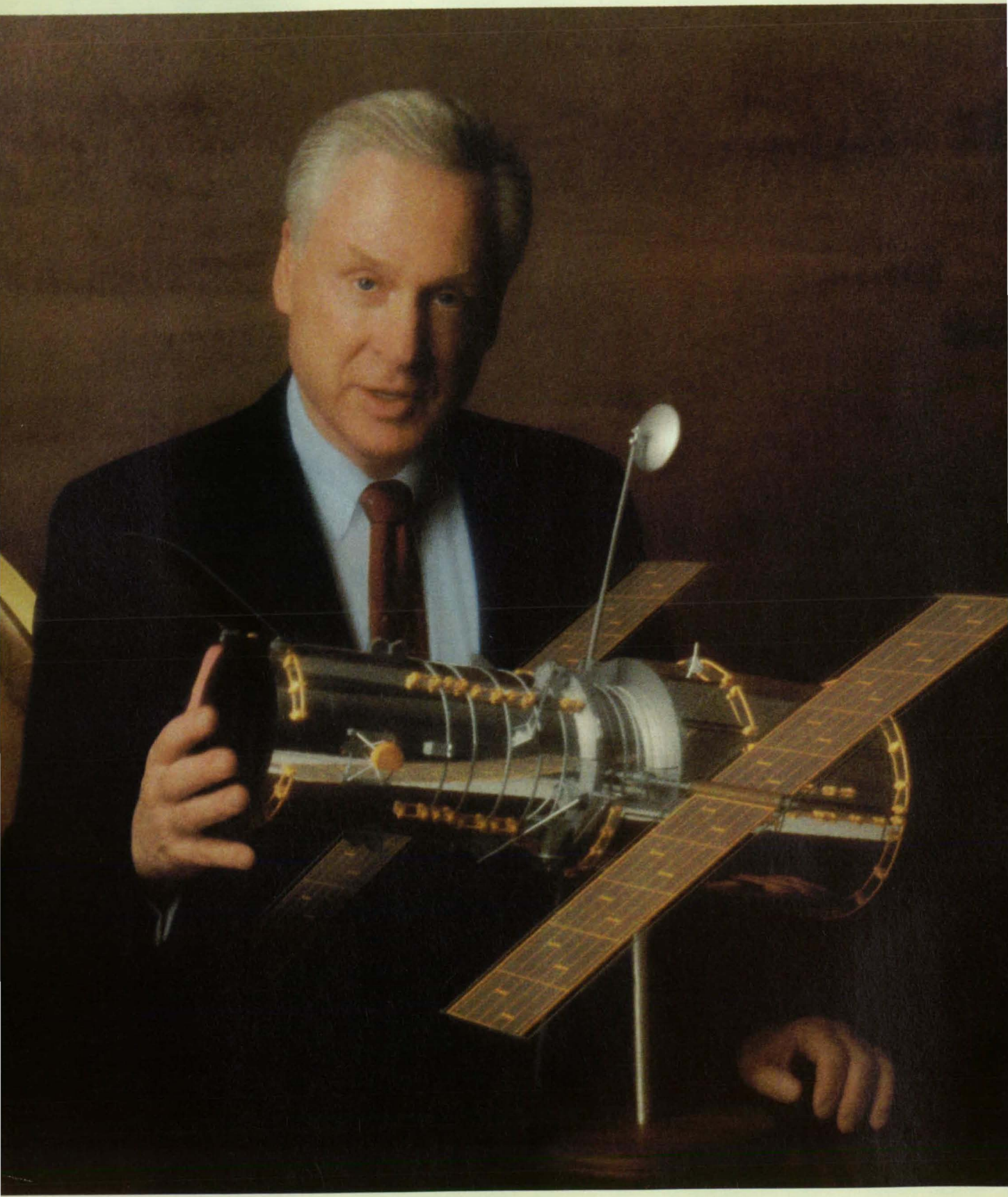
ORACLE®

FEDERAL DIVISION

Compatibility. Portability. Connectability. Capability.

Oracle Federal Division
3 Bethesda Metro Center, Suite 1400
Bethesda, MD 20814

Circle Reader Action No. 494



"We've had the vision to change the world. And now we're setting our sights on the universe."

Malcolm R. Currie
Chairman of the Board & CEO
Hughes Aircraft Company

Not since Columbus sailed to the edge of the world has discovery loomed so close on the horizon. But now, Hughes Aircraft Company has a telescope that's so far-reaching, it could help NASA change the course of history.

It's part of NASA's vision to explore the universe and the earth as no one has ever done before.

THE SPACE TELESCOPE

First up is the Hubble Space Telescope, the world's first complete space observatory. It is the greatest leap in astronomy since Galileo first gazed into a telescope in 1609.

No telescope has ever been this precise. Its eight-foot primary mirror is smooth to within a half-a-millionth of an inch. And its fine guidance system can lock onto a hummingbird 1500 miles away.

Both are part of Hubble's Optical Telescope Assembly, designed and developed by Hughes Danbury Optical Systems, formerly part of Perkin-Elmer and now a subsidiary of Hughes Aircraft Company.

Orbiting high above the earth's atmosphere, the Hubble Space Telescope will have a clear view of the universe. Seven times as far as the world's largest telescopes. 50 times as sensitive. And infinitely more revealing.

It could confirm the existence of planets in other solar systems. And it will hone in on stars so far away, we'll be looking 14 billion years into the past.

Near the beginning of time.

FUTURE MISSIONS

The Hubble Space Telescope, which will open the window to the universe, is the first of NASA's Great Observatory programs.

Soon NASA will also launch the Advanced X-ray Astrophysical Facility (AXAF). At the heart of this mission is an x-ray telescope system now being developed by Hughes Danbury Optical Systems. It will reveal light patterns in outer space that optical telescopes can't see. And it could help us uncover the secrets of "black holes," perhaps the key to understanding how the universe was formed.

We have also set our sights on something much closer to home. Our own planet.

In NASA's "Mission to Planet Earth," our technology will help scientists study the earth's environment from distant observation points, to find ways of making our precious planet a safer, healthier place. It is an extension of the LANDSAT program, in which we've been helping NASA map the earth's resources from satellites since 1972.

A SHARED VISION

We at Hughes are proud to be part of NASA's mission. And together, we'll bring to it the same commitment that has inspired many of our past joint achievements.

The Pioneer Venus Orbiter. The Jupiter-Galileo Probe. The Surveyor spacecraft that paved the way for man's first moon landing. And the more than 65 Hughes space instruments that have been so vital to earth observation and interplanetary exploration.

We'll also share the same inspired vision Columbus had 500 years ago.

Hughes. Exploring new worlds through technology.

HUGHES

Subsidiary of GM Hughes Electronics

Hughes' Currie with model of Hubble Space Telescope.

Circle Reader Action No. 349

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 25). NASA's patent-licensing program to encourage commercial development is described on page 25.

32-Bit-Wide Memory Tolerates Failures

An electronic memory system of 32-bit words corrects bit errors caused by some common types of failures — even the failure of an entire 4-bit-wide RAM chip. Furthermore, the system detects the failure of two such chips, so that the user can at least be warned that the memory output may contain errors.
(See page 38)

Crash-Resistant Shield

An impact-resistant shield has been designed to consist of an aluminum honeycomb structure sandwiched between inner and outer aluminum skins. The concept of the shield may be applicable to crashproof compartments for ground vehicles and aircraft.
(See page 71)

Fast, Capacious Disk Memory Device

A device for recording and playing back digital data from memory disks operates at high rate and utilizes the available recording area more fully than some older devices do. This arrangement can yield a data rate 95 percent of the ideal rate and utilize the recording area at 95.5 percent of the ideal utilization.
(See page 44)

Bar-Code System Tracks Test Equipment

A computer system uses bar codes to keep track of more than 2,200 items of test equipment. The users have found that they save on equipment purchases because they can allocate resources more efficiently and can recover missing equipment more quickly.
(See page 42)

Tough, Microcracking-Resistant, High-Temperature Polymer

Simultaneous synthesis from thermosetting and thermoplastic components yields a polyimide with outstanding properties. Tests have shown improved toughness at 368 J/m^2, resistance to microcracking at 0 microcracks/in., and glass transition temperature of 369 °C.
(See page 64)

Affinity Electrophoresis Using Ligands Attached to Polymers

Polymer molecules enhance electrophoretic separabilities. In the new technique, polyethylene glycol is added to the ligands. It is expected that other neutral, hydrophilic polymers like polyvinyl alcohol and copolymers of ethylene glycol and propylene glycol could also be used.
(See page 95)

Hawaii High Technology

Aloha:

To most people, Hawaii means a tropical paradise of white sands, palm trees, blue skies, and unlimited sunshine. To others, Hawaii also offers a unique opportunity for the development of high technology industry.

In astronomy and space, Hawaii offers the finest observatory site on the planet. A commercial spaceport is proposed for the island of Hawaii, which is ideally located for satellite launching.

Hawaii is a leader in natural energy research, with test and operational sites available for all alternate energy sources. Work is progressing, for example, on geothermal development and ocean thermal energy conversion.

Our mid-Pacific location and extensive Exclusive Economic Zone—along with outstanding faculty at the University of Hawaii—position Hawaii for leadership in ocean and marine science. The state's Deep Water Cable Project has positioned Hawaii and the United States as leaders in submarine power cable design and installation.

As you read this special section, you will learn about our centuries-old history in aquaculture, and about our local companies that have become leaders in biotechnology, information science, and electronics.

The High Technology Development Corporation is an agency of the state of Hawaii created to promote the growth of commercial high technology in the state. They stand ready to help you establish a high-tech business in Hawaii. Call the executive director, Bill Bass, at (808) 625-5293.

John Waihee
Governor of Hawaii

Hawaii: High Technology In Paradise

Photo courtesy Hawaii Natural Energy Institute

Harnessing the power of nature: Wind turbines on the Big Island of Hawaii

The very things that make Hawaii a favorite vacation destination—pollution-free, clear skies; tropical sunshine; balmy trade winds; and a mid-ocean location—also conspire to make Hawaii a leader in several major high technology areas. Renewable energy, for instance—no other U.S. location offers the opportunity to develop virtually every known renewable energy resource.

Or space exploration—Hawaii looks into space from what is universally agreed to be the finest observatory platform on the planet, the mountain of Mauna Kea on the Big Island of Hawaii. Among the telescopes in operation or under construction on Mauna Kea is the three-meter NASA infrared telescope, which is pioneering the use of infrared detector arrays that function much like a charge-coupled device (CCD) but are sensitive to infrared light.

The Big Island is also the proposed site for what could be America's first commercial satellite launch facility. As the southernmost point in the country, it offers the potential for both polar and equatorial launches.

As an island state, Hawaii has a long history of both marine research and aquaculture. The ancient Hawaiians invented aquaculture; they built ingenious fish ponds which were closed on all sides except for small openings to the sea. Young fish could enter through a grating of bamboo to feed on the rich nutrients in the pond. As the little fish ate, they grew too big to get back through the grate and out of the pond. Today Hawaii is a center of aquaculture development for the world.

Other high-tech developments seem to be happy accidents. In electronics, communications, and biotechnology, innovative companies were formed because the people who founded them happened to be in Hawaii. And they had a chance to succeed because the state has made a commitment to the support of high-tech industry as part of its goal of a diversified economy.

Renewable Energy

Since the 1973 oil crisis, Hawaii has encouraged the development of renewable energy alternatives aimed at energy self-sufficiency and has established several organizations to conduct research and foster the commercialization of renewable energy.

The Hawaii Natural Energy Institute is a child of the gas lines, created in 1974 at the University of Hawaii at Manoa, to "coordinate and undertake the development of non-polluting natural energy sources for Hawaii." Institute researchers calculate that Hawaii currently uses about 32 billion kilowatt hours equivalent of energy annually. In theory, any one of Hawaii's prime renewable energy resources—biomass, geothermal, ocean thermal energy conversion (OTEC), solar, or wind—could produce more than enough power to meet this demand. And the maximum combined potential from all renewable energy sources would yield almost fifteen times the current demand.

The Pacific International Center for High Technology Research (PICHTR) was established in 1983 to assist the state's High Technology Development Corporation in promoting educational, scientific, technological, and literary pursuits in the areas of high technology and to support Hawaii technology industry. PICHTR has become a major player—along with the Natural Energy Laboratory of Hawaii (NELH)—in the development of both open- and closed-cycle OTEC technology and is working to establish a model utility tied into natural energy sources on the island of Maui.

OTEC Research

In open-cycle OTEC, warm surface ocean water is brought into a vacuum chamber where it turns into steam to push a turbine. The steam is condensed by cold water pumped up from deep in the ocean. This maintains the vacuum and pressure on the turbine and also produces fresh water.

Closed-cycle OTEC uses warm surface water to evaporate ammonia, which expands and pushes the turbine, and is then condensed by cold, deep ocean water. In the late 1970s, the state conducted a mini-OTEC test project which showed a net gain in power after pumping the cold water up from two thousand feet below the surface. This provided conclusive proof of the concept, and could have led to commercialization of OTEC, had the price of oil not collapsed. Throughout the 1980s, NELH conducted experiments on bio-fouling of the plumbing that would handle the sea water. One of the high-expense items of OTEC in past analyses has been the heat exchanger, which had been made of titanium to prevent corrosion. A much less expensive alloy of aluminum that is resistant to sea water corrosion has been developed by the Argonne National Laboratory and tested at NELH, lowering the overall cost projections for successful OTEC operation.

PICHTR, with grants from the U.S. Department of Energy and the state of Hawaii, along with private and international financial support, will build a net-power-producing, closed-cycle plant. It is expected that by 1992 the world's first land-based OTEC plant will be producing electricity.

Geothermal Energy

Geothermal power is not a new idea—the Italians built the first commercially successful geothermal plant at Lardarello, Italy, in 1904. The Big Island, with two active volcanoes, is a prime geothermal location. The state had a demonstration plant producing about three megawatts of power on the Big Island from 1981 to 1989. Hawaiian Electric Company issued a request for proposals in May 1989 for development of geothermal power on the Big Island and delivery of the power generated to the island of Oahu, which contains 80 percent of the state's population. Five consortia responded and negotiations are under way with a group headed by Mission Power of Southern California and Bechtel.

Plants will be constructed in modules of 25 to 50 megawatts, adding up to a nominal 500 megawatts. To carry the power 300 miles from the Big Island to Oahu, an innovative deep water power cable is required. Research on the Hawaii Deep Water Cable Project ended with successful sea trials which laid a model cable early this year.

The Maui Model

Maui Electric Company was chosen to develop a model solar power project under the umbrella of a nationwide program, Photovoltaics for Utility Scale Applications (PVUSA), in which government and industry are working together to generate electricity cost-effectively using solar energy. The $500 thousand test system will produce 20 kilowatts of electricity.

Maui Electric is also the front-runner in a project headed by the Department of Energy to create a model Pacific utility, tying in several renewable energy sources. Maui Electric now has solar, wind, biomass, and hydroelectric power coming into its grid—in addition to power generated by fossil fuel—and looks to geothermal power for the future. The company is now interconnecting its neighboring islands of Lanai and Molokai. Therefore it can serve as a model power company for any Pacific island.

Basic Energy Sources

In Hawaii the trade winds blow almost continuously. On one hill on the Big Island alone, one can count 297 wind turbines at work. The problems with wind power under study by the Hawaii Natural Energy Institute and Hawaii's power companies are: almost constant variation in output due to fluctuations in the wind force; energy storage; and interface with the utility grid. One proposal would use excess wind power to pump water from the wet side of the island to a reservoir in the mountains, from which it could be released on the dry side to drive a hydroelectric plant and at the same time provide water for irrigation.

Hawaii's sugar mills burn the sugar cane plants, after the sugar has been extracted, to generate power to run the mills. Biomass from wood chips and other sources is also used for power generation. Excess power is sold to utility companies.

Electricity, however, accounts for only about 30 percent of the state's energy needs.

The Other Maui

The Maui Research & Technology Park is a new development on the island of Maui which boasts the fastest economic growth in Hawaii. The Park is an ideal location for high-technology enterprises and supporting activities such as research and development, office and business, manufacturing and warehousing, and other uses consistent with its general plan. A special Maui County R & T Park ordinance has streamlined the permit process to facilitate development, and the Park's design guidelines will ensure the integrity of long-term investment.

Within the Park, a state of Hawaii-sponsored Research & Technology Center will provide incubator space for emerging technology-based businesses and a phase-in center for established companies considering a location in the Park. It will also contain centers for video and telecommunications, business support, and University of Hawaii-related activities.

Maui's special geographic position makes it an advantageous location for firms doing business in the Asian/Pacific sphere — exchanges between the East Coast and the Far East are possible on the same business day; frequent non-stop flights are available from Hawaii to most major domestic and Pacific Rim cities; and satellite and fiber optics cable allow excellent communication worldwide. In addition, the state provides monetary incentives that include low interest loans and tax advantages.

Excellent ocean and mountain views are available, and all sites offer open space, privacy and security in a controlled environment. Located on 330 acres of former ranch land, the R & T Park is buffered from the highway by an 18-hole golf course. Fee simple sites in the first 60-acre phase are now available for sale.

For more information, contact

MAUI RESEARCH & TECHNOLOGY PARK

P.O. Box 187, Kahului, Hawaii 96732

Phone: (808) 871-9483 Fax: (808) 871-6366

Circle Reader Action No. 512

Far more energy is needed to fuel ships, aircraft, and surface vehicles. The Hawaii Natural Energy Institute and PICHTR are exploring ways in which methanol could be used to replace fossil fuel. This requires not only technical ability to create methanol from biomass, but also a parallel or alternative infrastructure which will provide methanol as a fuel, along with engines equipped to burn it.

Hydrogen may well be the fuel of choice in the 21st century. And Hawaii is the site of World Hydrogen Energy Conference Number Eight, in July, reflecting the state's preeminence in natural energy research.

Ocean Science and Marine Research

International law now recognizes a 200 mile zone—the Exclusive Economic Zone (EEZ)—within which coastal nations have sovereign and exclusive rights over living and nonliving resources. For Hawaii, the increase was dramatic. With the 200 mile zone extending around the entire archipelago from the Big Island to Kure Atoll, Hawaii jumped from 47th to second among states (behind Alaska) in combined land and sea area.

Several sites on the ocean floor appear to be rich in manganese crusts, from which the strategic metal cobalt can be extracted. There is potential for an undersea mining operation and a processing operation to extract the cobalt. Most estimates place this fifteen to twenty years away.

A growing area of research and development is the production of pharmaceutical products from the sea, which promises economic benefits from EEZ resources.

Hawaii is assuming a leadership position in ocean science and marine research. With one of the most extensive and accessible EEZs, Hawaii has the potential to become America's R&D center for EEZ use.

Deep Water Cable

An example is the Hawaii Deep Water Cable Project, designed to test the feasibility of carrying 500 megawatts of geothermal power from the island of Hawaii to Oahu. Most of the previous research on deep water cables remains the proprietary information of private companies outside the United States. The Deep Water Cable Project advances American scientific knowledge in this field to the cutting edge of current research activity. "The federal government doesn't care so much about geothermal energy in Hawaii," stated William A. Bonnet, director, engineering research, for Hawaiian Electric. "They've funded this research to pick up technology which can be used by American industry in the United States and elsewhere."

And there is real international interest. Boston Edison, for instance, wants to bring up to 1200 megawatts of power from a coal-fired generator in Nova Scotia, 250 miles away by sea. Further, the Iceland Power Company would like to export power to the United Kingdom via a 600 mile cable from Iceland to Scotland at a maximum depth of 3000 feet.

Makai Ocean Engineering, a Hawaii firm conducting research and development of ocean systems, created a real-time model for laying the cable at a precise tension in a specific location. At a depth of 4000 feet, technicians will have to install three cables which don't overlap within a width of 260 feet at a radius of curvature of four-tenths of a mile. In the at-sea test, the model cable had to be laid at the narrowest point within plus or minus ten meters of its intended path. The actual placement of the cable was plus or minus three meters.

Photo courtesy Seafloor Surveys Intl.

Computers turn sonar data into charts of the ocean floor.

"As a result of this project, nobody in the world knows more about designing and installing submarine power cables than the participants in this program," Bonnet said. "This is public information. But the expertise—the experience of having been through the process—is here in Hawaii."

Charting The Ocean Floor

Seafloor Surveys International is a Hawaii company whose specialty is charting the ocean floor. The company's clients include telecommunications giants such as AT&T, who is stringing fiber optic cable along the bottoms of the world's oceans. By creating precise charts of the ocean floor, Seafloor Surveys is able to recommend optimum routes for the cables. This makes life easier for the deployment crews and avoids the hazardous areas where accidents and cable losses can occur.

Seafloor's technology is based on side-scanning sonar and a proprietary computer program which turns the sonar data into a useful chart of the ocean bottom. For the scientists and engineers who study the maps, it is almost as though the ocean has been poured off, leaving only dry land. On one survey operation near Hawaii, the sonar encountered a puzzling formation which turned out to be the wreck of a B-24 bomber that disappeared during World War II.

A year ago the company built a survey system for a research vessel operated by the University of Tokyo and the Japanese Ministry of Education. Currently, the company is engaged in what chief engineer Grant Blackinton calls "one of the largest survey jobs ever done. Offshore Telecommunications Company of Australia has hired us to survey the route for a cable from Hawaii to New Zealand and from Australia to Guam."

SWATH Vessel

Navatek I, the pioneering high-technology SWATH (Small Waterplane Area Twin Hull) ship, is an example of "home-grown" technology. The patented design was invented by Professor Ludwig H. Seidl, chairman of the Department of Ocean Engineering at the University of Hawaii at Manoa. The principal components of a SWATH ship are two submerged lower hulls of varying cross section connected to upper hulls (sponsons) by four struts which pierce the water surface and connect to a platform riding above the water. The vessel is totally supported by buoyancy from those fully submerged hulls, rather than by hydrodynamic lift as with a hydrofoil or planing craft. The design is said to virtually eliminate seasickness and crew fatigue, offer more usable deck space, and permit the ship to maintain speed and direction in rough seas. Immediate application is as a passenger carrier. Navatek I has been chartered for use in the tourist industry, running whale-watching tours, charters, and dinner cruises.

Navatek I represents an exclusively private-sector investment of $4.5 million over twelve years by Hawaii-owned Pacific Marine. The company's subsidiary, Honolulu Shipyard, Inc., is exploring the economics and manpower requirements for fabricating SWATH subassemblies in Hawaii and perhaps even building complete SWATH vessels of a smaller size. Pacific Marine's R&D affiliate, PAMESCO, already designs SWATH ships in Honolulu, employing computer specialists, marine engineers, and design draftsmen.

Astronomy and Space

There is no better place on the surface of the Earth from which to look out into space than the 13,000 foot summit of Mauna Kea on the Big Island of Hawaii. According to Bob Joseph, director of the NASA Infrared Telescope Facility, "Images are really sharp from the top of Mauna Kea. Infrared light doesn't get through the atmosphere easily, but there are some windows. The higher and drier you are the better. Mauna Kea is high and dry."

Close behind is the 10,000 foot summit of Haleakala crater on Maui, home of the Mees Solar Observatory. The remarkable clarity, dryness, and stillness of the air above these isolated high-altitude sites has resulted in the state of Hawaii becoming, over the last 20 years, the most sought-after location in the world for the construction of large ground-based telescopes.

Six telescope facilities are in place on Mauna Kea. A seventh, the W. M. Keck Observatory, which will house the largest telescope in the world, is under construction.

Other projects under discussion or in the planning stages for Mauna Kea include the 7.5-meter Japanese Large National Telescope, an 8-meter National Optical Astronomy Observatory telescope, and antenna of the Very Long Baseline Array (VLBA) radio telescope.

The House of the Sun

Haleakala, which means "House of the Sun" in Hawaiian, is the site of the Mees Solar Observatory, which has a wide range of instruments for study of the sun and its corona. Haleakala is also the site of the Lunar Ranging Observatory of the University of Hawaii, which uses a Neodymium YAG laser to reflect pulses from the moon and from Earth satellites, yielding essential data for the study of continental drift, polar motion, and the determination of Universal Time. These observations are also relevant for studies of general relativity and the possible time dependence of the gravitational constant.

Satellite Spotting at Science City

The Maui Satellite Tracking Site (MSTS), located at Science City at the summit of Hal-

eakala, operates several space-related programs. MOTIF (Maui Optical Tracking and Identification Facility) consists of twin 1.2 meter telescopes mounted on opposite sides of a single polar or right ascension axis, and attached to a common declination axis, so that they move precisely in unison. MOTIF operates every night, tracking satellites.

AMOS (Air Force Maui Optical Station) is dedicated to furthering research and development efforts in electro-optics. Using AMOS, Avco Research Laboratory (ARL) -TEXTRON, which manages the facility for the Air Force, has helped more than 20 government agencies and several universities run experiments. "We've worked with Jet Propulsion Laboratory, MIT/Lincoln Labs, and many others," said Tom Reed, managing director of ARL-TEXTRON. "We have tested cameras for the University of California (Berkeley) and the University of Arizona. And we have recently been doing polarization measurements over the open ocean for the Navy."

GEODSS (Ground-Based Electro-Optical Deep Space Surveillance), operated by Emhart Planning Research Corporation, is the backbone of Space Command's Electro-Optical Sensor Systems, and dovetails nicely with MOTIF, while its method of operation is unique. The GEODSS system consists of three telescopes—two primaries and one auxiliary—that are smaller than either the MOTIF or AMOS telescopes.

According to Major Richard Kelly, MSTS site commander, "Ground-Based Electro-Optical Deep Space Surveillance, as its name implies, is primarily used for tracking objects in deep space or beyond 3000 miles. Due to constraints in the design, we physically cannot get a good track on anything closer." Unlike the other systems which lock onto particular objects and follow them as they pass overhead, GEODSS synchronizes its movement with the stars. "With GEODSS we can track an object the size of a grapefruit up to 20,000 miles out in space," said Kelly.

As the telescope slowly moves with the rotation of the Earth, the low-light-level TV cameras connected to GEODSS take a series of pictures which are overlaid and fed into a computer. The computer then erases the fixed star images, leaving visible only the trace of any non-fixed or orbiting object. Over a period of time these moving space objects produce a streak across the display screen which can be analyzed for position in orbits from 3000 to 22,000 miles. GEODSS tracks an average of 300 space objects a night, and with its close tolerances, there isn't much that escapes its notice.

Spaceport Project

Hawaii has been a part of America's space effort since the days of the Mercury Program. The Kokee tracking station on Kauai has been an integral part of manned space flight.

With one foot already on the stairway to the stars, Hawaii took another step toward space last year when Governor John D. Waihee named Admiral Thomas B. Hayward, retired U.S. Chief of Naval Operations, to serve as chairman of the Hawaii Space Development Authority and to be his special advisor on space.

State officials and consultants have been developing plans to build the world's first commercial launch center in Hawaii. If all goes well, by 1992—the International Space Year—ground will be broken for a commercial launch facility for unmanned, small to mid-sized rockets in the Ka'u region of the Big Island. This would take advantage of Hawaii's unique geography. Hawaii is nearer the equator than any other place in the U.S., allowing rocket launches to take advantage of the Earth's spin. And it is the only site in the U.S. where rockets can be launched into either an equatorial or a polar orbit without overflying populated areas.

Two possible sites have been identified for the spaceport—Palima Point and Kahilipali Point on the Big Island— and draft environmental impact statements for each are expected this summer.

The commercial launch facility would handle expendable launch vehicles (ELVs), including those similar in scale to the Scout and Delta II vehicles, and up to the commercial Titan III vehicle. Sub-orbital sounding rockets also could be launched.

Following release of the draft environmental impact statements, Hawaii will still have much to accomplish. The site must be acquired. Funding—in the form or one or more partners, probably international in scope, quite likely from Japan—must be achieved. And a launch facility must be built. But if all goes well, "an MLV could be launched from Hawaii in late '93 or early '94," Admiral Hayward said.

Information/Electronics

Hawaii designs and manufactures goods and services for telecommunications and electronics, and sells the products all over the world. With its mid-Pacific location, Hawaii is the hub for telecommunication flowing from the U.S. mainland to Asia and the Pacific.

"We have established Hawaii as a high-speed digital communications hub—both fiber and digital satellite," states Bill Martin of AT&T. "This means for businesses in Hawaii, service to the Pacific Rim is direct and less costly. Any place that AT&T goes by gateway is available from Hawaii."

A major long distance carrier, Long Distance USA (which has since merged with Sprint), got its start in Hawaii. SoftStyle, a computer software company which designed and published drivers for many major computer peripherals, began in Hawaii, and is now a part of Phoenix Technologies. On the consumer side, Hawaii took to automatic teller machines with a passion, while the mainland was still wondering if they weren't just a passing fad. And the island of Kauai became the first rural service area in the U.S. for cellular telephone service, when GTE Mobilnet began service there in August 1989.

Intelect Anniversary

Intelect, Inc., an international supplier of voice and data communications equipment for government and military systems, recently celebrated its 25th anniversary by moving into its new, 30,000 square foot facility at the Mililani Technology Park and announcing its entry into the commercial telecommunications market with its new Black Panther line of equipment.

The new product line begins with a digital voice-data switching platform from which Intelect plans to derive a family of advanced telecommunications products. The Black Panther is a digital multiple parallel bus system using pulse code modulation (PCM) time division switching. Two platforms using the same architecture will be available—one serving 32 to 1024 ports and the other 32 to 2048 ports.

Two key points differentiate the Black Panther from conventional PABXs and key systems: Each port card has its own microprocessor and memory, and each port has its own time slot. According to the company, "EPABXs are designed without a full complement of time slots for the absolute lowest manufacturing cost per port. EPABXs also can't afford the distributed processing that gives Intelect's Black Panther its full conferencing capacity and ease of adaptation to special consumer needs. The Black Panther line is aimed at a market that needs non-blocking, full availability traffic capacity."

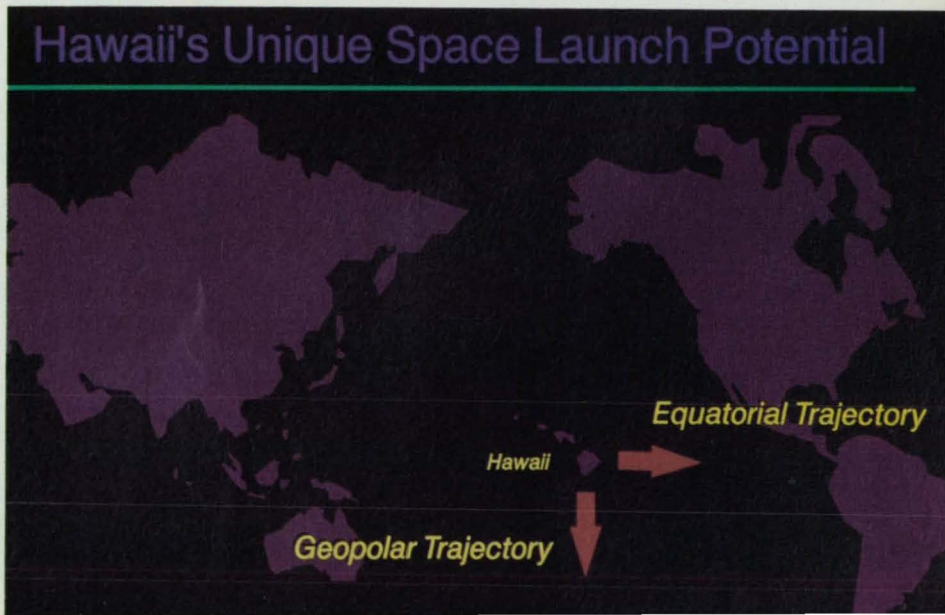
Automation Leader

VeriFone, Inc. was founded in Hawaii in 1981 by Bill Melton to develop, manufacture, market, and support transaction terminals and microcomputer systems. In eight years the company has become the international leader in the transaction automation business with 500 employees worldwide and offices throughout the U.S., Europe, the Far East, and Australia.

The company began in the new field of credit verification terminals, which check credit cards quickly and automatically. This

Hawaii offers the opportunity for both polar and equatorial launches of spacecraft.

Photo courtesy Hawaii Space Development Authority



replaced the lengthy process by which the clerk had to place a phone call, wait while the records were checked, and receive a verification number. Hard work and aggressive sales have given the company a majority of the market. "Since 1982, revenues have grown at 110 percent a year—compounded annually," according to Hatim A. Tyabji, president and CEO. The company shipped its one millionth system in September.

A critical factor in VeriFone's rapid growth has been the backing it received from Bank of Hawaii. According to Robert Paris, senior vice president and senior lending officer of the bank, "We took some risk because we saw some potential there. This goes all the way back to when they were waiting for their first venture capital. We gave them a $7 million line of credit when they were waiting for $5 million."

According to Paris, the most important thing was that VeriFone's management grew to keep pace with the company's expansion. "Too often people try to take their company too big too fast and they crash and burn. Melton took it to the point where it was starting to get too big for his expertise, and he went beyond Hawaii to recruit the people he needed. He found a financial person who had taken other companies public. And he got the right venture capital group."

Soft Warehouse

Founded in 1979 by Albert D. Rich, an applied logician, and David R. Stoutemyer, a university engineering professor, Soft Warehouse, Inc., has found its niche with two software products for use on IBM PCs and compatibles. muLISP-87 is a high-performance LISP language pseudo-code compiler, interpreter, and programming environment for the development of artificial intelligence software. Derive, A Mathematical Assistant, is a menu-driven symbolic math system which intelligently applies the rules of algebra, trigonometry, calculus, and matrix algebra to solve a wide variety of mathematical problems.

"Derive lets you do symbolic math on a PC," said co-founder Rich. "It's taking the education world by storm. It's the way math is going to be taught in the next ten years."

Other software developers in Hawaii include Data House, Boeing Computer, SAIC, and Martin Marietta.

Biotechnology

In the Manoa Valley, the Natural Products Laboratory of the University of Hawaii is the sole national source of a blue-green marine algae strain which is being used in research on cures for cancer, AIDS, herpes, and several viruses. The laboratory provides cultures from 1000 blue-green algae to the National Cancer Institute (NCI), which screens them for anti-cancer activity against various human cancer cell lines. NCI is looking for activity which is selective: Activity in marine algae that will just kill breast cancer cells or colon cancer cells.

Since 1983, Hawaii Biotechnology Group, Inc., a genetic engineering company in Aiea, has received $2,311,697 in federal Small Business Innovative Research (SBIR) awards —71 percent of the total won by Hawaii companies. Hawaii Biotech's research includes development of a flightless female medfly which could provide a genetic answer to the fruit fly problem, and work on a vaccine against dengue fever. Among its other efforts is a long-term project looking at a potential cancer cure derived from Palythoa toxica, a seaweed called in Hawaiian limu-make-o-Hana or "the deadly seaweed of Hana."

Another company, Moana Bioproducts, has developed an antibody for detecting ciguaterra, a poisonous substance that contaminates fish and shellfish in coral reefs. Funded in part by $45,000 in state and federal SBIR grants, the ciguaterra immunotoxin can be used by fishermen to do on-site testing. It changes the pigment of a fish's flesh from colorless to blue when the ciguaterra is present.

Valuable Waste

Universal Synergetics, Inc. (Unisyn Hawaii) takes waste material that nobody wants and turns it into something of value. The waste material is processed in an anaerobic digester, producing a biogas that is mostly methane and carbon dioxide. The methane is used as fuel to generate electricity. The carbon dioxide can be routed to an algae pond where Unisyn grows spirulina, which is then processed, freeze-dried, and sold in more than 350 health food stores on the mainland. Or CO_2 can be piped to Unisyn's three-and-a-half acre greenhouse to encourage plant growth. What remains in the digester is a single-cell protein which can be processed as either a feed for farm animals and aquaculture, or as an organic fertilizer.

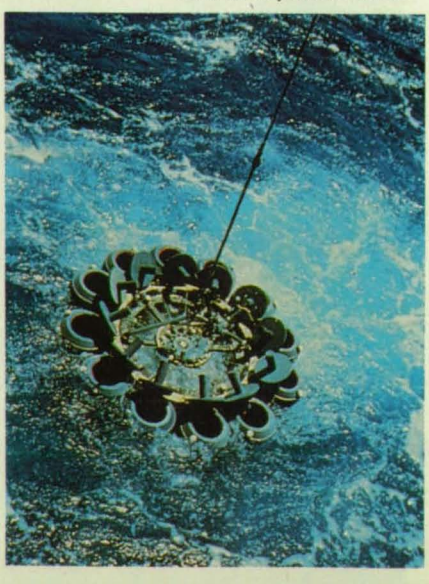
In its current configuration, the Unisyn system starts with manure, but James D. McElvaney, vice president, biotechnology and development, points out that "this shouldn't be thought of as a manure process. We want to look at every kind of waste treatment."

In February, Unisyn's proprietary process was licensed by Ecotechniek bv, a pollution abatement firm located in Utrecht, the Netherlands, for use in the Netherlands, Austria, Belgium, Denmark, Luxembourg, Switzerland, and West Germany. Unisyn will receive a licensing fee for the technology and assistance associated with Ecotechniek's first plant, a $50 million manure processing plant near Dordrecht, scheduled for completion in 1991.

"The Unisyn system gets rid of unwanted waste and produces products which otherwise would have to be imported," McElvaney said. "The integration of processes results in higher quality products at lower cost. For example, because we were producing our own electricity on site, we were able to consider freeze-drying our spirulina. Once we did that, we saw that there were quality advantages. We use no heat to dry the spirulina so there is no damage to pigment and no damage to the beta carotene. But if we hadn't had our own electricity, we probably wouldn't have tried it."

Instrumentation used in eddy study

Photo courtesy Oceanic Institute



Aquaculture

For nearly 30 years the Oceanic Institute, located just around Makapuu Point on the Windward side of Oahu, has been conducting research to increase the yield of food from the sea. For the most part, that means developing the techniques of intensive aquaculture.

Recently, the institute has had success in using hormones to get two popular food fish, mullet and milkfish, to spawn and grow to maturity in a high-density aquaculture environment. Other work has gone into improving shrimp culture, and restocking the Hawaii fishery with mullet to the benefit of Hawaii's sports fishermen. And the institute has aquaculture programs running internationally from Egypt to Indonesia.

Amorient Aquafarm, Inc., has been active in commercial aquaculture in Hawaii since 1977, raising prawns, shrimp, and some specialized food fish at a facility in Kahuku near the North Shore of Oahu. "We are really the only long-term operating shrimp farm out here," stated vice president and general manager Lyndon Burzell. "The others have come and gone."

Burzell sees the market for his products as both special and limited. "We got in thinking the market was better than it was. The only reason we can make it is that we have an isolated market with no natural supply. People are willing to pay a premium for fresh shrimp rather than frozen shrimp—for instance for sushi.

"The majority of the science is in the hatching and reproductive phases," Burzell said. Amorient gets about two-and-a-half crops of shrimp a year. "We had to manipulate the hormone level in the adults and trick them into thinking it was spring. In the wild, shrimp produce a huge number of offspring with a miniscule survival rate. Once you crack the problem, you have a superabundance of shrimp. With 250 males and 250 females we get 5-7 million babies per month."

Using OTEC Water

OTEC research led to the investigation of other ways to use cold, deep ocean water once it had been brought to the surface. Tanks, ponds, and pipes cover the NELH landscape, bringing the water to a series of experimental and commercial applications in natural energy, aquaculture, pharmacology, and agriculture.

Pumped up from 2200 feet, the water is about 9°C and not only nutrient-rich but relatively pathogen-free. Projects operating at NELH include an abalone farm, a company growing microalgae for health food, a company growing Maine lobsters, a project to grow opihi, and several aquaculture projects raising food fish, including salmon and trout.

Aquaculture Enterprises, for example, uses cold NELH water to test and demonstrate the technology of growing the lobsters. "You have to have cold water, because you can't raise lobsters in the tropics," Wilson said. Equally important, "the deep water is clean. Most places along the Continental United

States, the water is polluted." Raising the lobsters in this way has decreased the time it takes for a lobster to mature from seven years in nature to about two-and-a-half years under aquaculture conditions.

Ocean Farms

Ocean Farms Hawaii has had so much success in aquaculture using Keahole Point water that it has built three more ponds and installed four eighteen inch pipes to bring up the water from below 2000 feet. Early on, Ocean Farms found that both the abalone and the kelp to feed them grow more quickly and safely in Keahole water than in the natural conditions of the ocean off California. They also have about three million salmon and ten million oysters. "The combination of salmon and kelp is important," said company president George Lockwood. "The kelp absorbs the waste products of the salmon and produces a high level of oxygen, which the salmon need. And the oysters eat microalgae diatoms which otherwise would shade the kelp and retard growth."

Ocean Farms Hawaii expects to send to market this year 500,000 pounds of salmon, a million oysters, and 300,000 pounds of abalone.

State Resources

The state of Hawaii has placed substantial resources at the service of high-tech business in Hawaii.

High Technology Development Corporation

The HTDC is an independent corporation funded by the state to encourage, promote, and support the development of high technology industry in Hawaii. HTDC is responsible for development of major technology parks and incubator services. These include:

•The Kaimuki Technology Enterprise Center (KAITEC) for high-tech start-up companies;

•The 547-acre Hawaii Ocean Science and Technology (HOST) Park at Keahole Point on the Big Island, for companies with a use for Keahole's cold, nutrient-rich sea water;

•The 300-acre Maui Research and Technology Park at Kihei, planned for construction;

•The Manoa Innovation Center, now under construction, which will include the headquarters for the Pacific International Center for High Technology Research, the Research Corporation of the University of Hawaii, and the University's Office of Technology Transfer and Economic Development, and will provide incubation space for up to 50 high-tech start-up companies.

•A software service center.

HTDC administers the state's supplementary SBIR grants, and, assuming that the State High Tech Strategic Fund is passed by the state legislature, it will administer a fund of over $6 million to encourage high-tech business. It operates a resume summary service to match up technical graduates now on the mainland who would like to return to Hawaii with Hawaii companies looking for talent. And it publishes the Hawaii High Technology Business Directory.

For information about relocating a high-tech business to Hawaii, or starting one in the state, contact:

William M. Bass, Executive Director
High Technology Development Corp.,
Mililani Technology Park,
Leilehua Building, Suite 35,
Mililani, Hawaii 96789.
Telephone (808) 625-5293
FAX: (808) 625-6363

Other Technology Parks

Mililani Technology Park on Oahu is the home of Intelect, Inc., VeriFone, Inc., the HTDC, and several other Hawaii high-tech businesses. For information contact:

Mililani Technology Park
650 Iwilei Road, Third Floor
P.O. Box 2780
Honolulu, HI 96803
Telephone (808) 548-4885
FAX (808) 548-6690

Kapolei Business and Industrial Park is planned for Oahu's "second city," Kapolei, to be constructed west of Honolulu. This represents the next major growth area on Hawaii's most populated island.

Situated on 800 acres, the park will be developed for light industrial and maritime-related use. It is adjacent to Barbers Point Harbor and the existing James Campbell Industrial Park, both of which are extensions of Foreign Trade Zone Number Nine. Nearby is the 1000-acre resort of Ko Olina, under construction, which will feature 4000 hotel rooms, 5200 residences, a 400 slip marina, and an 18-hole golf course. More than 40,000 residential units are slated to be built in the Kapolei area in the next ten years.

For information contact:
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, HI 96813 ❑

Discover High Tech Hawaii

Sure—
We're beautiful and a lot of fun. . .

But did you also know we're hardworking and supportive?

From its headquarters in the Leilehua Building in Oahu's Mililani Technology Park, the High Technology Development Corporation (HTDC) directs a vigorous state support program for high technology businesses. This includes: Hawaii's largest high tech park, facilities for research and commercial production, incubation services, a software service center, SBIR grants, and much more.

The State of Hawaii is serious about high tech industry. We lead the world in astronomy research and alternate energy applications, and in many phases of electronics design and support software development, ocean science, telecommunications and information, and biotechnology. And we're not just sitting on our scenery—we're installing the infrastructure for true high tech support:

KAIMUKI TECHNOLOGY ENTERPRISE CENTER is Hawaii's original incubator facility, managed by HTDC. The first eight companies resident at KAITEC showed revenue growth of 600 percent from 1988 to 1989.

MANOA INNOVATION CENTER stresses synergy with office space for fifty companies in the secondary stage of development alongside the Pacific International Center for High Technology Research, the Research Corporation of the University of Hawaii, and the University's Office of Technology Transfer and Economic Development. Ground breaking is scheduled for April of 1990 with occupancy anticipated a year later.

MAUI RESEARCH AND TECHNOLOGY CENTER will be a multi-use facility with space for University of Hawaii Research, an incubator facility for high tech companies, and a telecommunications center located at Maui Research and Technology Park.

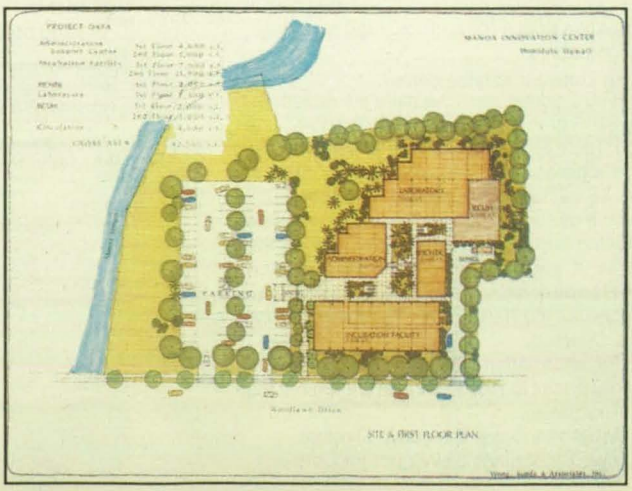
HAWAII OCEAN SCIENCE AND TECHNOLOGY (HOST) PARK located at Keahole Point on the Big Island of Hawaii offers 547 oceanfront acres with long-term leases for the commercial application and development of ocean science and technology.

For more information contact
William M. Bass,
Executive Director

High Technology Development Corporation
Leilehua Building
300 Kahelu Avenue, Suite 35
Mililani, Hawaii 96789

(808) 625-5293
Fax (808) 625-6363

Circle Reader Action No. 371



Manoa Innovation Center

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 Deel, Director
(405) 924-5094

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

NASA/Southern Technology Applications Center
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

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. *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 (acting)
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5568
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: Robert M. Barlow
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: Gordon S. Chapman
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
Patent Counsel: Paul F. McCaul
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
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
(202) 453-8377
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

Electronic Components and Circuits

Hardware, Techniques, and Processes

Nitric Oxide Enhances Charge-Coupled Device

The illuminated back surface is treated to raise the quantum efficiency.

NASA's Jet Propulsion Laboratory, Pasadena, California

A simple treatment increases and stabilizes the quantum efficiency of a charge-coupled-device photodetector illuminated on its back surface at wavelengths less than 4,500 Å. To obtain a high and stable quantum efficiency, the device must be biased in a strong accumulation mode. This, in turn, requires a high electric field at the back surface to repel photogenerated electrons and to direct those electrons toward potential wells on the front surface. The physical principle of the enhancement is explained more fully in "Metal Film Increases CCD Output" (NPO-16815), *NASA Tech Briefs*, Vol. 13, No. 4, page 24.

In the new treatment, the back side of a positively-doped silicon charged-coupled device is exposed to an atmosphere of nitric oxide, which is strongly electronegative and bonds strongly to the surface. The nitric oxide adsorbed by the device forms a negative charge on the back surface. This charge repels electrons toward the front, as required. Devices thus treated would be useful for imaging at wavelengths from ultraviolet to blue; for example, in astronomical observations.

This work was done by Michael H. Hecht of Caltech and Edward H. Poindexter of the U.S. Army Electronics Technology and Device Laboratory for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 101 on the TSP Request Card.*
NPO-17281

Iridium Film for Charge-Coupled Device

Usability is extended to different environments.

NASA's Jet Propulsion Laboratory, Pasadena, California

The application of a thin film of iridium to the back surface of a back-surface-illuminated charge-coupled device is expected to increase and stabilize the quantum efficiency of the device at wavelengths less than 4,500 Å. Like the surface layer of nitric oxide described in the preceding article, the iridium film would enhance the quantum efficiency according to the principle discussed in "Metal Film Increases CCD Output" (NPO-16815), *NASA Tech Briefs*, Vol. 13, No. 4, page 24.

The iridium would be deposited on a layer of silicon dioxide 30 Å thick on the back surface of the silicon charge-coupled device. Because iridium has a work function in the required range, this structure should constitute a metal/insulator/semiconductor Schottky barrier, which would repel photogenerated electrons to the front surface, thus assuring high quantum efficiency.

The device described in the referenced article is similar, except that its film is gold, nickel, or platinum. However, the platinum-coated device is sensitive to hydrogen unless oxygen is present, and the oxide in the platinum-coated device deteriorates in a dry atmosphere. The new iridium film does not react with hydrogen, so that the device need not be kept in oxygen: This is an advantage where the high absorption of ultraviolet light by oxygen would be undesirable; for example, when the device is used to make astronomical observations from high altitudes.

This work was done by Michael H. Hecht of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 116 on the TSP Request Card.*
NPO-17327

Silicide Schottky Barrier for Back-Surface-Illuminated CCD

A less catalytic, less reactive film would still maintain high quantum efficiency.

NASA's Jet Propulsion Laboratory, Pasadena, California

The quantum efficiency of a back-surface-illuminated charge-coupled device (CCD) would be increased by coating the back surface with a thin layer of PtSi or IrSi on a thin layer of SiO_2, according to a proposal. In its interaction with the positively-doped bulk Si of the CCD, the silicide/oxide layer would form a Schottky barrier that would repel electrons, thus promoting the accumulation of the photogenerated charge carriers in the front-side CCD potential wells. The physical principle responsible for the improvement is explained in "Metal Film Increases CCD Output" (NPO-16815), *NASA Tech Briefs*, Vol. 13, No. 4, page 24.

The back-surface coat described in the noted article is Pt/SiO_2. Because of a catalytic property of Pt, this combination of materials is sensitive to hydrogen unless oxygen is present; but oxygen is unsuitable in astronomical, airborne, or other operations that involve the detection of ultraviolet radiation, because it absorbs strongly in the ultraviolet range. Furthermore, the oxide is degraded by a dry atmosphere.

Both PtSi and IrSi have the work functions necessary to bias the CCD strongly in the accumulation mode. Neither PtSi nor IrSi reacts with hydrogen. The degradation of the oxide can be corrected by use of a low-temperature oxide-deposition process.

This work was done by Michael H. Hecht of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 127 on the TSP Request Card.*
NPO-17328

THE WAVE OF THE FUTURE

Rise above any waveform measurement challenge with the new Nicolet System 500.

It's the most powerful and flexible digital waveform acquisition system available. With more channels. More speed. More memory. Greater resolution. And in the optimum configuration, starting as low as $1,645 per channel.

Available in portable or rack mount, this premier *turnkey* system features:

Independent digitizer boards with maximum sampling rates of up to 10 MS/s.

Multichannel flexibility. Whether it's two or 200 channels, the 500 can handle it.

Local processing. Lightning-fast on board calculation capabilities save you time.

And . . . *Instant start-up.* The System 500 is ready to start working almost as soon as it's out of the box. Send now for free brochure.

Nicolet Test Instruments Division

Nicolet

INSTRUMENTS OF DISCOVERY

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

Circle Reader Action No. 696

Mobile Centers for Secondary Power Distribution

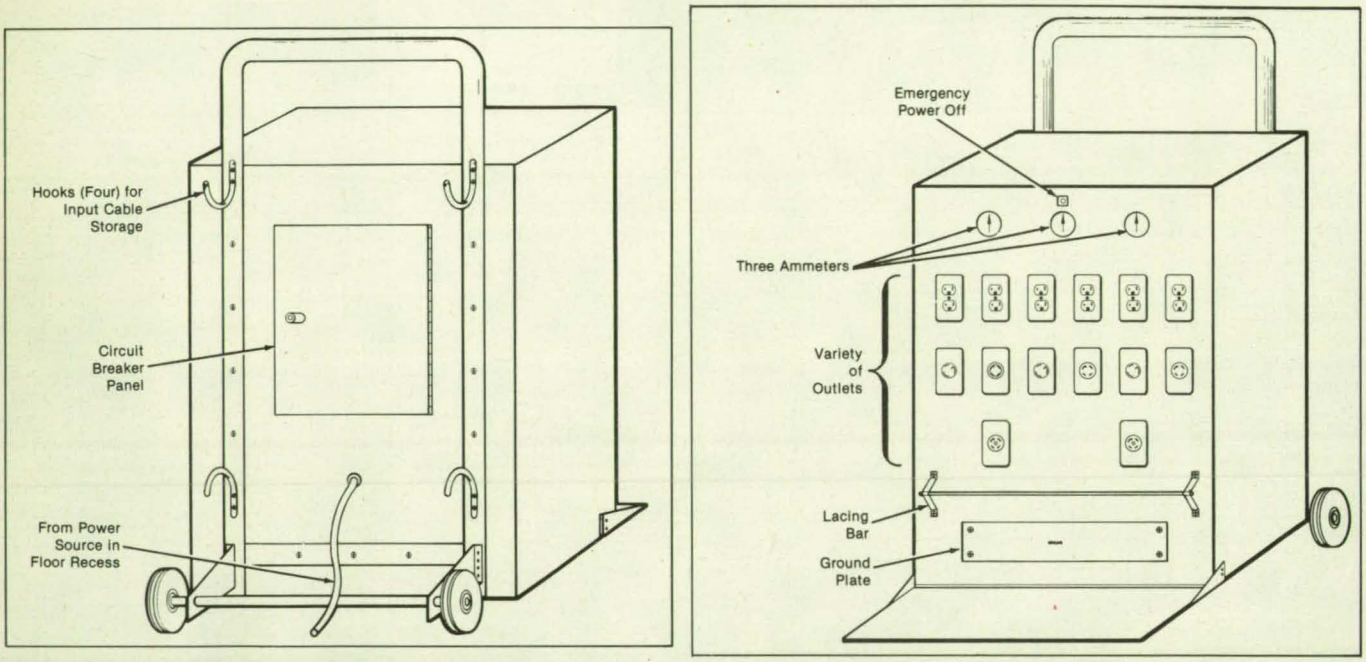
Power sources on wheels would need only short cables to equipment, reducing hazards and obstacles.

John F. Kennedy Space Center, Florida

A concept for the distribution of 60-Hz ac power in a large building devoted to the assembly and testing of equipment would improve safety, reduce the number of outlets and lengthy cables, and readily accommodate frequent changes in operations and configuration. According to the concept, power would be fed from floor recesses by cable to secondary distribution centers in the areas (see figure). Instead of being mounted in fixed locations on the floor, the power panels would be in carts and could be moved close to the equipment under test; multiple long cables on the floor would not be needed. One cart would furnish 25 kVA of power.

Where ordinary industrial loads are to be supplied, they could be connected directly to carts. For computers and other equipment susceptible to minor transient variations in voltage, instrumentation power isolated from the commercial powerlines would be provided. Two sources of power, industrial and instrumentation, would be available to these carts. The instrumentation power would meet tighter standards to feed computers and delicate instruments. The industrial-grade power would be suitable for power tools and other hardware. Three-phase and single-phase outlets would be available from each.

This work was done by Robert L. Mears of McDonnell Douglas Space Systems Co. for **Kennedy Space Center**. *For further information, Circle 24 on the TSP Request Card. KSC-11410*



Power From Floor Recess would be fed via an unobtrusive cable to a portable power management center. The center, a cart containing a variety of outlets and circuit breakers, could be wheeled to a convenient location near equipment to be assembled or tested. The power distribution system would present a larger range of operational configurations than a fixed location.

Analog Delta-Back-Propagation Neural-Network Circuitry

Changes in synapse weights due to circuit drifts would be suppressed.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed fully parallel analog version of an electronic neural-network processor would be based on the delta-back-propagation algorithm. The processor would be able to "learn" when provided with suitable combinations of inputs and enforced outputs. It would include programmable resistive memory elements (corresponding to synapses), the conductances (synapse weights) of which could be adjusted during learning. It would also include buffer amplifiers, summing circuits, and sample-and-hold circuits arranged in layers of electronic neurons in accordance with the delta-back-propagation algorithm. The algorithm would be modified to suppress unintended changes in synapse weights caused by circuit drifts.

In the analog neural network of Figure 1, the neurons are represented by summers and threshold-function (f) circuits connected in series. The degree to which a given "neuron" is activated depends on the activation of the neurons in the preceding layer and on the conductances of the "synapses" leading to the neuron.

A major consideration in the design of neural networks is how to adjust the synaptic weights. In the delta-back-propagation scheme, the weights are adjusted (that is, the network is trained) by example. For the task at hand, the network is repeatedly trained by applying representative input values and simultaneously applying the desired outputs to the network. A back-propagation system is then used to modify the weights so that the target output is more likely to occur given the applied input. Because the weights cannot be changed greatly during a back-propagation pass (otherwise previously stored information may be corrupted), many thousands or millions of back-propagation training passes may be necessary to train such a network fully.

The design and use of back-propagation circuitry is quite complicated. In one implementation, the back propagation is serially performed one layer at a time. In the exam-

TEAM WORK

ARIANE PUTS SATELLITES INTO SPACE THAT SPEAK 27 LANGUAGES. AS INDUSTRIAL ARCHITECT AEROSPATIALE COOPERATES WITH 11 EUROPEAN COUNTRIES PROVIDING SPACE-AGE TECHNOLOGY AND MANAGEMENT SKILLS. WITH THE NUMBER OF SATELLITES LAUNCHED FOR AMERICAN COMPANIES, WE PROVE OUR CAPABILITY OF WORKING TOGETHER. AND AEROSPATIALE HAS BUILT MORE THAN 40 TECHNICALLY DIVERSIFIED SATELLITES, MANY OF THEM WITH AMERICAN PARTNERS. WORKING AND CREATING TOGETHER KEEPS US UP THERE. MEET THE TEAM.

aerospatiale

aerospatiale

AEROSPATIALE INC. 1101. 15TH STREET N.W. WASHINGTON DC 20005
PHONE: 202 293 0650

Circle Reader Action No. 661

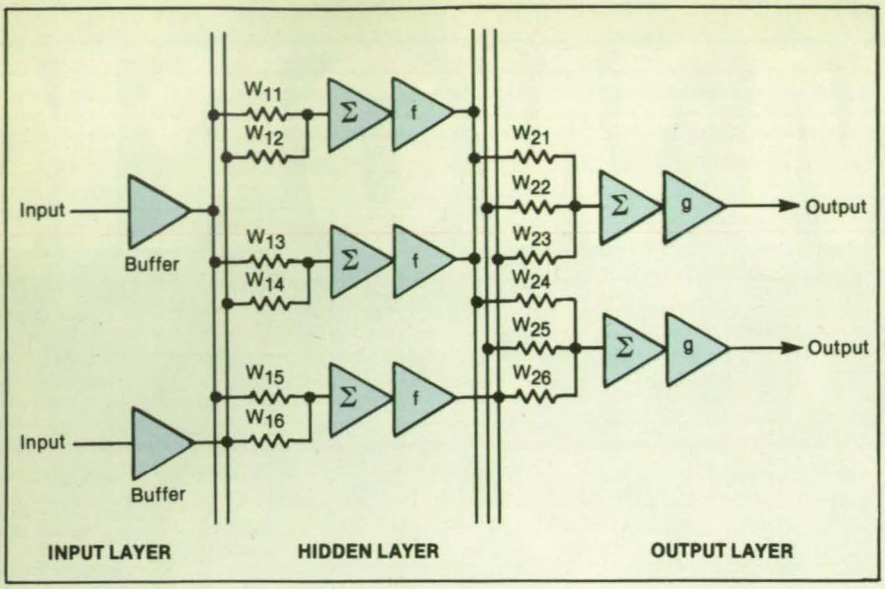


Figure 1. This **Electronic Neural Network** includes three synaptic layers. In general, the number of layers, the number of neurons in each layer, and the weights of the synapses are selected according to the task that the network is to carry out.

ple of Figure 2, the final synaptic layer of the circuit of Figure 1 is adjusted first. Assuming that feedforward has been performed on one element of a training set, the difference between the actual output and the desired target value is calculated. This difference is an error signal, which is multiplied by the feedforward activation weighted by the derivative g' of the output-activation function g. For each weight that is connected to that output neuron, the error signal is multiplied by the output of the previous layer neuron, and the resultant product is used to adjust the weight by a small increment. The adjustment of weights in the preceding synaptic layers involves the back propagation of error signals through the layers in a recursive manner and requires storage of error signals in sample-and-hold converters.

This work was done by Silvio Eberhart of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 159 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's Resident Office-JPL [see page 25]. Refer to NPO-17564

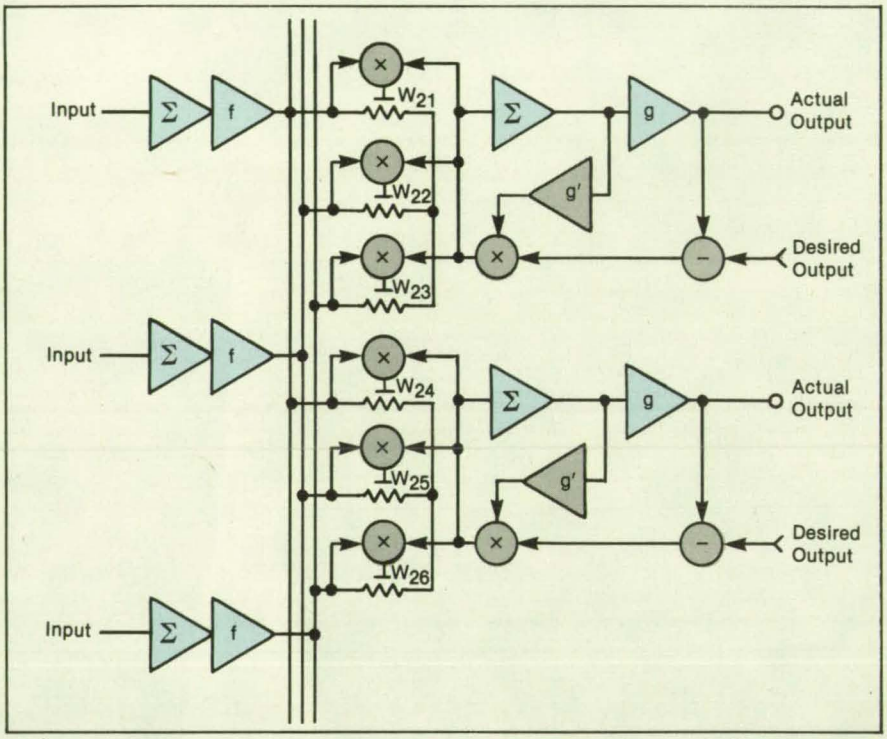


Figure 2. **Delta-Back-Propagation Circuitry** is incorporated into the network of Figure 1 to adjust the weights (conductances W_{21} through W_{26}) of the synapses in the output layer. Similiar but more complicated circuitry is required to propagate the adjustments to the hidden and input layers.

Control Circuit for Two Stepping Motors

Single or repeated steps are selectable.

Goddard Space Flight Center, Greenbelt, Maryland

A control circuit operates two independent stepping motors, one at a time. The circuit provides the following operating features:

- After a selected motor has been stepped to its chosen position, its power can be turned off to reduce dissipation.
- The control circuit includes two up/down counters that remember at which one of eight steps (each motor steps in 45° increments) each motor has been set. For the selected motor, this step is indicated by the illumination of one of eight light-emitting diodes (LED's) in a ring. (The number of revolutions of each motor must be recorded separately to obtain a complete indication of position.)
- The selected motor can be advanced one step at a time or repeatedly (auto-stepping) at a rate that can be controlled.
- The motor current — 30 mA at 90° positions, 60 mA at 45° positions — is indicated by the high or low intensity of an LED that serves as a motor-current monitor.
- A power-on reset feature provides trouble-free starts.
- To maintain synchronism between the control circuit and the motors, the stepping of the counters is inhibited when the motor power is turned off.

The up/down counters are CD4516 integrated circuits, indicated in the figure as U4 and U8. The three bits of lowest order of the counter selected by motor-selector switch SW4A are gated through U5 (a CD4019 and/or-selecting circuit) to the inputs of U6, a CD4028 binary-to-decimal decoder. The decoder interprets the output of the selected counter to cause only one of its eight connected output lines to be high.

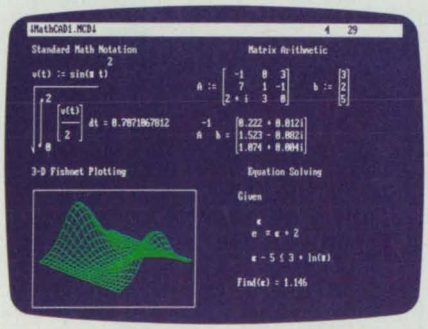
The eight outputs of the decoder are connected through CD4049 inverter buffers to the eight LED's that indicate the rotational-step position of the counter and the corresponding motor. The same eight outputs are also connected through four CD4075 OR gates and four 2N2222 current-driver transistors, in such a manner that when each of the eight outputs is high, it provides a current sink to one motor wind-

After centuries of practice, mankind perfects engineering calculations: MathCAD.

Announcing MathCAD 2.5: The Dawn of a New Age.

What the historians will call it, only time will tell.

Perhaps the Century of Speed, or the Era of Ease. But whatever the name, this is the age of MathCAD 2.5, the only math package that looks and works the way you think.

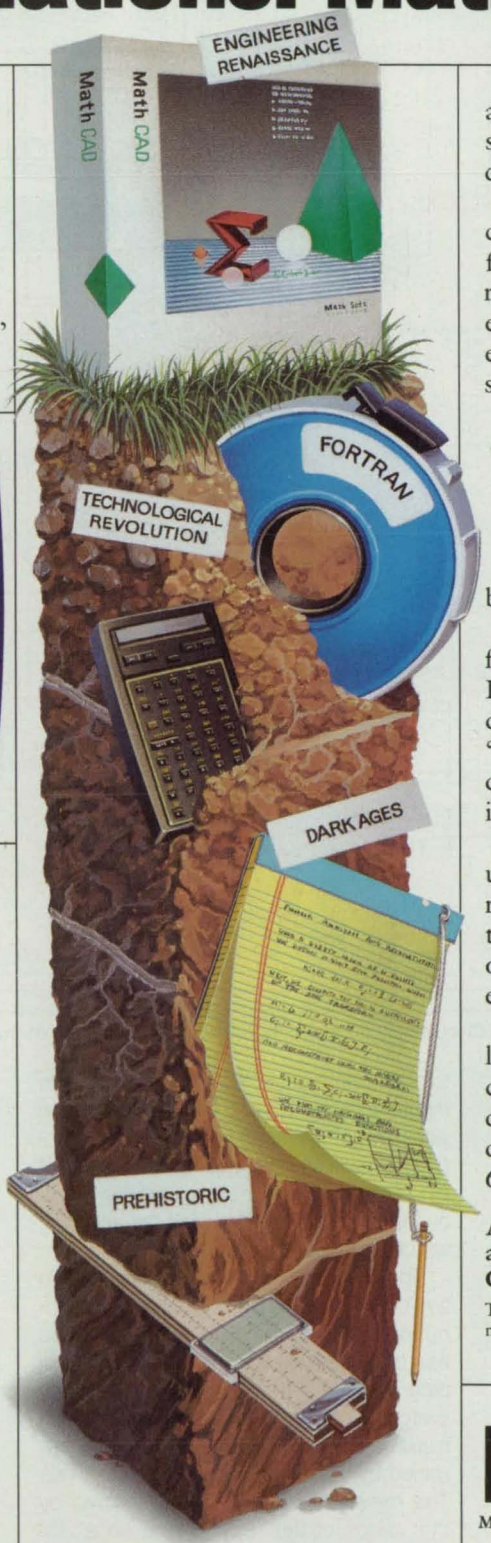


MathCAD 2.5 includes 3-D plotting, HPGL sketch import, and PostScript output.

MathCAD is far and away the best-selling math package in the world. Because it lets you perform engineering and scientific calculations in a way that's faster, more natural and less error-prone than the way you're doing them now—whether you're using a scratchpad, calculator, spreadsheet or program that you wrote yourself.

And now there's MathCAD 2.5, a dramatically improved version that includes three-dimensional plotting, enhanced numerical analysis, PostScript® printer support, and HPGL file import from popular CAD programs like AutoCAD.®

And like before, MathCAD's live document interface™ lets you enter equations anywhere on the screen, add text to support your work, and graph the results. Then print your analysis in presentation-quality documents.



UNIX version now available.

It has over 120 commonly used functions built right in, for handling equations and formulas, as well as exponentials, differentials, cubic splines, FFTs and matrices.

No matter what kind of math you do, MathCAD 2.5 has a solution for you. In fact, it's used by over 90,000 engineers and scientists, including electrical, industrial, and mechanical engineers, physicists, biologists and economists.

But don't take our word for it; just ask the experts. PC Magazine recently described MathCAD as "everything you have ever dreamed of in a mathematical toolbox."

PC MAGAZINE EDITOR'S CHOICE
March 14, 1989 issue.
Best of '88
Best of '87

And for Macintosh® users, we present MathCAD, rewritten to take full advantage of the Macintosh interface. Entering operators and Greek letters into equations is pure simplicity!

Look for MathCAD 2.5 at your local software dealer, or give us a call. For more information, a free demo disk, or upgrade information, dial 1-800-MATHCAD (in MA, 617-577-1017).

Available for IBM® compatibles and Macintosh computers.
Call for UNIX platform availability.

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

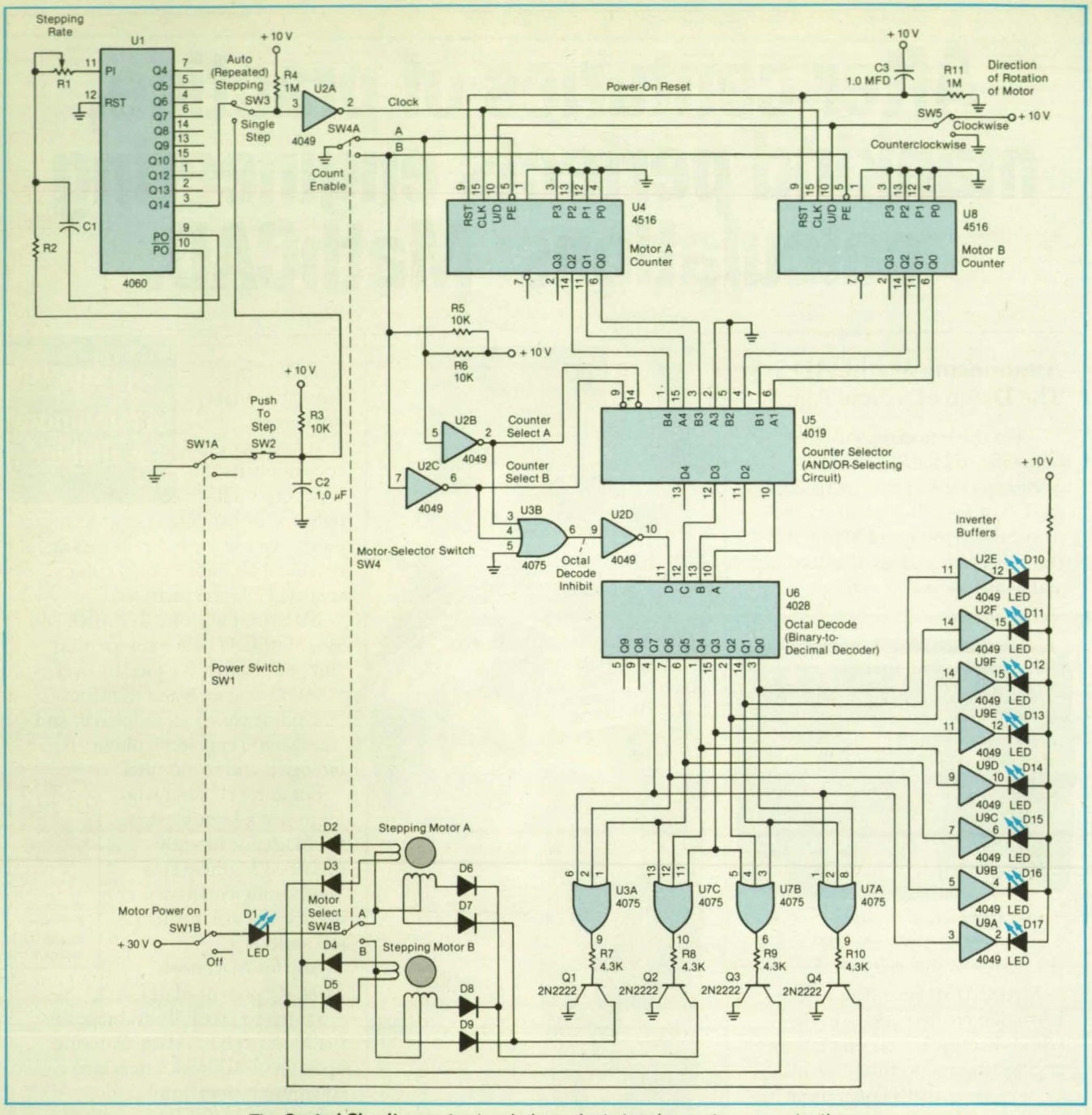
MathCAD®

MathSoft, Inc. 201 Broadway, Cambridge, MA 02139

22

U.K.: Adept Scientific 0462-480055; **France:** ISE CEGOS 1-46092768; **Germany:** Softline 07802-4036; **Japan:** CRC 03-665-9762; **Finland:** Zenex Oy 90-692 7677 *PE*

Circle Reader Action No. 682



The **Control Circuit** operates two independent stepping motors, one at a time.

ing (90° positions) or two motor windings (45° positions).

The current for the motor windings is provided through the power switch, SW1B, the motor-current-indicating LED, the motor-selector switch, SW4B, and the one or two motor windings selected by the count in the counter and the position of the motor-selector switch. Eight diodes are used to provide isolation between the two motors.

Clock pulses are applied to both counters U4 and U5, but only the counter selected by switch SW4A is enabled to count. This same switch, acting through CD4049 inverters U2B and U2C, enables the outputs of only that counter to be gated through U5. The three-input CD4075 OR gate U3B with output pin 6, and inverter U2D with output pin 10, were incorporated to prevent decoder U6 from interpreting its inputs as a zero during the transition time when switch SW4A is operated. This is accomplished by applying a high level to input pin 11 of U6 during the transition time, thereby forcing the decoder to put out an eight, which is not used.

The source of the clock pulses for the two counters is either the single-step push-button, SW2, circuit, if single-step mode has been selected, or else the auto-stepping circuit, if it has been selected by switch SW3. In the single-step mode, the maximum width of the clock pulse is determined by the duration of closure of SW2. The minimum duration is determined by the values of the resistor and capacitor connected to SW2.

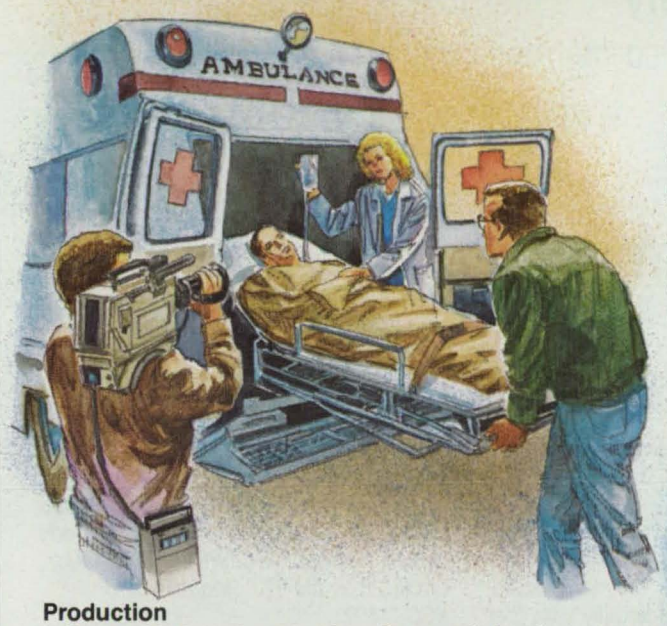
To prevent unintentional auto-stepping of the motors in the auto-stepping mode, the circuit has been configured to require depressing switch SW2 in addition to selecting the auto-stepping mode with switch SW4. The repetition rate of the auto-stepping is determined by the fixed reistors, capacitor, potentiometer, and length of the divider chain selected.

The clock pulses from either circuit are inhibited when the motor-power switch, SW1, is off. This prevents advancement of the counters when the motors are not able to track them.

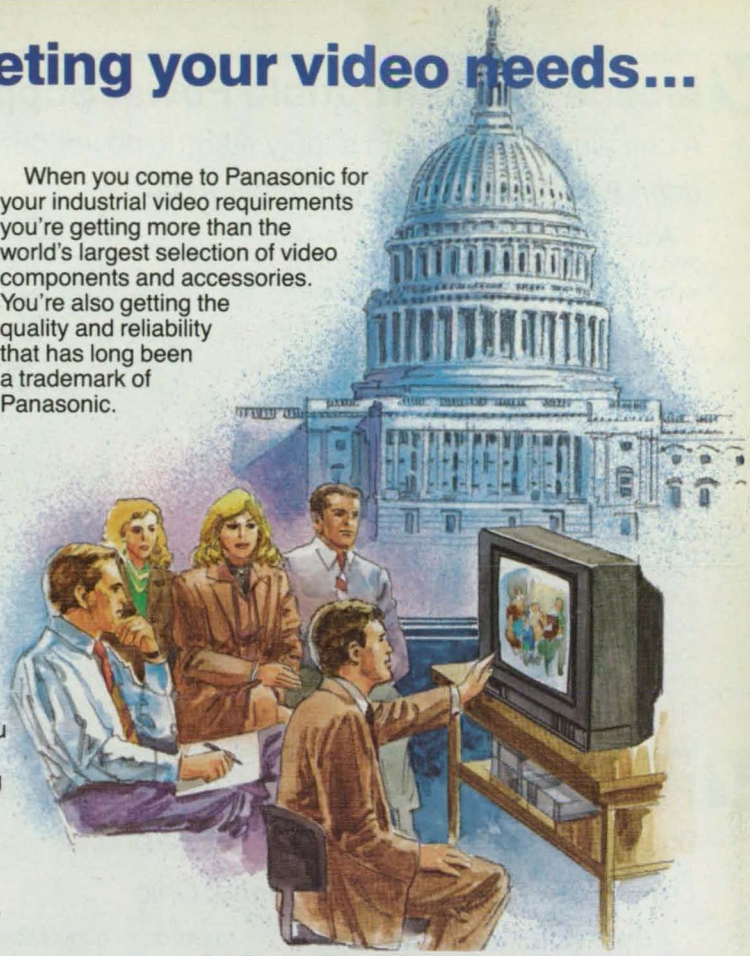
This work was done by Roger Ratliff, Kenneth Rehmann, and Charles Backus of **Goddard Space Flight Center**. *For further information, Circle 19 on the TSP Request Card.*

GSC-13202

When it comes to meeting your video needs...



When you come to Panasonic for your industrial video requirements you're getting more than the world's largest selection of video components and accessories. You're also getting the quality and reliability that has long been a trademark of Panasonic.

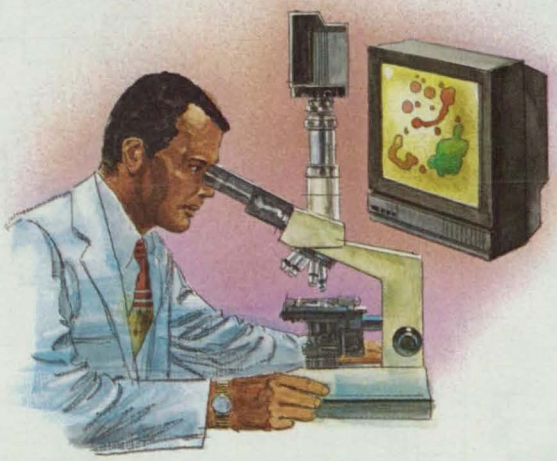


Production

For sophisticated productions Panasonic has just what you need. Including a wide variety of single chip and three-chip cameras as well as special effects generators and ½" editing systems—both VHS and S-VHS.

For documentation, there are a variety of lightweight cameras and portable VHS recorders and camcorders. All with features to make documentation simple and fast. Like One-Touch Recording, Auto-White Balance and Auto-Focus.

One number fits all - Panasonic GSOOK88AGS0130.



Surveillance

For your security and surveillance operations Panasonic offers a wide choice of CCTV components. Choose from cameras in both color and black and white. There are also small and ultra-durable solid-state color and black and white cameras, time-lapse VCR's and, of course, monitors in virtually every size and configuration.

By now it should be clear: there's only one number you need to know when it comes to industrial video. GSOOK88AGS0130.

Distribution

For your video networks Panasonic offers a multitude of VHS recorders and players. There are even video decks and monitors combined in a single unit. And of course you can't find a larger selection of black and white or color monitors.

For more information contact your local Panasonic Industrial Video Dealer. Federal Government Agencies: For your copy of the Authorized Communications Schedule Price List call or write the Government Marketing Department, Panasonic AVSG, 52 West Gude Drive, Rockville, Maryland 20850. 301/738-3840.

Panasonic
Industrial Company

Circle Reader Action No. 380

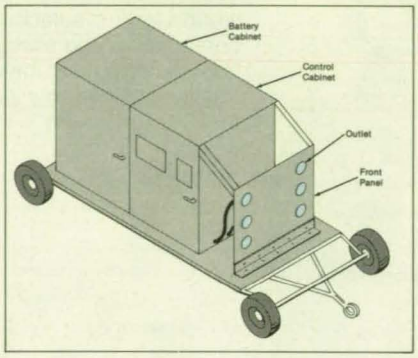
Mobile Uninterruptible Power Supply

A unit would continue to supply electric power during interruptions of the normal power supply.

John F. Kennedy Space Center, Florida

A proposed mobile unit would provide 20 kVA of uninterruptible power. The unit would be used with mobile secondary power-distribution centers to provide power to test equipment with minimal cabling, hazards, and obstacles. It would be wheeled close to the test equipment and the system being tested so that only short cable connections would be needed. It could be quickly moved and set up in a new location.

The mobile uninterruptible power supply is intended for tests in which data would be lost or equipment would be damaged during even a transient power failure. It would provide power for 15 minutes after a failure in the main supply, thereby allowing the equipment to be turned off safely if the failure lasts longer.



The unit would include batteries and control circuitry on a cart (see figure). Self-contained static rectifier inverters would charge the batteries continually with the alternating current from a mobile power-distribution center. The unit would furnish ac power at rated voltage and frequency before, during, and after failure of the power supplied to it.

The **Front Panel** of the mobile uninterruptible power supply would hold outlets for power at a variety of voltages and frequencies, depending on local needs. Power-conditioning circuits in the control cabinet on the cart would make the necessary transformations of voltage and frequency.

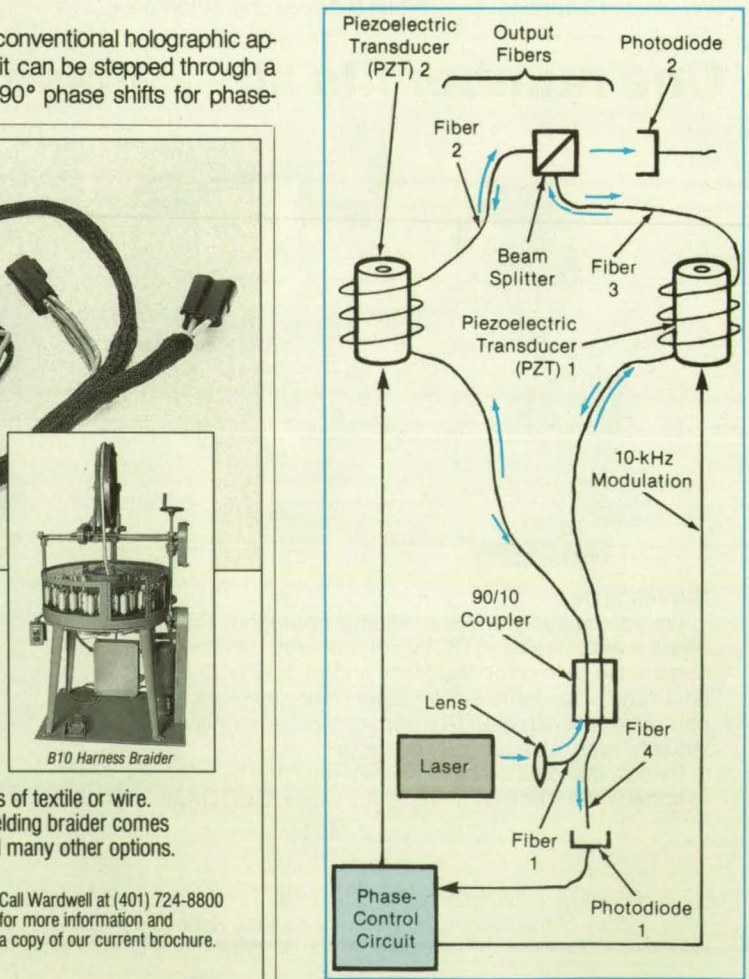
This work was done by Robert L. Mears of McDonnell Douglas Corp. for **Kennedy Space Center**. *For further information, Circle 28 on the TSP Request Card.*
KSC-11409

Phase-Compensating System for Fiber-Optic Holography

Phase steps can be held to a precision of 0.02°.

Lewis Research Center, Cleveland, Ohio

A phase-compensating system controls the relative phase (θ) of laser light emitted from two optical fibers. The phase can be stabilized for conventional holographic applications, or it can be stepped through a sequence of 90° phase shifts for phase-



The **Phase-Compensating System** controls environmental fluctuations in the phases of light emitted by the output fibers.

stepping holographic interferometry. The closed-loop system compensates for phase fluctuations caused by mechanical stresses and temperature changes in the fibers, providing long-term phase stability and phase steps that are accurate to within 0.02°.

The phase-compensating system is integral with a fiber-optic light-delivering system (see figure). Light from a 25-mW He/Ne laser fed into optical fiber 1 travels through a fiber coupler to output fibers 2 and 3. Fiber 2 is wound tightly around piezoelectric transducer PZT2, and fiber 3 is wound around PZT1. The light emitted from one of the output fibers is used as the object beam for an interferometric system; the light from the other output fiber creates the reference beam. The output fibers are shown forming an interferometer for direct detection of the relative phase θ, but one advantage of this system is that the phase control is independent of fiber placement, so that these fibers can be set in any configuration.

Some of the light traveling through the output fibers is reflected by the glass/air interface at the fiber faces and returns through the coupler, travels through optical fiber 4, and is detected by photodiode 1. A 10-kHz sinusoidal voltage applied to PZT1 modulates the phase of the light traveling through fiber 3, thereby modulating the light detected by photodiode 1. A lock-in amplifier multiplies the signal generated by photodiode 1 by the modulation signal and filters the result, producing an error voltage that is proportional to sin 2θ. This voltage is applied to PZT2 to alter the optical path length of fiber 2 until the error voltage is nulled, stabilizing θ.

Manipulating the sign of the output of photodiode 1 relative to the modulation signal forces 2θ to be an even or odd multiple of 180°, so that θ can be set to any multiple of 90°. To produce a monotonically increasing sequence of 90° phase steps for phase-stepping interferometry, the phase controller is temporarily deactivated, and voltage steps are applied to PZT2 to change the relative phase by roughly 90°. When reactivated, the controller quickly provides the fine tuning that is required to produce and maintain an accurate 90° phase step.

This work was done by Carolyn R. Mercer and Glenn Beheim of **Lewis Research Center**. *Further information may be found in NASA TM-101295 [N88-26641], "Active Phase Compensation System for Fiber Optic Holography."*

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-14864

Electronic Systems

Parallel Architecture for Robotics Computation

The system is a reconfigurable algorithmically specialized architecture with both MIMD and SIMD capabilities.

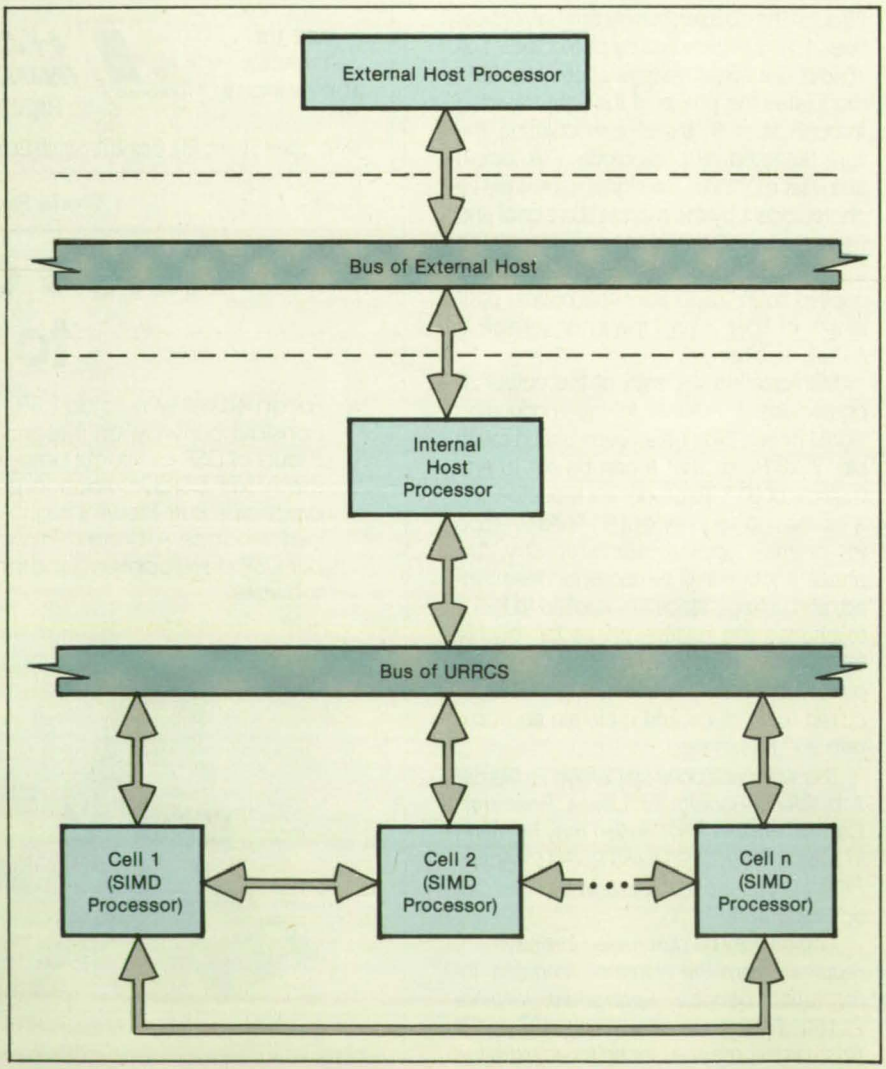
NASA's Jet Propulsion Laboratory, Pasadena, California

The Universal Real-Time Robotic Controller and Simulator (URRCS) is a highly parallel computing architecture for the control and simulation of robot motion. URRCS is the result of an extensive algorithmic study of the different kinematic and dynamic computational problems arising in the control and simulation of robot motion. This study has led to the development of a class of efficient parallel algorithms for these problems. URRCS represents an algorithmically specialized architecture, in the sense that it is capable of exploiting the common properties of this class of parallel algorithms.

Previous proposals for parallel computation of the kinematic and dynamic problems have been based on rather conventional parallel architectures; i.e., either Multiple-Instruction/Multiple Data (MIMD) or Single-Instruction/Multiple-Data (SIMD). The drawback of these proposals is that they either require rather complex architectures (as in most SIMD proposals) or are capable of exploiting only one type of parallelism (mostly coarse grain parallelism as in MIMD proposals), which is not the most significant parallelism and leads to the inefficiency in the computation. In order to exploit different types of parallelism at different computational levels efficiently, URRCS is designed with the capability of both MIMD and SIMD types of parallel processing. In this sense, it is a reconfigurable parallel architecture that, depending on the algorithmic requirements, can perform the computation as an MIMD/SIMD or SIMD/SIMD architecture. Another possible configuration of the URRCS is MIMD/SIMD/SIMD. This is particularly suitable for inverse dynamics computation, which allows the exploitation of parallelism at three computational levels.

For the purpose of interfacing to the outside world, URRCS is an attached processor that can be interfaced to the bus of an external host as part of the bus memory (see figure). It includes *n* SIMD processors called "cells" and an internal host processor, which acts as an interface with the external host, controls the activities of the cells, and performs the input/output operations. Each cell is capable of exploiting fine grain parallelism. Specifically, each cell can perform two matrix-vector operations in parallel while fully exploiting parallelism in each operation. The cells' architecture is optimized for the size of matrices and vectors involved in the computation. However, due to the architectural flexibility, parallelism can also be efficiently exploited in operations with matrices and vectors of larger size or in purely scalar operations.

The cells are interconnected through a ring structure, which enables a rapid communication between adjacent cells as well as the reliable distribution of the global clock signal among the cells. The perfect-

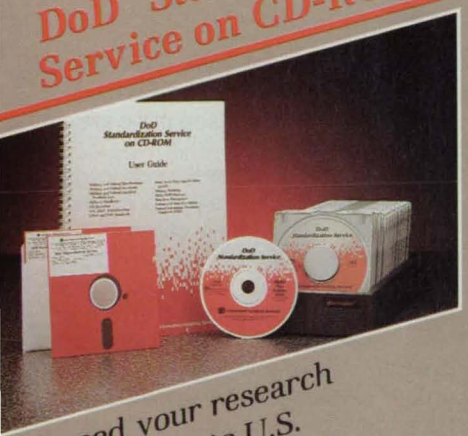


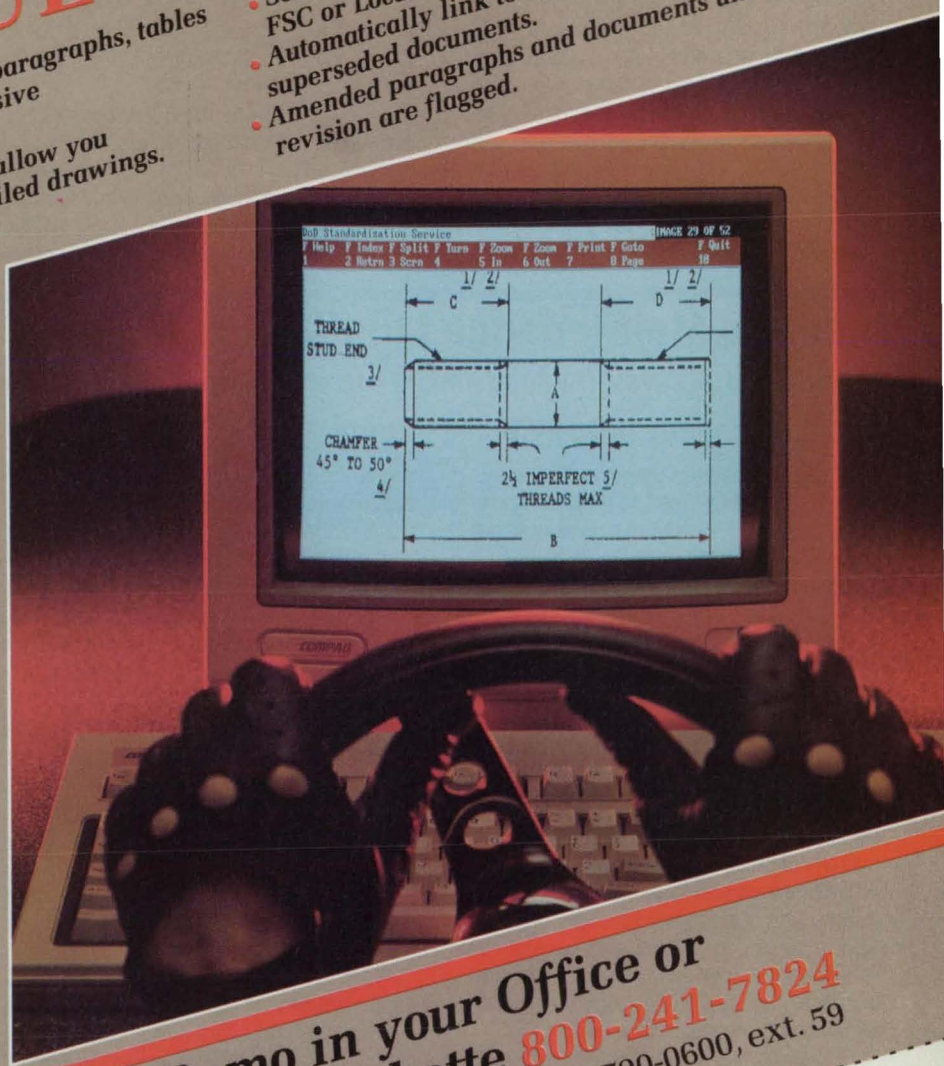
The **URRCS** can be regarded as a processor that is attached to the bus of an external host processor, as part of the bus memory.

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

shuffle topology, which is required for parallel computation of some kinematic and dynamic problems, and global broadcasting can be provided by synchronized message passing. The fast and synchronous communication among the cells reduces the overhead caused by message passing. The basic synchronization mechanism of the architecture is data-driven, which, similar to the wave front array processors, provides local synchronization among the cells. However, because all the cells are driven with the same global clock and because of the regularity of the computations, global clock-based synchronization similar to the systolic arrays can also be used.

The internal host controls the activities of the system by interpreting the instructions sent by the external host. The instructions are decomposed into a series of computations to be performed by the cells. For the internal host, the cells are considered as memory units that are connected to its memory bus and can be accessed randomly. Depending on the required computation, the internal host distributes the data among the cells and initiates their activities by procedure calls. The activities of the cells are then carried out independently from the internal host. The end of the computation is indicated by the cells to the internal host, which then transforms the results to the external host.

URRCS represents a successful approach to the design of algorithmically specialized parallel architectures in which the algorithmic study has resulted in the practical implementation of a low-cost and high-performance architecture for a class of problems. For a six-degree-of-freedom general robot manipulator (with no optimization), the computation time of the inverse dynamics problem, using the Newton-Euler formulation, has been measured as 187 μs, and that of the forward kinematics plus Jacobian as 75 μs.

This work was done by Amir Fijany and Antal K. Bejczy of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 21 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA's Resident Office-JPL [see page 25]. Refer to NPO-17629

Remote Maintenance Monitoring

An automated system gives new life to an aging network of computers.

John F. Kennedy Space Center, Florida

A remote maintenance monitoring system is being developed to diagnose problems in a large distributed computer network. The network consists of data links, displays, controls, software, and more than 200 computers. The computers, the average age of which is more than 10 years, have no built-in self-testing ability. The monitoring system uses sensors to collect data on failures and an expert system to examine the data, diagnose the causes of failures, and recommend cures.

The monitoring system was designed to be retrofitted into the launch processing system at Kennedy Space Center, which will not be replaced for several years. In the interim, the system will reduce downtime and lower the workload and expense of maintenance. It will also make the network less dependent on human expertise, which is becoming increasingly scarce.

The system is based on integrated diagnostics, a systems engineering approach in which all elements that affect maintenance are combined. These elements include built-in testing, maintenance aids, management tools, training, artificial intelligence, logistics support, data bases, and automatic test equipment. Ideally, integrated diagnostics should be included in the design of a network. Retrofitting integrated diagnostics into an existing network should nevertheless improve maintenance significantly.

Hardware monitors are implanted in the computers of the network. The monitors capture memory-dump data, back-trace instructions and addresses from the central processing unit, monitor regulated voltages, and record a variety of signals. In effect, the monitors integrate and automate the data-collection activities of maintenance personnel.

A UNIX-based workstation is used as a data manager. All of the data captured by the hardware monitors is transfered to and cataloged by the data manager. The information is then provided 10 various applications for display and analysis. A real-time coprocessor within the data manager monitors system message traffic and captures all relevant information. The message data allows a configuration status of the system to be maintained.

An expert system uses the monitor data to create probable failure scenarios and to determine the most likely cause of such things as memory parity errors and power-supply anomalies. The expert system employs knowledge acquired from maintenance personnel; the knowledge base explicitly defines the reasoning process used in diagnosis. Because maintenance personnel apply a mixture of heuristics and causal modeling to diagnose failures, the expert system is both rule-based and model-based.

This work was done by Richard C. Owens and Lorenz Simkins of **Kennedy Space Center** *and Donn Rochette of Grumman Technical Services. For further information, Circle 40 on the TSP Request Card.*

KSC-11398

32-Bit-Wide Memory Tolerates Failures

Correct data are supplied even if a whole RAM chip fails.

Lyndon B. Johnson Space Center, Houston, Texas

An electronic memory system of 32-bit words corrects bit errors caused by some common types of failures — even the failure of an entire 4-bit-wide random-access-memory (RAM) chip (one of eight such chips in the system). Furthermore, the system detects the failure of two such chips, so that the user can at least be warned that the output of the memory may contain errors.

Circuits to detect and correct errors are usually included in the memory subsystems of computers designed for high reliability. By use of Hamming encoding, a variety of commercially available circuits correct single-bit errors and detect (but do not correct) double-bit errors. Where the number of erroneous bits exceeds two, such a circuit may fail to detect the errors or may erroneously alter the erroneous data in the attempt to correct them.

Where low power, compactness, and high performance are required in computer memories, 4-bit-wide dynamic RAM's (DRAM's) are usually the best choice. However, common types of failures in such a DRAM can cause errors in one, two, three, or all four bits. To overcome this disadvantage, the new 32-bit-wide memory includes eight 4-bit-wide

MATH ADVANTAGE®

FORTRAN VERSION

TOOLSMITH SERIES®

FUEL EFFICIENT.

Get maximum compute-engine performance for every application, with Math Advantage® from QTC.

Math Advantage is the de facto standard for math libraries in high-speed computing environments. It's developed and optimized by QTC's team of mathematicians, applications engineers, and supercomputer experts. It features over 260 frequently used but hard-to-program subroutines. And it runs on over 40 systems ranging from Cray X-MP to IBM PC, Cyber to VAX, Sun to Mac.

Best of all, Math Advantage gives you FORTRAN, C, and Ada versions of algorithms like FFTs, eigensolvers, matrix operations, and BLAS, all completely *ready-to-run*. So it helps you optimize the most valuable resource of all—your time.

Because it's from QTC, the experts in high-performance development tools, Math Advantage also comes with unmatched documentation, support, and technical excellence.

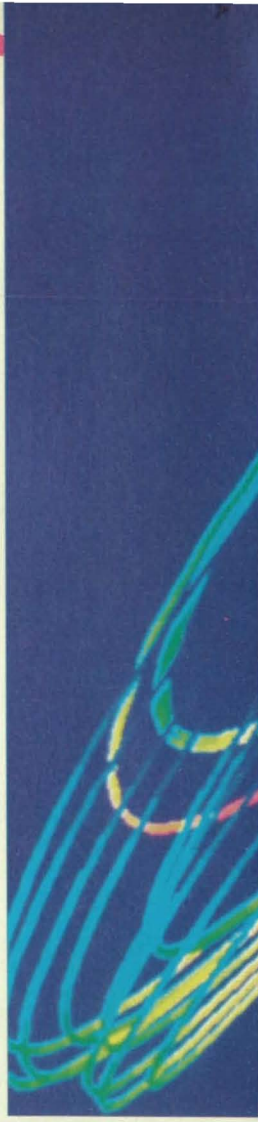
See for yourself—over 10,000 Math Advantage users already have. Contact QTC at 1-800-234-0168, or Telex 910 240 2827 for more information.

QTC

Quantitative Technology Corporation

Circle Reader Action No. 570

NASA invites you to the high-tech show of 1990!



WHERE INDUSTRY CAN

access technology *from NASA and its contractors*

meet NASA technology transfer experts

find new partners *for R&D projects*

learn what's in the pipeline *from current NASA programs*

look at the future *of applied space-based research*

share the experiences *of current spinoff companies*

ALL ABOUT TECHNOLOGY 2000

High-tech innovation — from the revolutionary to the incremental, from the million dollar idea to the .05% reduction in cost — is what **TECHNOLOGY 2000** is all about. Join NASA and NASA Tech Briefs Magazine as they launch the first annual exposition and conference of NASA technology and technology transfer.

In two jam-packed days, government and corporate trailblazers will bring you up to date on the latest innovations in telecommunications, robotics, computational fluid dynamics and other areas — with a focus on potential commercial applications.

Between and after these sessions, you will visit the idea-stocked exhibit area, making contact with experts from all nine NASA research centers as well as many of the leading-edge companies around the country. You will have ample opportunity to meet these leaders, to develop personal contacts with potential R&D partners, and to learn what's directly ahead in a variety of high-tech fields.

Many firms have picked up NASA's ideas and run with them - creating new processes and products both large and small. Others have used space-based technology to hone their internal operations or improve their manufacturing systems. All have fulfilled NASA's stated goal of making American industry more competitive.

You too can benefit from this wealth of government-sponsored research. Join NASA, its leading contractors and spinoff companies at **TECHNOLOGY 2000.**

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.

EXHIBITS

Exhibits will be open from 11 a.m. to 5 p.m. on Tuesday and Wednesday, November 27 and 28.

WHO SHOULD ATTEND

Top management, research directors, project leaders, senior/design engineers, scientists and technology transfer agents from public and private organizations. The industries represented include: aerospace, electronics, computers, industrial equipment, defense, communications, bio-medical, materials, power, transportation and chemicals.

THE PROGRAM

NASA management has invited space agency researchers and key industry leaders to address **TECHNOLOGY 2000** audiences. **Several concurrent sessions are planned for 8:30 - 11 a.m. and 2:30 - 5:30 p.m. on both Tuesday and Wednesday, November 27 and 28.** The symposia topics include:

POWER AND ENERGY
ROBOTICS AND ARTIFICIAL INTELLIGENCE
SOFTWARE ENGINEERING
LASERS/OPTOELECTRONICS
COMPUTATIONAL FLUID DYNAMICS
TELECOMMUNICATIONS
BIO-MEDICINE
MATERIALS SCIENCE
SENSOR TECHNOLOGY

A final list of specific topics and speakers will accompany registration confirmations; attendees may then choose the sessions they wish to attend.

THE LOCATION

All sessions will be held at the Washington Hilton Hotel and Towers, 1919 Connecticut Ave., N.W., Washington D.C. 20036. The hotel is conveniently located near the DuPont Circle stop on the Metro Red Line, and offers indoor parking.

REGISTRATION AND FEES

The full registration fee is $150, and includes symposia and exhibits for both days. For those who can attend for only one day, registration for technical sessions and exhibits is $100. Attendees may visit the exhibit area only at a cost of $20/day.

Clip the coupon opposite and return with your payment to: Technology Utilization Foundation, 41 East 42 Street, Suite 921, New York, N.Y. 10017 (212)490-3999

HOTEL ACCOMMODATIONS

Reservations must be made directly with The Washington Hilton, Reservations Department, 1919 Connecticut Ave., N.W. ,Washington, D.C. 20036 (202)483-3000

access the power

TECHNOLOGY 2000

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

The Washington Hilton
Washington, D. C.

November 27-28, 1990

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? (Check one)

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__Mgt. other than engineering	3__Engineering
2__Engineering management	4__Research

5__Other (specify)_____

Your principal job function is: (Check one)

1__General & Corporate Mgt.	2__Design & Develop.Eng.
3__Eng. Svc.-Tests/Quality	4__Basic Research
5__Manufacturing & Prod'n.	6__Purchasing & Procurement

8__Other (specify)_____

Your engineering responsibility is:

A__Manage Eng. Dept.	B__Manage a Project Team
C__Manage a Project	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 $_____

Return with your payment to: **Technology Utilization Foundation**, 41 East 42 Street, Suite 921, New York, N.Y. 10017

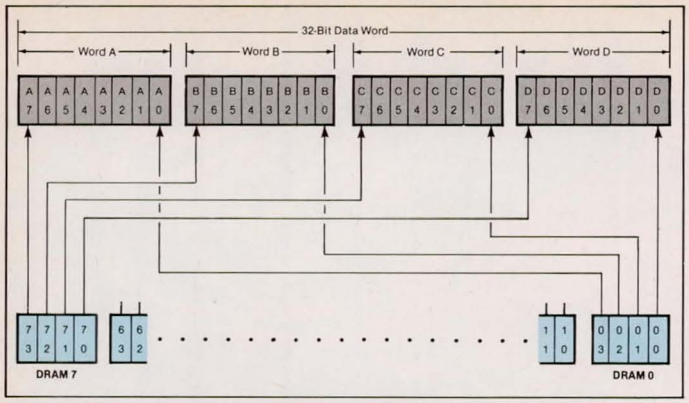


Figure 1. **Data Bits From Eight 4-Bit-Wide DRAM's** are grouped into four parallel 8-bit words to form a 32-bit word. Each 8-bit data word contains only 1 bit from each DRAM.

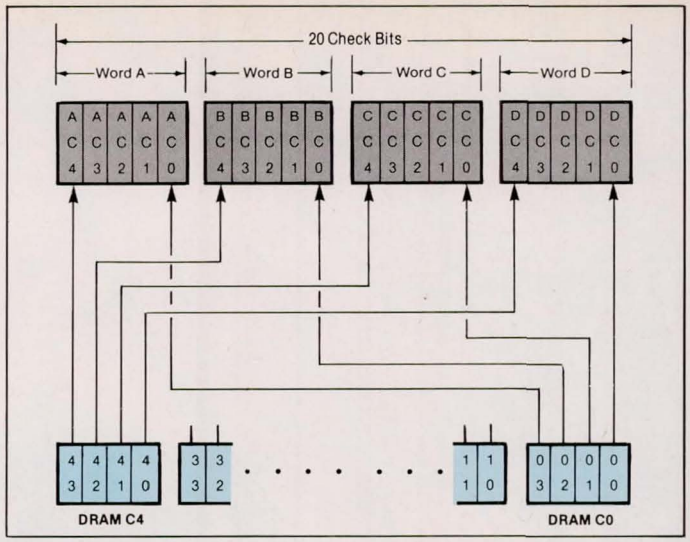


Figure 2. **Check Bits From Five 4-Bit-Wide DRAM's** are grouped into four 5-bit words, one for each 8-bit word of Figure 1. Each 5-bit check word contains only 1 bit from each DRAM.

DRAM's configured so that each bit of each DRAM is assigned to a different one of four parallel 8-bit words. Thus, each DRAM contributes only 1 bit to each 8-bit word.

Hamming encoding for single-bit correction/double-bit detection is applied to each 8-bit word. The requisite 8 bit modified Hamming error-correction algorithm can be implemented in each 8-bit word by an Advanced Micro Devices AM2960 (or equivalent) circuit. If an entire 4-bit-wide DRAM fails, no more than 1 bit in each 8-bit word is in error. Thus, the resulting errors are corrected in all four eight-bit words, and the memory can still put out correct data. If two entire 4-bit-wide DRAM's fail, then no more than 2 bits in each 8-bit word are in error, and the error-detecting circuits signal that an error or errors may be present.

The error-correction-and-detection scheme requires 5 check bits for each 8-bit data word, so that a total of 20 check bits is required. The check bits are stored in five 4-bit-wide DRAM's. Each bit of each such DRAM is assigned to the set of check bits for a different one of the four parallel 8-bit data arrays, in a manner similar to that of the assignment of data bits (see Figure 2). Thus, a total of 13 4-bit-wide DRAM's (eight for data bits and five for check bits) is required.

This work was done by Glenn A. Buskirk of IBM for **Johnson Space Center**. *No further documentation is available. MSC-21566*

Bar-Code System Tracks Test Equipment

Administration of a complicated system is speeded and simplified.

John F. Kennedy Space Center, Florida

A computer system uses bar codes to keep track of more than 2,200 items of test equipment. The system, called BETUS for Barcode Equipment Tracking and Utilization System, maintains a data base on what items have been borrowed, who is using them and where, and when they have been calibrated. BETUS also keeps records on tools and small electronic components.

Each item holds an aluminum tag containing a unique six-character bar code. Each coded tag represents a record in the BETUS data base:

- part number,
- serial number,
- manufacturer,
- description,
- date due for calibration,
- calibration-cycle time,
- malfunctions,
- number of times and total number of days the item has been checked out by technicians,
- number of times and total number of days the item has been in the calibration laboratory, and
- the supply area wherein the item resides or the name of the person who has checked it out.

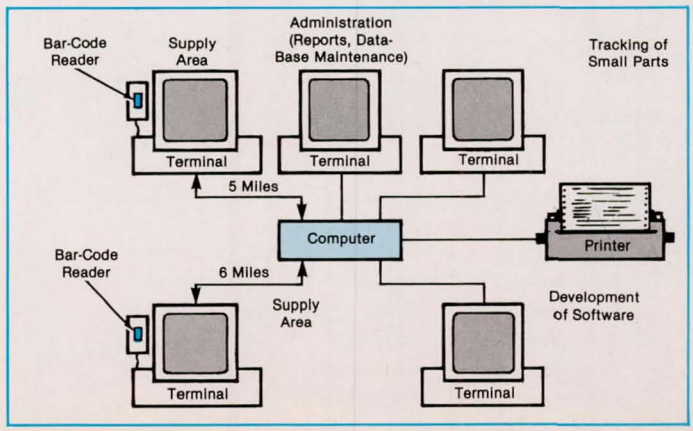
Technicians and engineers who draw equipment from supply areas have their own bar-coded user cards, small enough to fit in wallets or on identification cards. Each card bears a three-digit number that is cross-referenced in the data base to the user's name, mail stop, and telephone number.

BETUS currently includes five terminals (see figure). Asynchronous modems, operating at 9,600 baud, connect the terminals to a host microcomputer. The host software is a multiuser, menu-driven data-base-management package.

When a user checks out an item at a supply area, the supply clerk selects the check-in/checkout menu from the main menu and passes a bar-code wand over the equipment tag, the user's card, and the bar code on the checkout menu for the location to which the item will be taken. The information is fed to the data base, with the time of the transaction, as it is entered. When the item is subsequently checked back in, BETUS calculates the time during which it was in use.

BETUS prints daily activity reports that show the number of times equipment has been checked out to technicians or for

The **Host Microcomputer** serves terminal areas 5 and 6mi (8 and 10km) distant. It also serves a terminal that generates reports and maintains the data base, one that determines the statuses of small parts, and one used to develop software.



Get a close look at the big picture.

With the new HI JetPro™ printer/plotter.

Select your drawing. Preview it on your monitor. Zoom in on the tightest detail. Clip it, scale it, mark a "window." Then press a key to get a high-quality hardcopy of the segment you want.

You can do all of this—*plus* high-speed draft and letter-quality printing—with one machine: the HI JetPro printer/plotter.

The flexible hardcopy control system

Whether it's an E-size drawing or a scanned data file, HI JetPro delivers the flexibility you need and the image you want. With HI's JetPro, you have a complete hardcopy control system that includes hardware and software for high-speed, high-resolution printing and plotting—in both vector and raster environments.

Convenient, quiet, and precise

HI JetPro produces your images on ordinary paper, in sizes up to 16.5 × 23.3 inches (DIN A2), with the incredibly sharp clarity of 360 dpi. And because it's a bubble-jet, it prints and plots quickly and quietly.

Simple to use and easy to maintain, the HI JetPro printer/plotter is fully backed by Houston Instrument's reputation for price-performance, quality, and support.

To get a closer look, call *1-800-444-3425* or 512-835-0900.

HOUSTON INSTRUMENT™

8500 Cameron Road, Austin, TX 78753

Circle Reader Action No. 550

calibration. BETUS prints monthly utilization reports based on surveys of selected locations conducted with a portable bar-code reader. These reports give information on the items in use and help to find lost equipment.

The users of BETUS have found that they save on equipment purchases because they can allocate resources more efficiently and can recover missing equipment more quickly. They also have found that they have cut check-in and checkout time by 90 percent.

This work was done by Jacob R. Rogers, Lesa M. Benton, and Roberta A. Perry of **Kennedy Space Center**. *For further information, Circle 27 on the TSP Request Card.*
KSC-11370

Fast, Capacious Disk Memory Device

Features include high data-transfer rates and fuller utilization of the recording area.

Goddard Space Flight Center, Greenbelt, Maryland

A device for recording digital data on, and playing back the data from, memory disks has a high recording or playback rate and utilizes the available recording area more fully than some older devices do. The underlying concept of the device is applicable to magnetic or optical disks.

As shown in Figure 1, the device includes two reading/writing heads, one on each of two disks. (Alternatively, two heads on opposite sides of one disk could be used.) The data are recorded in concentric tracks on the disk. The tracks on one disk are numbered starting with track 1 near the outer edge, while the tracks on the outer disk are numbered starting with track 1 at the inner edge of the recording area. The combined lengths of the two tracks designated by the given number is constant, equal to the combined length of two tracks designated by any other number. If the data are recorded on all tracks at the same high density (number of bits per unit length of track), then the recording area is utilized fully, and the combined capacity of every numbered pair of tracks is a constant.

To simplify control and access, the disks are turned at constant speed. This means that the data rate in each reading/writing head is proportional to the radius of its track, and the sum of the data rates in the two heads positioned on any numbered pair of tracks is a constant.

As shown in Figure 2, data to be recorded are first fed into a buffer. A master oscillator and programmable frequency synthesizers generate clock signals at the appropriate data rates, and these clock signals are used to transfer the data from the buffer to the recording circuits at the rates appropriate for the two tracks in use. During readout, data from the two reading circuits are fed into the buffer. With the help of either timing signals interspersed with the data or clock signals from the master oscillator, the buffer reassembles the data from the tracks into an output signal containing the sequence of data recorded previously. Since each numbered pair of tracks contains the same constant number of bits, the data rate is also a constant.

If the number of tracks on each disk is large, the circuitry necessary to generate the correspondingly large number of recording and playback frequencies can be excessively complicated. In that case, it is more practical to group convenient numbers of adjacent tracks together and use the same data rate on all tracks within each group on a disk. For example, on a pair of disks with 100 tracks each, tracks could be arranged in groups of 10, with a combined data rate of 2.9 Mb/s on each numbered pair of tracks. In this example, tracks 91 through 100 would have a data rate of 1.0 Mb/s on disk A and 1.9 Mb/s on disk B. On a disk on which the outermost track has twice the radius of the innermost track, this arrangement yields a data rate 95 percent of the ideal rate and utilizes the recording area at 95.5 percent of the ideal utilization.

This work was done by Ronald M. Muller of **Goddard Space Flight Center**. *For fur-*

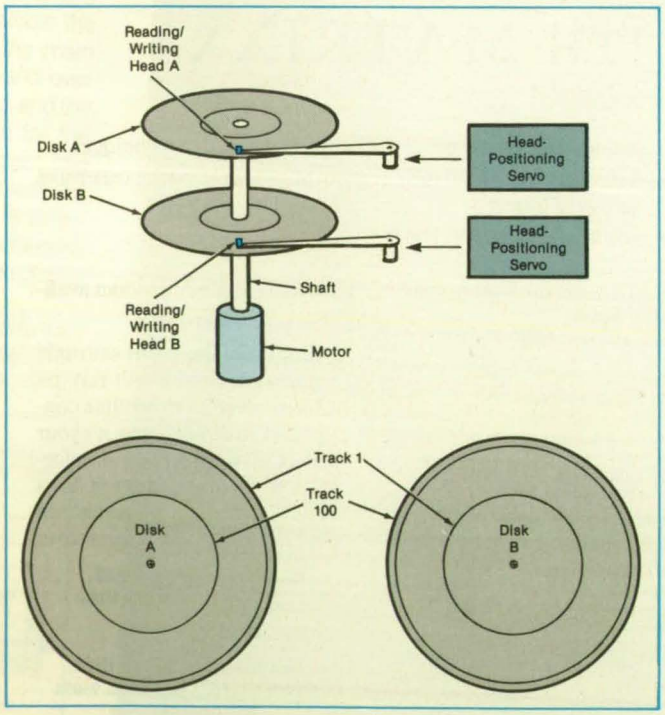
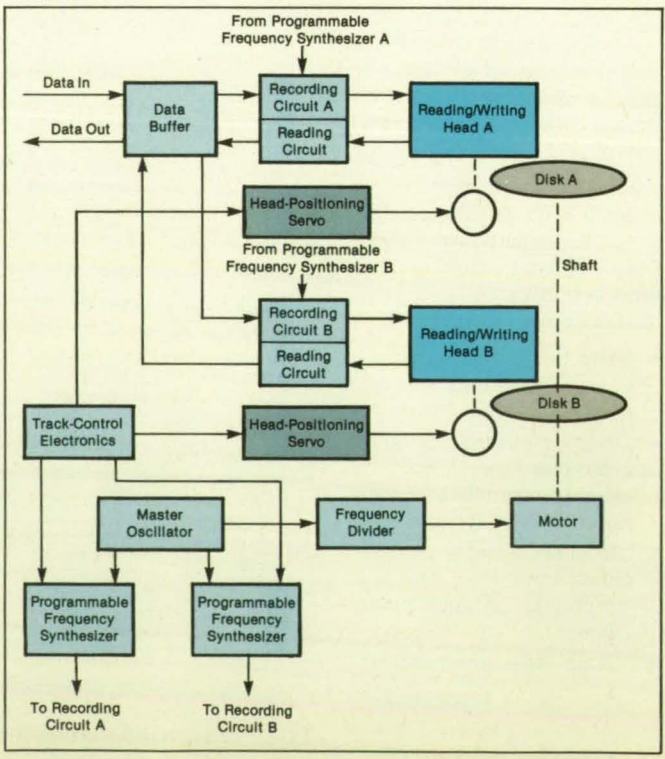


Figure 1. **Two Disks,** each with its own reading/writing head, are used to record data at the same time. The head on disk A operates on one of the tracks numbered from the outside in; the head on disk B operates on the track of the same number in a sequence from the inside out.

Figure 2. This **Timing, Motor-Drive, Recording, and Playback Circuitry** is essential to the operation of the fast, high-capacity disk drive.



ther information, Circle 22 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 25]. Refer to GSC-13196

Double Differential Encoding and Detection in MPSK

It would not be necessary to estimate Doppler shifts.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed communication system based on multiple-phase-shift-keying (MPSK) modulation would include a double differential encoder in the transmitter and a double differential detector in the receiver. The overall effect of the double-differential scheme would be to cancel the effect of the Doppler shift on the modulation in the received signal. It would not be necessary to estimate the Doppler shift to correct for it — an important advantage where the Doppler shift is unknown or is changing rapidly.

In the transmitter (see Figure 1), the baseband sinusoid $s(t)$ with the original phase modulation $\phi(t)$ (where t = time) would first be differentially encoded with delay T (where T = one symbol period) to obtain a signal $s_1(t)$ with phase modulation $\theta_1(t) = \theta_1(t-T) + \phi(t)$. This signal would be further differentially encoded with delay $2T$ to obtain the transmitted baseband signal, which would have phase modulation

$$\theta_2(t) = \theta_2(t-2T) + \theta_1(t)$$

(see Figure 1).

At the receiver, the incoming baseband signal would be of the form

$$x(t) = \rho(t)\exp\{j[\theta_2(t) + \omega_d t + \eta(t)]\}$$

where $\rho(t)$ = the amplitude of the received signal plus noise, ω_d = the Doppler shift in angular frequency, and $\eta(t)$ = the phase noise. This signal would first be differentially detected with delay $2T$ to obtain $x_1(t)$, in which the Doppler component of the phase would be "frozen" at $2\omega_d T$ (see Figure 2). Signal $x_1(t)$ would then be further differentially detected with delay T to remove the "frozen" Doppler component and recover the original phase modulation $\phi(t)$. Specifically, the phase of the double-differentially detected signal $x_2(t)$ would be $\phi(t) + \delta\eta(t)$, where $\delta\eta(t)$ is the double-differential phase noise

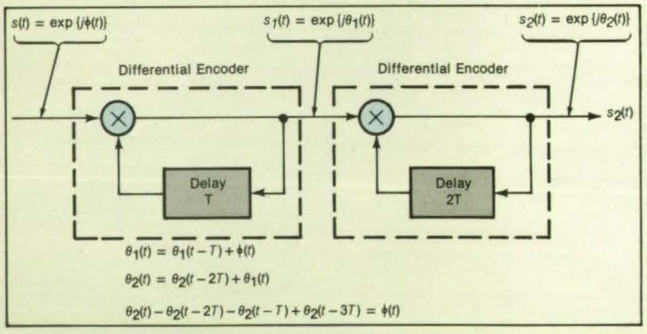
$$\eta(t) - \eta(t-2T) - \eta(t-T) + \eta(t-3T)$$

The decision regarding the received phase modulation $\phi(t)$ would be made in the traditional manner for MPSK. The system would work as described as long as the Doppler component of phase would not vary appreciably during at least $4T$.

The double-differential scheme corrects for a phase error that has a first derivative (only) with respect to time. It could be generalized to a multiple-differential scheme to correct for the rate of change of the Doppler frequency shift and other higher-order derivatives. In general, the output of the kth differential detector would be free of the first k derivatives of the phase error.

This work was done by D. Divsalar and M. K. Simon of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 96 on the TSP Request Card. NPO-17666*

Figure 1. The **Double Differential Encoder** in the transmitter would generate a phase-modulated signal suitable for decoding and detection by the subsystem illustrated in Figure 2. The baseband signals at three stages of the encoding process are represented in complex-number form.



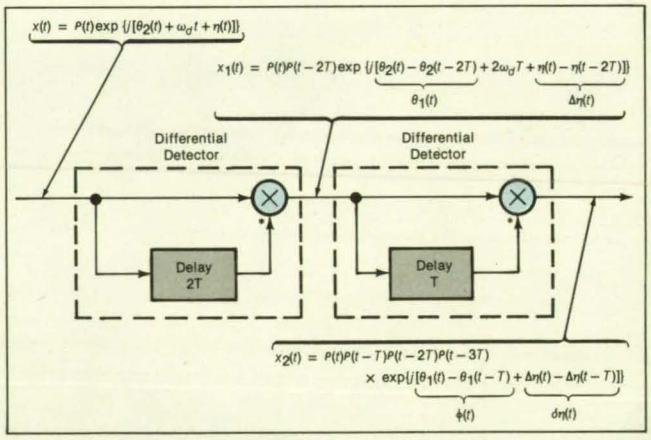


Figure 2. **Double Differential Detector** would remove the Doppler-frequency component from a noisy, Doppler-shifted signal that had been encoded in a subsystem like that shown in Figure 1. The asterisk near each multiplier symbol denotes multiplication by the complex conjugate of one of its input signals.

Programmable Remapper

An input image is remapped rapidly and accurately onto a different coordinate grid.

Lyndon B. Johnson Space Center, Houston, Texas

An analog/digital electronic image-processing system is being developed to warp input images onto arbitrary coordinate grids at video rates. In one potential application, the transformation of an image from Cartesian to polar-exponential or log-spiral coordinates would change rotational motions or simple magnifications in the input scene into translations in the output scene, and the translation-invariant properties of the output scene could be utilized by a pattern-recognition robotic-vision subsystem. Other applications include real-time corrections of distortions in the input optics of image sensors, corrections for repeatable nonlinear scanning, and aiding persons of impaired vision by deliberately distorting images onto remaining functional portions of their retinas.

The figure illustrates the many-to-one aspect of the transformation performed by the system. First, each picture element of the 1,024- by 1,024-element input image is assigned a sequence number. The intensity of each picture element is digitized in sequence to 8 bits. The sequence number is used as an address pointer for two "lookup

Get a close look at the big picture.

With the new HI JetPro™ printer/plotter.

Select your drawing. Preview it on your monitor. Zoom in on the tightest detail. Clip it, scale it, mark a "window." Then press a key to get a high-quality hardcopy of the segment you want.

You can do all of this—*plus* high-speed draft and letter-quality printing—with one machine: the HI JetPro printer/plotter.

The flexible hardcopy control system

Whether it's an E-size drawing or a scanned data file, HI JetPro delivers the flexibility you need and the image you want. With HI's JetPro, you have a complete hardcopy control system that includes hardware and software for high-speed, high-resolution printing and plotting—in both vector and raster environments.

Convenient, quiet, and precise

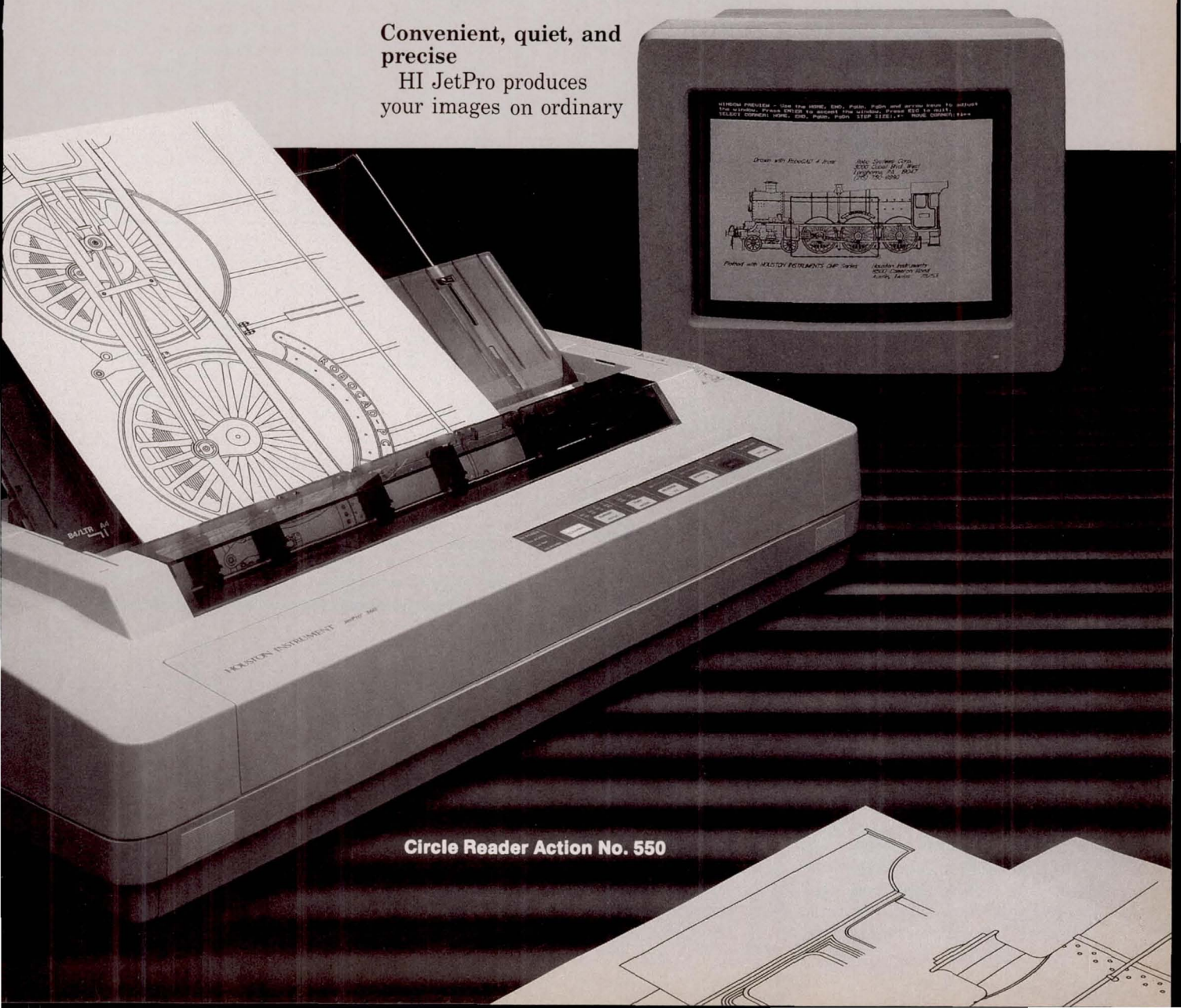
HI JetPro produces your images on ordinary paper, in sizes up to 16.5 × 23.3 inches (DIN A2), with the incredibly sharp clarity of 360 dpi. And because it's a bubble-jet, it prints and plots quickly and quietly.

Simple to use and easy to maintain, the HI JetPro printer/plotter is fully backed by Houston Instrument's reputation for price-performance, quality, and support.

To get a closer look, call *1-800-444-3425* or 512-835-0900.

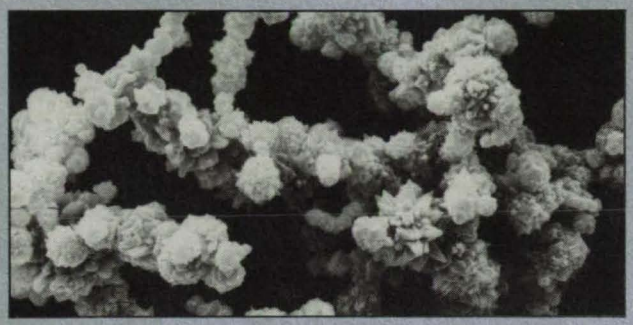
HOUSTON INSTRUMENT™

8500 Cameron Road, Austin, TX 78753

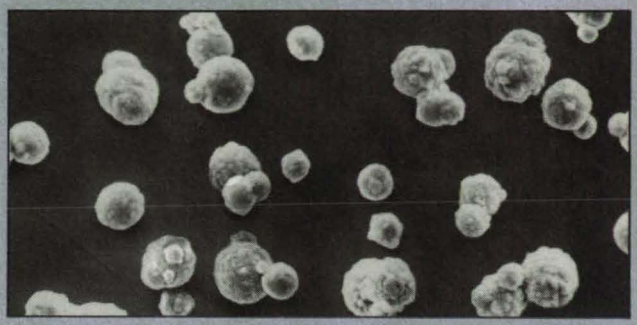


Circle Reader Action No. 550

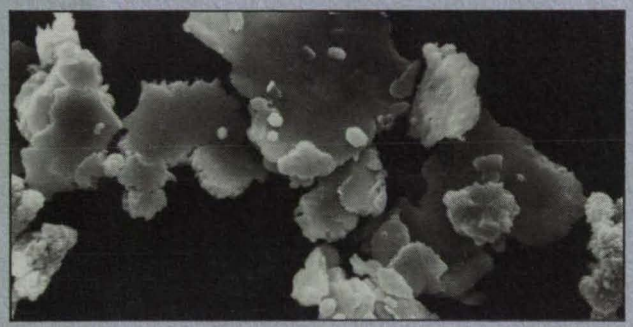
SPECIFY INCO SPECIALTY POWDERS FOR WIDE RANGE OF ELECTRONIC APPLICATIONS



Inco Type T 287 Filamentary Powder, particle size (FSSS) 2.6-3.3 microns, apparent density 0.75-0.95 g/cc, relative surface resistivity 0.30 ohms per square (□).



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



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

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

Inco Specialty Powder Products now has a wide range of nickel and coated powders with exceptional conductive and magnetic properties. These properties make them ideal for a spectrum of electronic applications such as conducting film technology, coatings, adhesives, gaskets and EMI shielding.

EXTENSIVE PRODUCT RANGE

The development of computer processed control coupled with the continuous powder production improvements enables us to meet your most stringent powder specifications for electronic applications.

In addition to the products pictured above, INCO SPP has available the following high performance powder products. Novamet Conductive Nickel Spheres, particle size (FSSS) 8-9 microns, apparent density 3.2-3.5 g/cc, surface resistivity 1.0 ohms per square. Novamet 525 Conductive Nickel Pigment, screen mesh 100% minus 400, particle size 3.2 microns, 0.65 BET surface area m^2/g, surface resistivity 0.35 ohms per square. Silver Coated Nickel Flake, 15% Ag, 2.6 g/cc apparent density, particle size (FSSS) 15 microns, screen mesh 99% minus 200, surface resistivity 0.04 ohms per square.

Magnetic ferrites and surge arrestor applications also use our specialized range of nickel oxides. High Purity Black Nickel Oxide, 77.2% Ni, BET 75 (m^2/g) particle size (FSSS) 5.2 microns, minus 325 mesh 99% plus. Green Nickel Oxide, 78.5% Ni, BET 3 (m^2/g) particle size 1.6 microns, −325 mesh 100%.

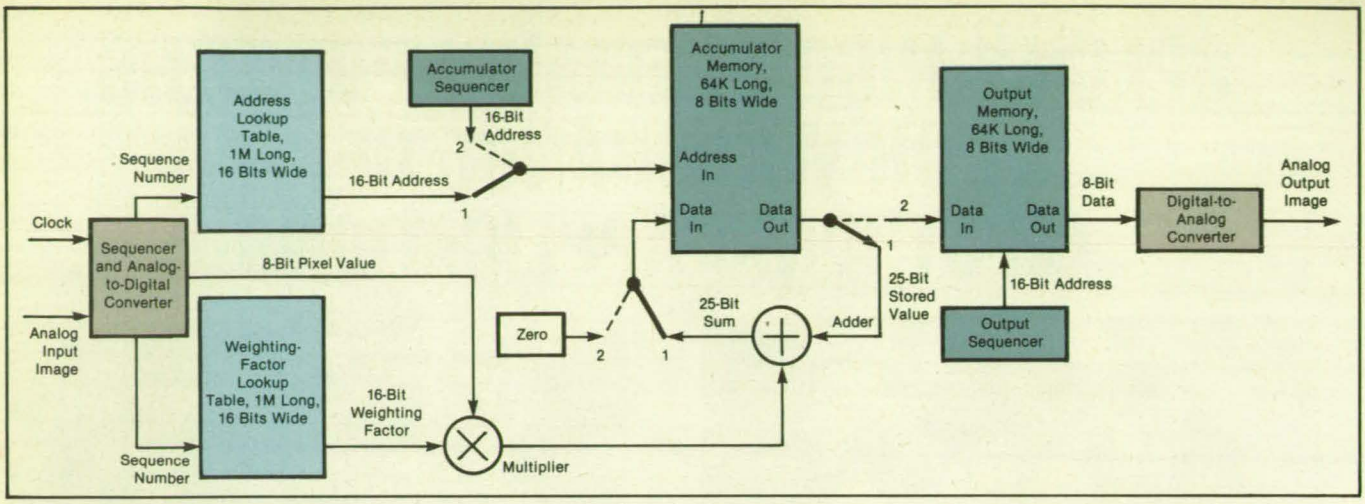
Inco Specialty Powder Products is your unique source for custom fitting high performance powders into electronic applications. Our customer focused, world-wide marketing service group is ready to help you with your current and future needs.

For more information write INCO Specialty Powder Products, Dept. 1-90, Park 80 West-Plaza Two, Saddle Brook, NJ 07662

INCO SPP

Park 80 West-Plaza Two, Saddle Brook, NJ 07662
Shin-Muromachi Building, 4-3 Nihonbashi-Muromachi 2-Chome, Chuo-ku, Tokyo 103 Japan
1-3 Grosvenor Place, London SW1X7EA England
15/Fl Wilson House, 19-27 Wyndham Street Central, Hong Kong

Circle Reader Action No. 452



The **Many-to-One Processor** performs a rapid geometric transformation of a higher-resolution input image into a lower-resolution output image. The numerical values of the transformation are fetched from a "lookup-table" memory generated from the equations of the transformation.

tables" contained in programmable random-access memories: One table contains the weighting factor of each picture element for the geometric transformation; the other table contains the address in an accumulator memory that corresponds to the location of the picture element in the 256- by 256-element output image onto which the input picture element is to be mapped.

The result of each weighting multiplication is accumulated at the appropriate address in the accumulator memory along with the results of any previous multiplications from other input picture elements that contribute to the same output picture element. After all the input elements in a frame have been so processed, the 8 most significant bits of each output picture element are dumped to an output memory, and the accumulator memory begins to accumulate the next frame. An output sequencer feeds the contents of the output memory to a digital system for further processing or to a digital-to-analog converter for display as the output image.

For simplicity, the figure does not include the subimage processor, which is a subsystem that performs a partly one-to-many mapping. The subimage processor synthesizes picture elements in the input image that lie between the actual elements; this is necessary in regions where the transformed coordinate grid becomes so fine that it requires picture-element spacings smaller than those of the input image. The subimage processor operates on 4- by 4-element patches of the input image, performing a combined interpolation of up to cubic order and remapping via an algorithm distinct from that of the many-to-one processor. The many-to-one and subimage processors operate in parallel on each frame of data, and the outputs of both are processed into one composite image.

The principal advantages of the new system include the antialiasing effect of the many-to-one data path and the speed of lookup-table operation. Furthermore, the lookup tables can be reprogrammed easily with the help of a computer that generates the table values from a mathematical description of the desired transformation.

This work was done by Richard D. Juday and Timothy E. Fisher of **Johnson Space Center** *and Jeffrey B. Sampsell of Texas Instruments, Inc. For further information, Circle 136 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 25]. Refer to MSC-21350

Simplified Dynamic Control of Redundant Manipulators

Extra degrees of freedom are used to perform subtasks.

NASA's Jet Propulsion Laboratory, Pasadena, California

A simplified scheme has been proposed for the dynamic control of a robotic manipulator that has redundant joints; that is, extra degrees of freedom beyond those needed to perform the task, which is to position and orient the end effector at a specified position and/or move it along a specified trajectory. The extra degrees of freedom can be used to perform a simultaneous subtask (for example, to avoid obstacles or to keep joint angles within ranges that maximize manipulability). The new control scheme is adaptive and is based on the observed performance of the manipulator. It involves neither a complicated mathematical model of the dynamics of the manipulator nor a time-consuming inverse kinematic transformation.

In a system of n degrees of freedom, the position and orientation of the end effector are represented by an m-dimensional coordinate vector $\mathbf{Y}$, while the kinematic functions are represented by the r-dimensional vector $\boldsymbol{\phi}$, where $r+m=n$. The redundancy can be utilized by placing kinematic equality constraints on $\boldsymbol{\phi}$ to specify the subtask. Then the task and subtask vectors can be combined to obtain $\mathbf{X} = \begin{pmatrix} \mathbf{Y} \\ \boldsymbol{\phi} \end{pmatrix}$, the augmented n-dimensional vector, which increases the apparent dimension of the task space from m to n. In this formulation, the configuration of the manipulator is fully specified and is not redundant.

The velocities of the manipulator are related via

$$\dot{\mathbf{X}}(t) = J(\theta)\dot{\theta}(t)$$

where t = time, θ represents the joint angles, and

$$J(\theta) = \begin{pmatrix} J_e(\theta) \\ J_c(\theta) \end{pmatrix}$$

is the $n \times n$ augmented Jacobian matrix. The $m \times n$ submatrix $J_e(\theta)$ is associated with the end effector, while the $r \times n$ submatrix $J_c(\theta)$ is related to the kinematic functions. The two submatrices J_e and J_c combine to form the square augmented Jacobian matrix J.

The problem is to devise a scheme that makes $\mathbf{X}(t)$ track the desired trajectory $\mathbf{X}_d(t)$ as closely as possible. In the control scheme shown in Figure 1, the actual end-effector coordinates $\mathbf{Y}(t)$ and the current values $\boldsymbol{\phi}(t)$ of the kinematic functions are computed and fed back to the controller. The controller uses this feedback information together with the commanded end-ef-

MATLAB™

High-Performance Numeric Computation and Data Analysis

MATLAB has rapidly become an industry standard for engineering and scientific research. Its unique interactive interface, algorithmic foundation, easy extensibility, and speed make MATLAB the software system of choice for ***high productivity and high creativity*** research.

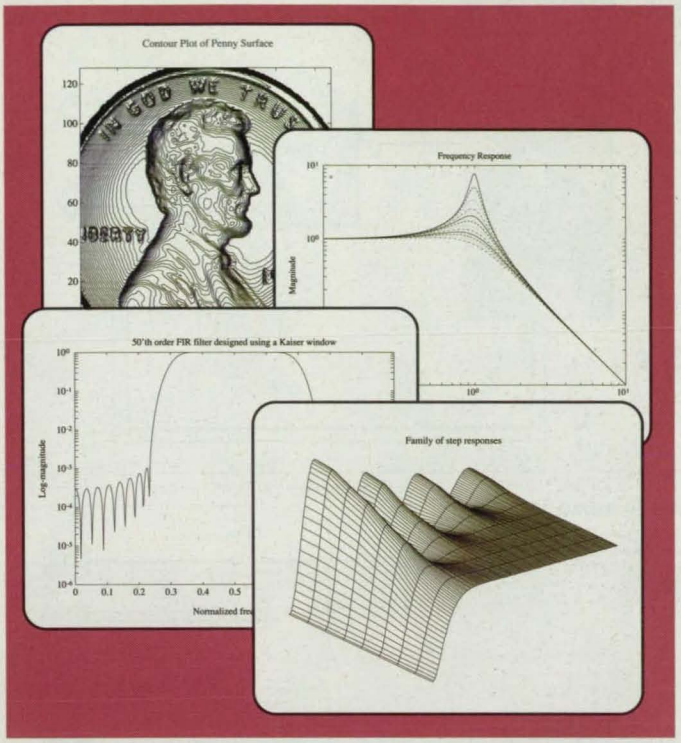
Problems and solutions are expressed just as they are written mathematically—***without the need for traditional programming***. As a result, you can solve numerical problems in a fraction of the time required to write a program in Fortran, Basic, or C. Then plot the results as 2-D and 3-D graphics, with publication-quality output to plotters, dot-matrix printers, and laser printers.

"I can create algorithms so easily that it almost seems like cheating."

Amnon Aliphas, Personal Engineering & Instrumentation News

Add to MATLAB your choice of tools for digital signal processing, system identification, control system design, and more. MATLAB's open-system design lets you see the algorithms and the implementations, even change them to suit your specific requirements.

MATLAB is developed by The MathWorks, a leader in software for data analysis and mathematics. Our users—in thousands of companies and universities—know that MATLAB enables them to work more creatively and productively. Take a look at how MATLAB can do the same for you.



Over 300 Built-In Functions

- eigenvalues
- matrix arithmetic
- matrix decompositions
- convolution
- spectrum estimation
- complex arithmetic
- 1-D and 2-D FFTs
- filtering
- curve fitting
- cubic splines
- Bessel functions
- elliptic functions
- nonlinear optimization
- linear equation solving
- differential equations
- polynomial arithmetic
- descriptive statistics
- 2-D and 3-D graphics

Plus Toolboxes for:

- digital signal processing
- parametric modelling
- control system design
- chemometric analysis, and more

"MATLAB is the undisputed choice for computation-intensive engineering work."

Charles Seiter, Macworld

"MATLAB's power and ease of use go a long way toward taking the drudgery out of repetitive analysis projects."

Richard Santalesa, IEEE Spectrum

Computers supported

PCs and ATs
386-based PCs
Macintosh
Sun
Apollo
HP 9000/300
DECstation
VAX/VMS
VAX/Ultrix
Stardent
Convex
Encore
Alliant
Cray
and more

To find out more about MATLAB, call us at **(508) 653-1415**. Or simply return the completed coupon to the address below.

Name _____

Company _____

Department _____

Address _____

City, State _____

Zip _____ *Country* _____

Telephone _____

Computer(s) _____

The MATH WORKS Inc.

21 Eliot Street
South Natick, MA 01760
Phone: (508) 653-1415
Fax: (508) 653-2997

NASA 6/90

Circle Reader Action No. 503

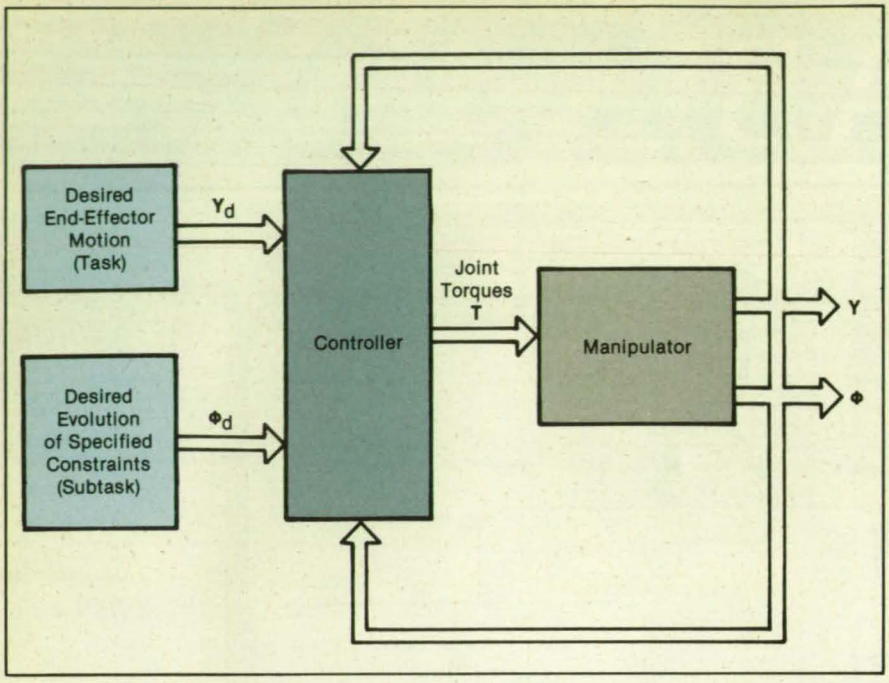


Figure 1. The **Control Scheme for the Redundant Manipulator** makes the actual manipulator trajectory $\begin{pmatrix} Y \\ \Phi \end{pmatrix}$ track the desired trajectory $\begin{pmatrix} Y_d \\ \Phi_d \end{pmatrix}$.

fector motion $\mathbf{Y}_d(t)$ and the desired kinematic functions $\Phi_d(t)$ to compute the driving torques $\mathbf{T}(t)$ that are applied at the manipulator joints so as to meet the task and subtask requirements simultaneously.

The scheme involves feedforward and feedback paths with adjustable gains, which implement a control law based on the theory of model-reference adaptive control, and is illustrated in Figure 2. The control signal is produced on the basis of the performance of the manipulator, with minimal information on the manipulator and payload. Thus, the scheme can cope with unpredictable gross variations of the payload.

This work was done by Homayoun Seraji of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 16 on the TSP Request Card.*
NPO-17593

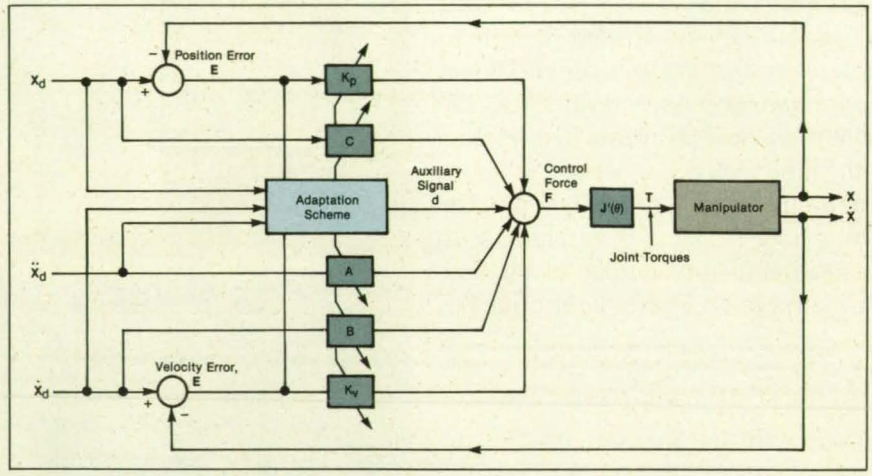


Figure 2. The **Adaptive Controller** implements a model-reference control law. The controller is very simple because the gains (represented by the symbols in the rectangles) are calculated by numerical integration using, for example, the trapezoidal rule. Thus, the time required for the computations is very short.

Compact Analyzer/Controller for Oxygen-Enrichment System

This system controls hypersonic air-breathing engine tests.

Langley Research Center, Hampton, Virginia

An O_2-enrichment system was needed for NASA Langley Research Center's new 8-ft (2.4-m) High-Temperature Tunnel (8′ HTT), which will be used for testing hypersonic air-breathing engines. To test this system, a compact analyzer/controller has been developed, built, and tested in a small-scale wind tunnel that is a prototype of the 8′ HTT.

The atmosphere in the system is sampled through a specially designed probe and transported to a platinum-coated zirconia cell kept at a temperature of 800 °C. This cell produces a voltage proportional to the difference between the O_2 contents of the gases on the two faces of the cell. Air is used as the reference gas.

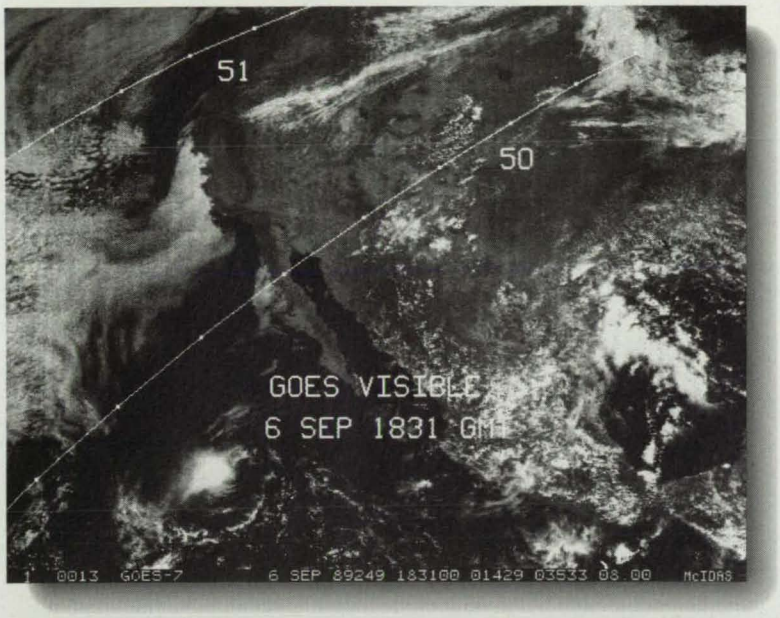
The sampling probe is cooled, thus cooling the sample gas and necessitating an in-line heater to bring the sample back up to 300 to 800 °C to improve the response of the sensor. In addition, a compressor is used to increase the flow of the sample to about 6,000 to 8,000 cm^3/min and to raise simultaneously the pressure of the gas sample. A vent to the atmosphere is provided to ensure that the sample is at atmospheric pressure when it arrives at the face of the cell. This arrangement keeps the pressure constant across the zirconia cell and allows the use of relatively simple equations to calculate the O_2 content of the sample gas.

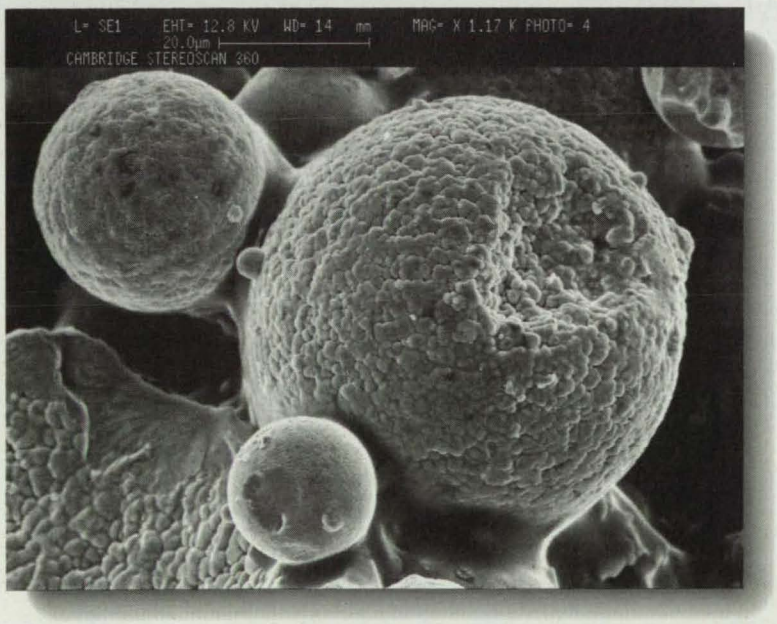
The result of a typical run is shown in the upper right portion of the figure. When the wind tunnel is started with air, the continuous-immersion probe displays the 20.95-percent O_2 content of air. The accuracy of the readout is about 1.0 percent. The sensor reading is updated every 0.2 second, making the system capable of essentially real-time control of the liquid-oxygen valve. The response time of the detector is only about 30 ms, but the total response time of the system is about 200 ms, achievable with short lengths of the probe-to-detector line.

When combustion is established, the O_2 content drops rapidly to 5 percent or less. The system is brought to a stable total pressure and temperature, with typical values of 800 to 2,000 psia (5.5 to 14 MPa absolute) and 3,000 to 3,500 °R (1,700 to 1,900 K), respectively. The system for the addition and control of liquid oxygen is then brought on-line, and the O_2 content rapidly rises. The addition of liquid oxygen is controlled manually and then switched to the automatic preset or closed-loop control to bring the O_2 content to the desired level of 20.95 percent, simulating air.

The control of the system is remarkably stable, with very little overshoot, thus minimizing the time required before the engine could be inserted in the test medium. To determine fully the stability and controlla-

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.

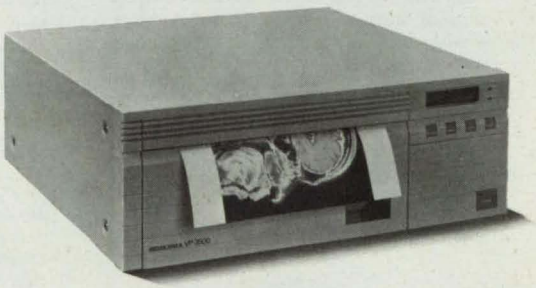
Our 1280-line, multi-format video printer can make things perfectly clear.

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

bility of the system, preset values of O_2 content greater and less than that of air were tried with equally good results and without any abnormality in the control.

The prototype system has been thoroughly tested and will serve as the basis for a similar system for use in the full-scale 8′ HTT. For the full-scale system, control will be managed by a high-speed computer and control system with all of the logic and controls emanating from the computer, except for an emergency manual override. The incorporation of an automatic oxygen control in the 8′ HTT will ensure meaningful ground tests of hypersonic engines in the range of speeds from mach 4 to mach 7.

This work was done by Richard L. Puster, Jag J. Singh, and Danny R. Sprinkle of **Langley Research Center**. *Further information may be found in:*

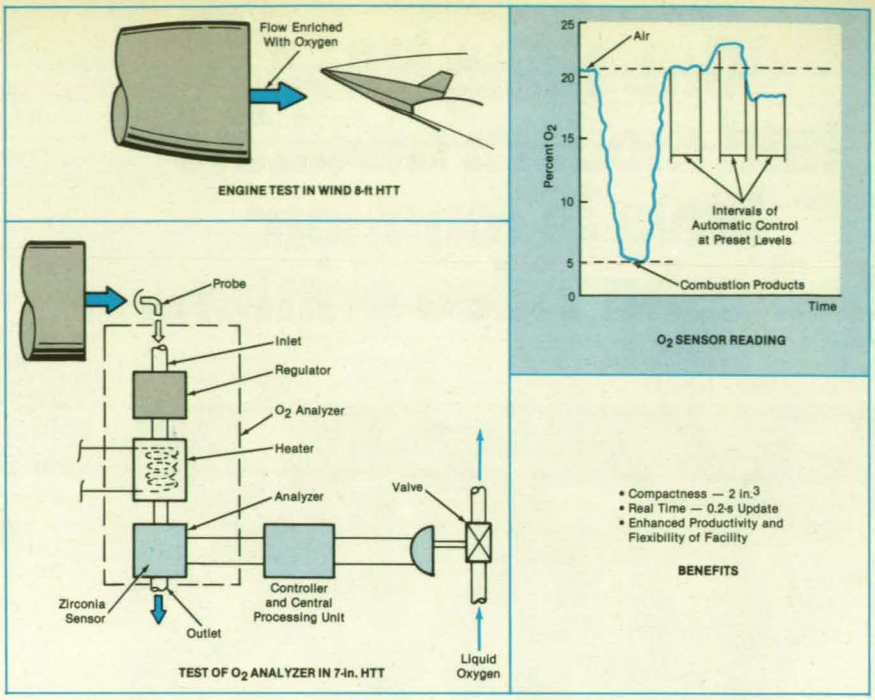
NASA TP-2218 [N84-11460], "Proposed Fast Response Oxygen Monitoring and Control System for Langley 8-Foot High Temperature Tunnel,"

NASA TP-2531 [N86-20753], "New Method for Determining Heats of Combustion of Gaseous Hydrocarbons," and

NASA TP-2682 [N87-20514], "A Simplified Method for Determining Heat of Combustion of Natural Gas."

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-14016



The Compact Analyzer/Controller monitors the level of oxygen and controls the addition of liquid oxygen to enrich the atmosphere for combustion.

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.

Robust Adaptive Control in Hilbert Space

This analysis is particularly relevant to the control of large, flexible structures.

A paper discusses the generalization of a scheme for the adaptive control of a finite-dimensional system to an infinite-dimensional Hilbert space. This is an important topic because all physical systems are distributed, and therefore, complete representations would require, in principle, infinite numbers of degrees of freedom. These considerations are particularly relevant to systems for the active control (e.g., the suppression of vibrations) of large, flexible structures.

The goal of this study is to find a methodology for the design of model-reference adaptive controls for systems of both finite and infinite numbers of dimensions, of both single-input/single-output and multiple-input/multiple-output, and in which the orders of the plants to be controlled are unknown. The approach involves a generalization of the command-generator tracker (CGT) theory. The appeal of this method is that it does not require the reference model to be of the same order as that of the plant, and the knowledge of order of the plant is not needed. In fact, state space may even have an infinite number of dimensions. However, alternative assumptions are needed to ensure closed-loop stability.

This method is naturally suitable for application to high-order systems inasmuch as its main emphasis is on the adjustment of a low-order feedback-gain matrix. The disadvantage is that instead of the dimensionality requirement, there are other conditions to be satisfied. While the generalization of the CGT technique to the infinite-dimensional systems is not straightforward, it is very promising. The three principal obstacles to the generalization are the following: (1) the solution of the Lyapunov equation may not be coercive, (2) the invariance principle cannot be applied immediately, and (3) strict positive realness is never attainable without positive feedthrough.

A previous modification of the adaptive control law of the finite-dimensional controller partially overcame these obstacles. In exchange, only the Lagrange stability of the error signal has been shown. This paper suggests a further modification, in which the error signal is shown to be driven to a residue set asymptotically.

It is shown that if there exists an output feedback in the further-modified controller such that the closed-loop system is close to positive realness (in the sense that there exists a small fictitious feedforward that makes the closed-loop system positive real), then Lagrange stability is assured. This is an improvement in that stability is achieved in the original space and asymptotic stability is maintained for the finite-dimensional case (i.e., the modification is a true generalization and the performance in the finite-dimensional case is not compromised). As an additional bonus, Lagrange stability is preserved under a variety of perturbations; e.g., singular and regular perturbations, bounded state and output noises, and the perturbation of the model-matching condition (the CGT condition).

The example of a simple damped beam is presented to illustrate the techniques. The nominal, the sensor-actuator-misaligned, and the noise-disturbance cases are simulated to show that behavior of the closed-loop system agrees with the theory.

This work was done by John Ting-Yung Wen of Caltech and Mark J. Balas of the University of Colorado for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Robust Adaptive Control in Hilbert Space," Circle 80 on the TSP Request Card.*
NPO-17588

Selecting Modulation Indices for Telemetry and Ranging

Undesired signals are suppressed and power is divided optimally among channels.

A report describes an algorithm for the selection of optimum modulation indices in a system for communication between a ground station and a spacecraft, in which the ranging channel is operated simultaneously with the data (command and telemetry) channel. The algorithm provides for the optimum division of power among the data, ranging, and carrier channels and reduces the degradation of performance by undesired interferences among signals.

The effects that one seeks to minimize are due mainly to the feedthrough of various modulation, intermodulation, cross-modulation, and noise components. The algorithm calculates the magnitudes of these effects and searches for the modulation indices for which (a) the radio-frequency-carrier demodulator does not degrade the threshold value of the signal-power-to-noise-density ratio (SNR) of the data channel, (b) the data channel achieves a desired performance in the presence of the ranging signal, (c) a specified ranging accuracy can be achieved, and (d) the useful power in the first-order sidebands of both data and ranging channels is as large as possible while still consistent with constraints (a), (b), and (c).

The algorithm consists of the following steps:

1. Calculate the threshold requirements.
2. Using the results from step 1, calculate the ratio of the SNR's of the data and carrier channels and the ratio of SNR's of the data and ranging channels.
3. Specify the desired degradation Δ_D(dB) in the data channel due to interference from the ranging channel, the required bit-error rate, and the required SNR; and calculate the maximum ranging power level P_t(dB) that falls in the data channel.
4. Calculate the ranging suppression, Δ_S, relative to the data channel for the specified Δ_D.
5. Using the result from step 4, calculate the design factor k, which depends on (among other things) the SNR's of the ranging and data channels.
6. Using the value of k from step 5, determine whether too much power is being allocated to the data or to the ranging channel for the specified degradation Δ_D.
7. For a particular modulation scheme, develop the expressions for the power in each channel as a function of the modulation indices.
8. Using the relation found in step 7, plot the ranging modulation index as a function of the data modulation index. A specific set of modulation indices can now be obtained.
9. Find the ratios of first-order data-sideband and first-order ranging-sideband power to total power corresponding to the particular set of modulation indices; plot these power ratios as a function of the data modulations in the same plot described in step 8.
10. Bound the values of the modulation indices of the data and ranging channels, observing that these modulation indices are mutually dependent subject to the requirement that the carrier threshold be equal to or lower than the data threshold.
11. Select the set of modulation indices for the data and ranging channels that correspond to the largest values of the curves of step 9 that satisfy the specified degradation Δ_D, constraining these values to within the boundary set established in step 10.

This work was done by Tien M. Nguyen of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Technique To Select the Optimum Modulation Indices for Suppression of Undesired Signals for Simultaneous Range and Data Operations," Circle 152 on the TSP Request Card. NPO-17535*

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® fluoropolymer 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

Physical Sciences

Compounds Generate Optical Second Harmonics

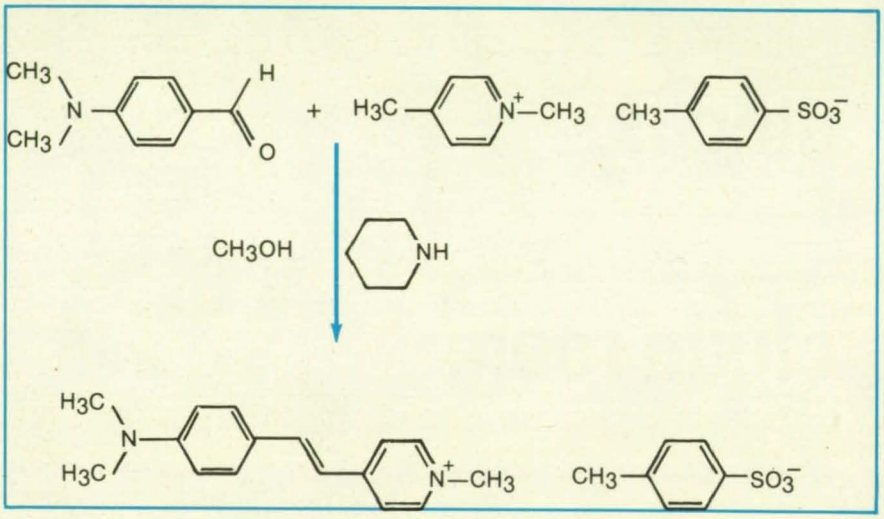
Large second-order nonlinear susceptibilities are observed.

NASA's Jet Propulsion Laboratory, Pasadena, California

Newly synthesized organic salts have been found to generate relatively large second-harmonic signals when illuminated by fundamental signals in the near-infrared spectrum. These and other compounds that have large nonlinear optical properties may eventually find use in electro-optical modulators, switches, and signal-processing equipment.

The new organic salts have the general formula $R(CH=CH)_n-(p-C_5H_4N-CH_3)^+X^-$, where R can be one of a variety of organic electron-donor moieties; $n = 1$, 2, or 3; and X can be, for example, Cl^-, $CF_3SO_3^-$, BF_4^-, PF_6^-, $p-CH_3-C_6H_4SO_3^-$, $CH_3SO_4^-$, or HSO_4^-. These compounds were "designed" to have molecular structures that enhance second-order nonlinear electric susceptibilities. They are made by crystallizing, with appropriate counterions, organic ions that have large molecular hyperpolarizibilities. By selection of the species of counterions, one can strongly affect the packing of molecules and the structures of crystals of these molecules. The species of counterions that yield structures favorable to second-order nonlinear susceptibilities can be found by experimentation.

The figure illustrates the experimental synthesis of one of the new salts. The two main ingredients shown at the top of the figure were reacted in methanol in the presence of piperidine at a temperature of 60 °C for 4 hours. The product was filtered and precipitated with diethyl ether to obtain a 60-percent yield of the salt, shown at the bottom.



The **Organic Salt** synthesized by this process has the highest second-harmonic-generating efficiency of any compound tested thus far.

The visible-absorption spectrum of this salt includes a charge-transfer band, the middle wavelength of which is sensitive to solvents. When the salt is dissolved in acetonitrile, this band lies at 468 nm; in methanol, it lies at 474 nm. When illuminated with 1.907-nm light (produced by Raman shifting, in hydrogen, the 1.064-μm light of a neodymium:yttrium aluminum garnet laser), a powder of this salt exhibited a second-harmonic-generating efficiency 1000–2000 times that of a urea reference standard.

This work was done by Seth R. Marder and Joseph W. Perry of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 58 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 25]. Refer to NPO-17731

Determining Polarities of Distant Lightning Strokes

Two features of the signal from each stroke appear to be correlated.

Marshall Space Flight Center, Alabama

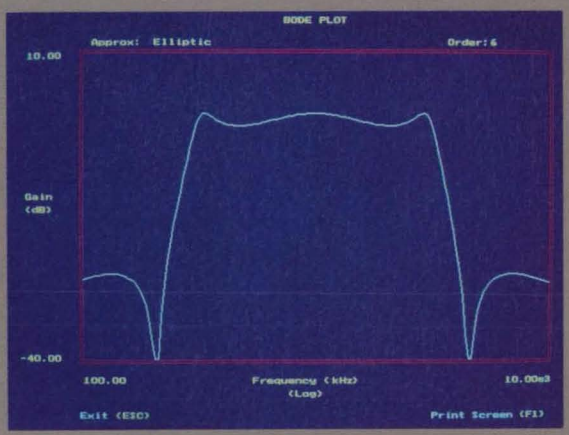
A method for determining the polarities of lightning strokes more than 400 km away is the subject of continuing research. There is a growing awareness among scientists investigating lightning that the polarities of return strokes may be important indicators of phenomena in thunderstorms and that the predominance of positive strokes in winter thunderstorms may be particularly significant. At present, lightning networks can reliably determine the polarities of only those return strokes that occur within about 500 km of the receiving stations.

The return stroke is the main stroke, the intensely luminous streamer that propagates upward from the ground in the last phase of each stroke of cloud-to-ground lightning. The polarity of the return stroke is defined as the polarity of the electric charge lowered to ground. The polarity is determined from the polarity of the initial deflection in the very-low-frequency (up to 30 kHz) waveform of the electric and/or magnetic field radiated by the stroke. When a receiving station is more than about 500 km away from a lightning stroke, the determination of polarity by the conventional method is subject to uncertainty because the signal includes a strongly attenuated ground wave that may or may not be detected and a much stronger wave of

PSpice

MicroSim Corporation

The Standard for Circuit Simulation Has Expanded



Filter Designer Bode Plot

Filter Designer: *New* Front End Design Tool

Filter Designer, a member of the PSpice family, is an interactive design aid giving you the ability to design and analyze active filters. Features include a menu-driven interface, hard copy report summaries and plots, cascading multiple designs, and interfaces to PSpice and SWITCAP.

Filter Designer uses a well established methodology in applying classical approximations to your filter specification. Available filter types include low pass, high pass, band pass, and band reject, all of which may be synthesized by Butterworth, Chebyshev, Inverse Chebyshev, and Elliptic (Cauer) functions.

A full editing capability allows you to insert, delete, and reorder stages, and modify coefficient values. These editing features allow a filter expert to fine tune a design, or quickly make a small modification to an existing design.

Filter Designer supports both active RC and switched capacitor biquad filter structures. The components may be scaled or resized to center the values in preferred ranges.

Both Bode and pole-zero plots are available. Normally, you can determine the acceptability of your design by the inspection of its Bode plot. The Filter Designer plots gain, phase, and delay vs. frequency. For sampled data designs, you can plot your choice of the s- or z-domain transfer function. Pole-zero plots allow you to inspect the roots of the transfer function in either the s-domain or z-domain.

Filter Designer works with our PSpice circuit simulation package. PSpice and its options form an integrated package for the analysis of electronic and electrical circuits. The software enables you to create a "computer breadboard" of your circuit for testing and refinement without building hardware.

Each copy of PSpice and Filter Designer comes with our extensive product support. Our technical staff has over 150 years of experience in CAD/CAE, and our software is supported by the engineers who wrote it. Since its introduction over six years ago, PSpice has sold more copies than all other SPICE programs combined.

For further information about Filter Designer or any other PSpice product, please call us at (714) 770-3022 or toll free (800) 245-3022.

20 Fairbanks • Irvine, CA 92718 USA • FAX (714) 455-0554

Circle Reader Action No. 320

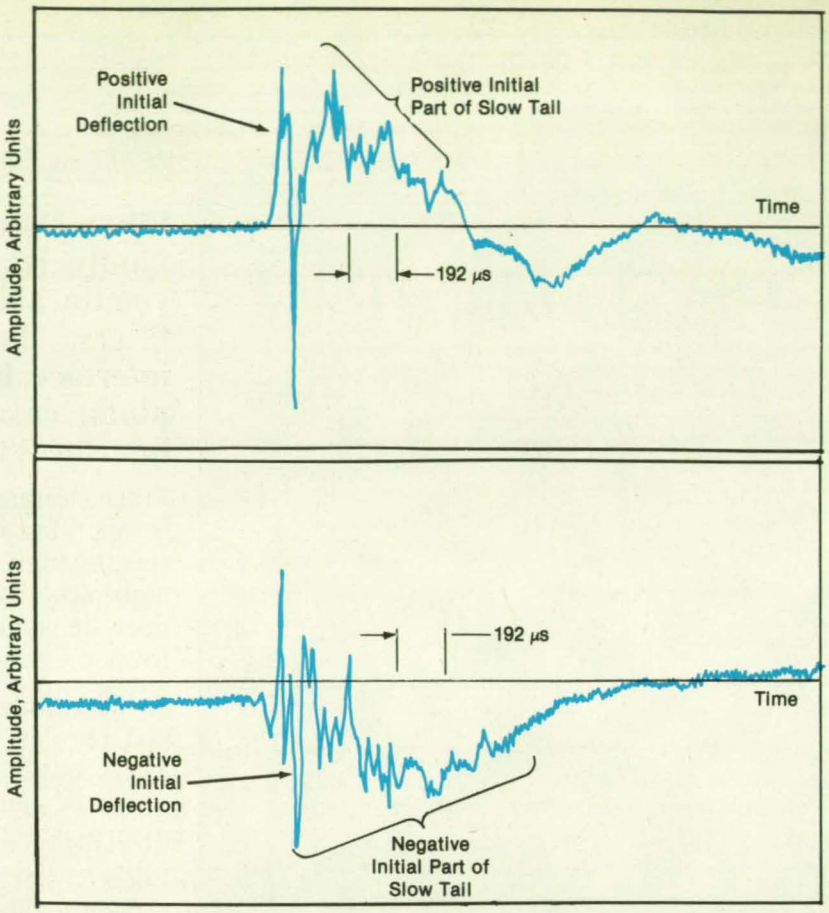
reverse polarity reflected from the ionosphere.

The very-low-frequency waveform includes a slow tail that is a low-frequency dispersion effect in the zeroth mode of the waveguide formed by the ground and the ionosphere. Probably not all cloud-to-ground lightning produces a slow tail in the waveform. However, there is some evidence that a slow tail indicates continuing current in the cloud-to-ground lightning flash. This continuing current is primarily responsible for lightning-caused forest fires and other lightning-related damage.

The new method is based on the fact that for each stroke observed thus far for which the polarity can be determined unambiguously, the initial polarity of the tail is the same as the polarity of the initial deflection before the initial-deflection signal is altered by propagation effects (see figure). In the new method, the receiving station is equipped with an electric-field-change antenna coupled to a charge amplifier that has a time constant of the order of 1 to 10 seconds. The output of the amplifier is fed to signal-processing circuitry, which determines the initial polarity of the tail.

This work was done by Richard J. Blakeslee of **Marshall Space Flight Center** *and Marx Brook of New Mexico Tech. For further information, Circle 111 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-26102



These **Electric-Field Signals** were received at Albany, NY from distant lightning strokes. The upper trace is from a stroke 895 km away at a bearing of 239°; the lower trace is from a stroke 2054 km away at a bearing of 212°. In each case, the initial polarity of the slow tail is the same as the polarity of the initial deflection.

Compact Sunshade for Telescope Antenna

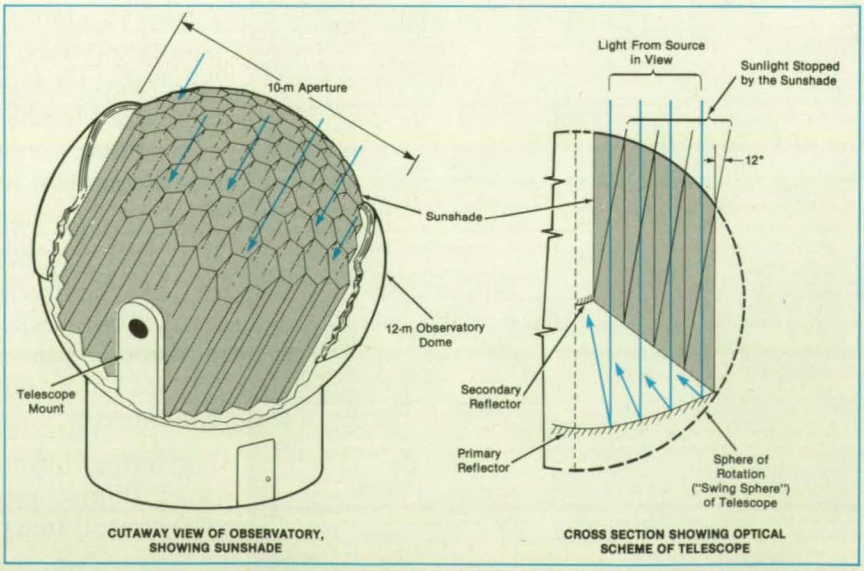
An optical receiver could detect sources apparently close to the Sun.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed built-in sunshade would enable a large-aperture reflecting telescope to view a laser transmitter apparently close to the Sun, without adding excessive size or mass to the telescope. With the sunshade, a telescope would be able to discern signals from sources only 12° from the line of sight to the Sun.

The conceptual sunshade consists of a closely spaced set of hexagonal tubes (see figure). The tubes are positioned in front of the primary reflector of the telescope and are aligned with their axes parallel to the line of sight of the telescope. The hexagonal walls of the tubes correspond to the edges of the hexagonal segments of the primary reflector so that the walls do not obstruct the aperture appreciably.

The tubes extend downward toward the primary reflector, ending at the envelope of the focused beam of light from the primary to the secondary reflector. The outer ends of the tubes are trimmed so that they fit within a sphere, the diameter of which is



The **Telescope Would Look** through the sunshade from behind and below it. The tops of the hexagonal tubes would be trimmed to a spherical shape corresponding to the sphere of rotation of the telescope. The sunshade could support the secondary reflector.

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

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.

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 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 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, 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, call your AT&T Federal Systems Account Executive, or 1 800 553-8805. (N.C. residents, call collect: 919 697-9580.)

We've got solutions down to a science.

*Developed in part under a DARPA sponsored contract.

AT&T

The right choice.

Circle Reader Action No. 665

only 20 percent greater than the diameter of the primary reflector.

In contrast, a conventional sunshade like a visor would be mounted outside the telescope. To enable a telescope 10 m in diameter to view a signal source within 12° of the Sun, a conventional sunshade would have to be 47 m long. A telescope equipped with so long a sunshade would be unwieldy indeed, requiring a large, expensive observatory dome.

The hexagonal sunshade structure would be strong enough to support the secondary reflector. A separate support for the secondary reflector would not be necessary, and the mass and inertia of the telescope would thus be reduced further.

So that the telescope could track sources within even smaller angles of the line of sight to the Sun, the sunshade could be equipped with internal vanes running the lengths of the tubes. The telescope could then receive signals from sources within 6° or even 3° of the apparent position of the Sun.

This work was done by E. L. Kerr of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 131 on the TSP Request Card.*
NPO-17674

Fast Quenching for Hydrogen-Embrittlement Tests

Hot specimens are cooled rapidly in high-pressure hydrogen.

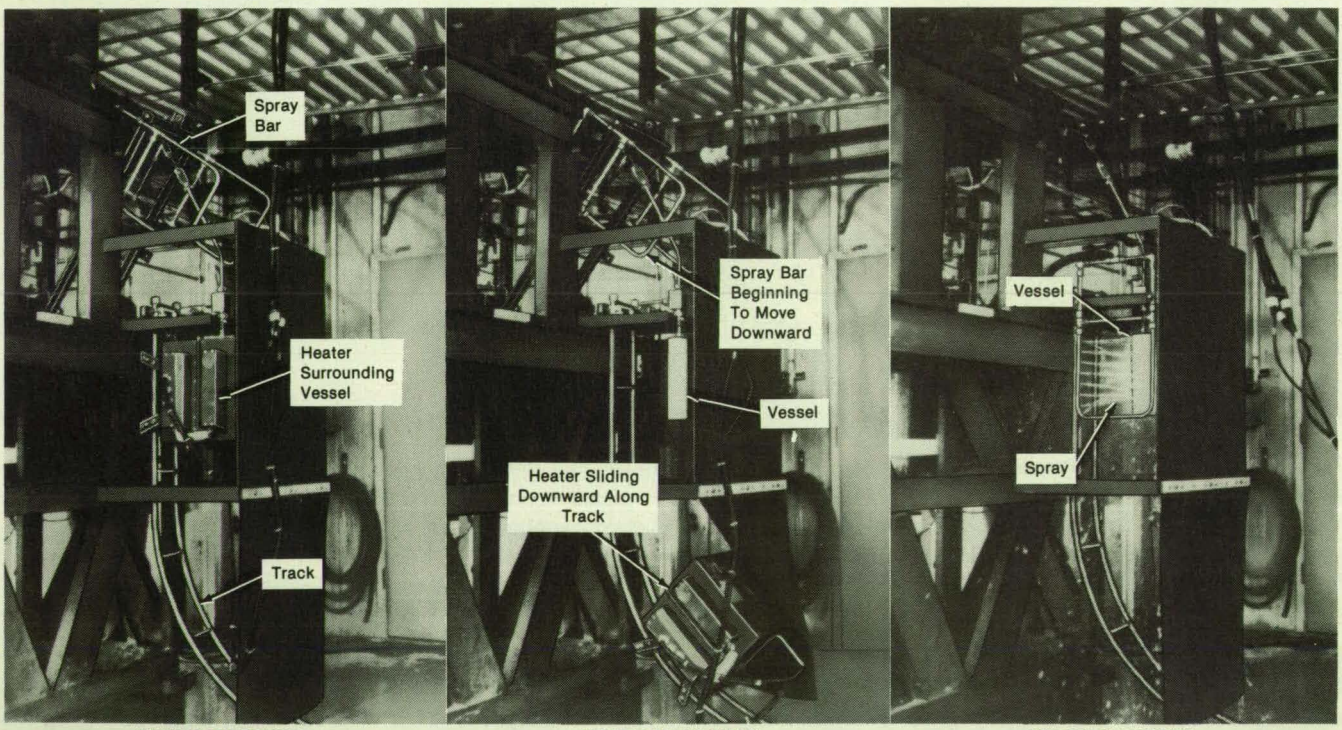
Marshall Space Flight Center, Alabama

An apparatus exposes hot metal specimens in hydrogen atmospheres to sudden cooling. The apparatus was developed to evaluate the susceptibilities of the specimens to embrittlement by hydrogen. The apparatus cools specimens by 1,050 °F (580 °C) in 160 s.

A specimen is enclosed in a cylindrical stainless-steel vessel pressurized with hydrogen. A resistance heater encircles the vessel and maintains it at 1,200 °F (650 °C). At the push of a button, the heater drops away from the vessel, sliding to a stop along a stainless-steel track (see figure).

As the heater falls, a spray bar is released from overhead. The bar falls into position around the vessel, triggering a microswitch that turns on a water supply at a pressure of 150 lb/in.^{2} (1 MPa). Issuing from the spray bar, the spray engulfs the vessel and chills its contents, trapping the absorbed hydrogen in the specimen.

This work was done by Mark J. Petri, Richard L. Burkhart, and Joseph F. Koncel of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 103 on the TSP Request Card.*
MFS-29549



HEATER SURROUNDS VESSEL | **HEATER FALLS AWAY AND SPRAY BAR BEGINS TO DESCEND** | **VESSEL IS SPRAYED WITH COLD WATER**

The **Heater Surrounds the Pressure Vessel** initially. On command, the heater slides downward on the track, exposing the vessel. A spray bar falls over the vessel and directs high-pressure jets of cold water at it.

Measuring Concentration of Ozone Automatically

An airborne photometer measures absorption of ultraviolet.

Ames Research Center, Moffett Field, California

A photometer automatically measures ozone concentrations in the atmosphere to an accuracy within 10 parts per billion. The compact, lightweight, low-power instrument was developed for use on a high-altitude research airplane.

The instrument shines ultraviolet light at a wavelength of 253.7 nm from a mercury lamp through a sample of air in a chamber (see figure). The light impinges on a vacuum phototube (the sample detector), the electrical output of which decreases with increasing concentration of ozone and the consequent increases in absorption of the ultraviolet light in the sample. An electrometer circuit processes the output of the phototube.

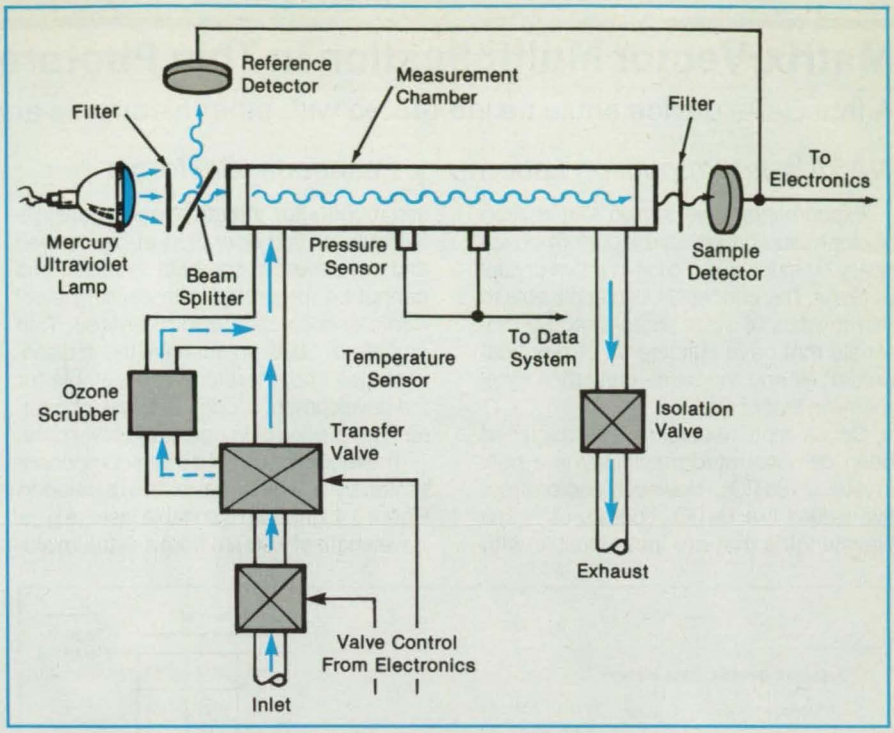
Air flows into the instrument from a

probe on the outside of the airplane. An inlet valve admits the air once the airplane has attained an altitude of 1,500 m, where there is little chance of ingestion of airborne debris. A transfer valve switches the airflow alternately between the measurement chamber and a scrubber chamber in which manganese dioxide removes ozone from the air. Scrubbed and ozone-laden samples thus enter the chamber alternately. The instrument uses the scrubbed samples to compensate for variations in constituents other than ozone.

A beam splitter diverts parts of the ultraviolet beam as it leaves the mercury lamp. A second vacuum phototube (the reference detector) measures the diverted beam, which does not pass through the sample chamber. The output of this phototube is used to compensate for variations in the intensity of light emitted by the lamp. Both phototubes are "solar blind" devices. They do not respond to visible radiation, but only to a narrow wavelength band between 160 and 320 nm. There is therefore no need for extensive filtering of external light.

A microprocessor controls timing and the acquisition of data. A random-access memory backed by a battery stores data on the transmission of ultraviolet through the samples, on temperature, on pressure, and on navigation of the airplane. An experiment can last as long as 8 hours. When the airplane lands, the data are transferred to a portable computer.

A single-board computer in the instrument simultaneously calculates the concentration of ozone in real time (but with less resolution). This value is displayed on an analog meter in the cockpit to guide the pilot in seeking regions of various concentrations of ozone.



Air Collected Outside the airplane enters the photometer by way of the transfer valve. The pressure and temperature of the air are measured simultaneously with the transmissivity of the air to ultraviolet light from the lamp. The instrument has a mass of 20.5 kg and fits in an aluminum box measuring 78 by 58 by 25 cm.

This work was done by Joseph R. Lavelle of **Ames Research Center**. *Further information may be found in NASA TM-100064 [N88-21404], "An Automated Ozone Photometer."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12230

Photochemical Degradation of Organic-Solvent Fumes

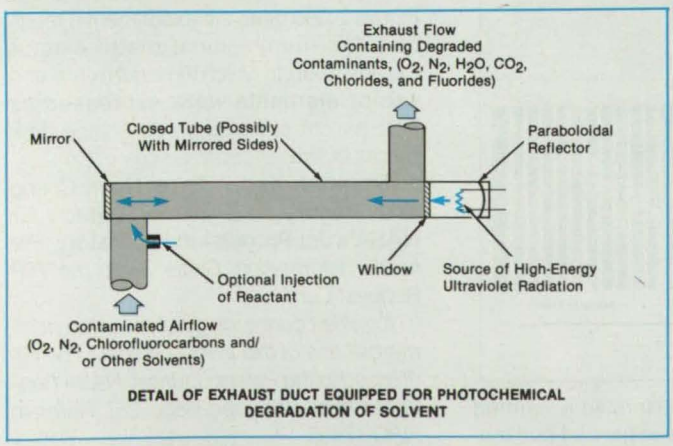
The quality of air would be enhanced.

Marshall Space Flight Center, Alabama

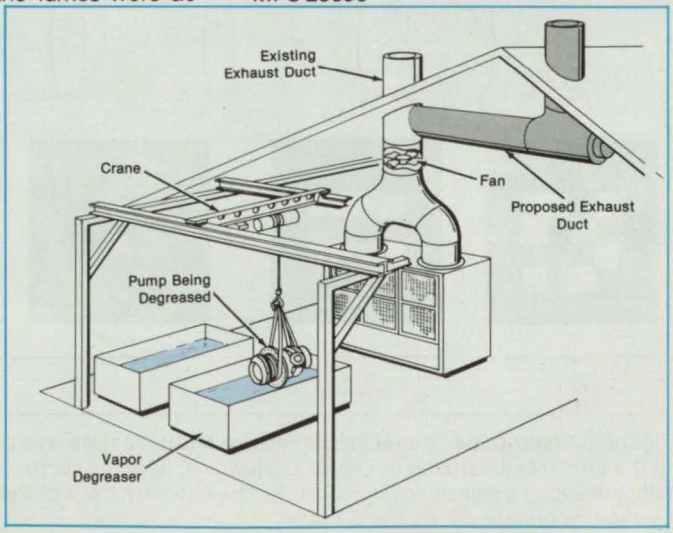
The quality of air in a laboratory or industrial ventilation airstream would be enhanced by a proposed technique. It is desirable to remove the residual fumes of organic solvents from such airstreams, both to protect workers and to prevent the discharge of the fumes to the environment. Heretofore, there has been no economical way to do this.

According to the proposal, a source of ultraviolet light would be placed in the airstream (see figure) to degrade the fumes photochemically. If the fumes were acceptable in degraded form, then no further processing would be needed. Alternatively, the degraded fumes could be removed by conventional scrubbing.

This work was done by James J. Herzstock of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29596



DETAIL OF EXHAUST DUCT EQUIPPED FOR PHOTOCHEMICAL DEGRADATION OF SOLVENT



Ultraviolet Light would be projected along the exhaust duct to degrade toxic fumes photochemically.

Matrix·Vector Multiplication in Thin Photorefractive Crystal

A thin GaAs device could be integrated with other electronic and optoelectronic devices.

NASA's Jet Propulsion Laboratory, Pasadena, California

Experiments have shown that matrix•vector multiplication can be performed optically by four-wave mixing in a thin crystal of GaAs. The concept is also applicable to thin crystals of other photorefractive materials that have suitable electro-optical properties and the same crystalline symmetry as that of GaAs.

Optical matrix•vector multiplication had been demonstrated previously in a bulk crystal of $BaTiO_3$. However, photorefractive oxides like $BaTiO_3$ operate at visible wavelengths that are incompatible with semiconductor injection lasers, are unsuitable for fast operation at high speed and low power in compact systems, and cannot be integrated with existing electronic and optoelectronic devices. Thin crystals of GaAs do not have these disadvantages and, therefore, are suitable for the development of compact, fast, concurrent processing of imagery and other data.

The multiplication of a three-component vector by a 3-by-3 matrix is illustrated in Figure 1. Light from a suitable laser (e.g., a wavelength of 1.06 μm from an yttrium aluminum garnet laser) is expanded and split into vertically polarized beams 1 and 2 and horizontally polarized beam 3. Beam 1 passes through a transparency, the transmissions of three horizontally adjacent portions of which are proportional to the components a_j of the vector to be multiplied. Horizontal cylindrical lenses then expand the beam vertically to form three column beams within each of which the intensity is uniform, and these beams strike perpendicularly the wide [001] face of the GaAs crystal.

A polarizing beam splitter reflects beam 2 perpendicularly onto the [110] face (the left edge) of the crystal. In the crystal, the interference of beam 2 with the column subbeams of beam 1 acts through the photorefractive effect to form three index-of-refraction gratings that have strengths proportional to the components of the vector. Beam 3 passes through a transparency, the transmission of which varies spatially in proportion to the elements m_{ij} of the matrix and strikes the other wide face of the crystal perpendicularly.

Each element of the matrix beam is diffracted by the grating that it strikes, and the intensity of its contribution to the total diffracted beam is proportional to the product of the intensities of the matrix and vector elements. The diffracted beams travel from right to left in the figure so that all the diffracted beams from the elements in the *i*th row of the matrix coincide spatially and are automatically summed. The diffracted beams, which are horizontally polarized, pass through the beam splitter. The pattern of intensity in these beams is proportional to the resultant vector

$$b_i = \sum_{j=1}^{3} m_{ij} a_j$$

Figure 2 illustrates the experimental result of a four-dimensional matrix•vector multiplication, in which the input matrix and vector elements were expressed as transparent squares on otherwise dark pieces of film.

This work was done by Li-Jen Cheng and Gregory O. Gheen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 73 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 25]. Refer to NPO-17455

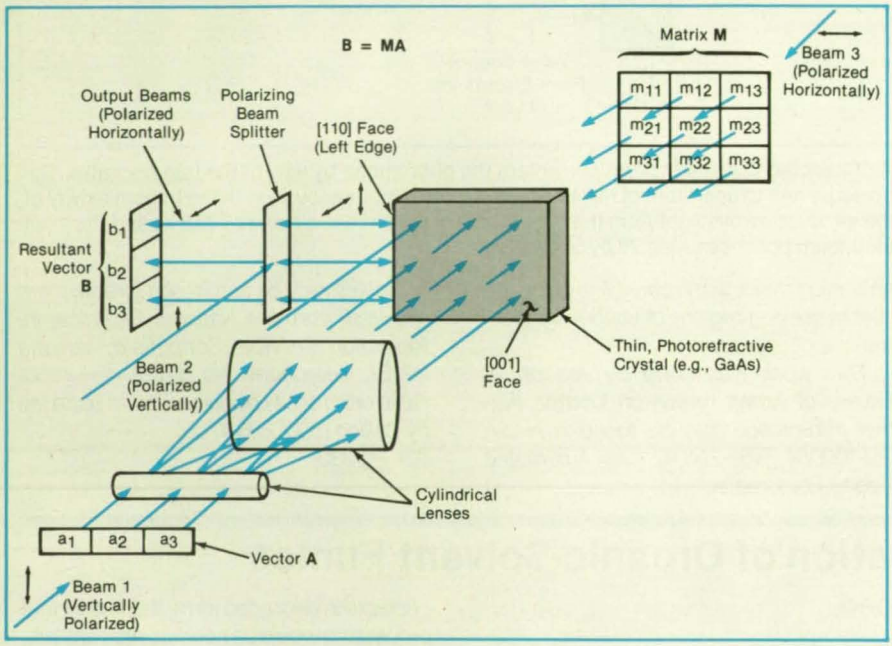


Figure 1. The **Matrix•Vector Multiplication** $b_i = \sum_{j=1}^{3} m_{ij} a_j$ is performed by four-wave mixing in a thin photorefractive crystal. The vector and matrix elements are represented by regions of different transmission that intercept incident laser beams 1 and 3.

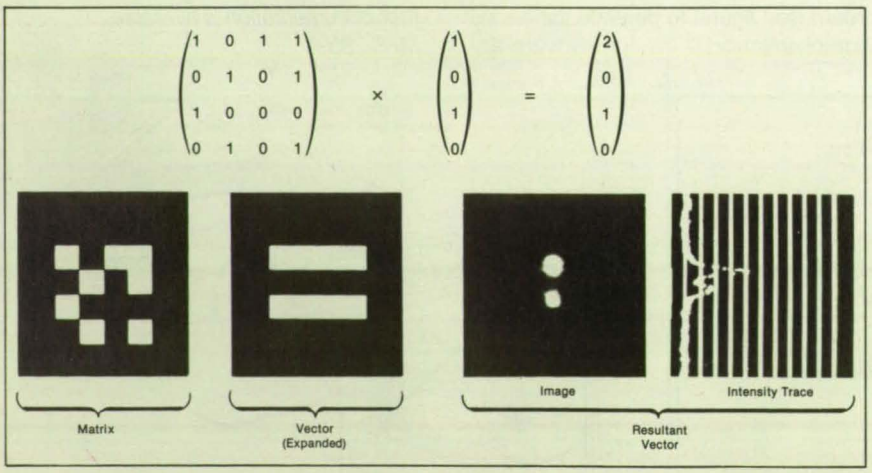


Figure 2. A **Four-Dimensional Matrix•Vector Multiplication** was performed according to the principle illustrated in Figure 1. (However, here the vector is expanded horizontally instead of vertically as in Figure 1.) The intensity trace of the image of the resultant vector clearly shows the 2:1 ratio.

Books and Reports

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

Nano-G Laboratory

A freely floating platform would be isolated from all but gravity gradient forces.

A report describes a conceptual orbiting spacecraft laboratory that would create an environment in which acceleration would not exceed 10^{-9} that of the normal acceleration at the surface of the Earth. The laboratory would be used for research in such delicate phenomena as the λ transition in helium, the growth of crystals, and the formation of alloys that would separate into their constituents before solidification if gravitation (G) were present.

The laboratory would consist of two parts: an outer part (the spacecraft) and a separable inner free-floating part that would house the experimental apparatus. During launch and insertion into orbit around the Earth, an arresting mechanism would hold the inner part rigidly within the outer part. Once in orbit, the spacecraft would be oriented with its main axis along the orbital velocity. The arresting mechanism would be deactivated to allow the inner part to float freely within the outer part.

As long as the inner part remained near the center of gravity and did not strike the outer part, the former would be subjected only to the gravitation that governs the orbit and would be protected against disturbances caused by spacecraft thrusters, vibrations, rotations of the spacecraft, atmospheric drag and the like. To keep the gravity gradient forces also small, the largest dimension of the experiment has to be aligned along the flight path (See von Bun et al, Acta Astron. vol. A, No. 5, pp. 579-583, 1988). Sensors would measure the position of the inner part with respect to the outer part and would trigger the firing of thrusters to keep the center of gravity of the spacecraft at the designated position within the inner part of the laboratory and the axis of the spacecraft oriented along the orbital velocity. In effect, once the inner part is set free, the trajectory of the spacecraft would be adjusted repeatedly to follow the "real gravitational" trajectory of the inner part of the laboratory.

Power would be fed to the inner part via two equal microwave and/or laser beams from two opposite directions. Provided that the inner part is symmetrically shaped, the resulting radiation pressure would be balanced and would, therefore, produce no additional undesired acceleration of the inner part. The inner and outer parts would be equipped with radio and/or optical communication links for the control of the experiment and the recording of data. A battery that could be recharged by the microwave or laser beams could be used to supply power to the inner part when the demand for power is low.

This work was done by Friedrich O. von Bun of **Goddard Space Flight Center** *and O. K. Garriott of* **Johnson Space Center**. *To obtain a copy of the report, "A Nano-g Research Laboratory for a Spacecraft," Circle 52 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 25]. Refer to GSC-13197

Calibration of Airborne Visible/IR Imaging Spectrometer

The calibration applies to all AVIRIS science data collected in 1987.

A paper describes the laboratory spectral and radiometric calibration of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) that was applied to all AVIRIS science data collected in 1987. It describes the instrumentation and procedures used and demonstrates that the calibration accuracy achieved exceeds the design requirements. The AVIRIS was developed for use in remote-sensing studies in such disciplines as botany, geology, hydrology, and oceanography.

The AVIRIS includes four spectrometers, the spectral ranges of which overlap slightly, to acquire images in contiguous 10-nm spectral bands at wavelengths from 0.4 to 2.45 μm. Flown at an altitude of 20 km, the instrument scans through an angle of 30° to cover a swath 10.5 km wide on the ground. After processing, each scan line of the image contains 550 picture elements, each representing a surface area approximately 20 m across.

Optical fibers connect the foreoptics to the spectrometers. The first spectrometer has a 32-element line array of silicon detectors and covers the spectral range 0.4 to 0.71 μm. The remaining spectrometers cover the ranges 0.68 to 1.28, 1.24 to 1.86, and 1.83 to 2.45 μm; each has a 64-element line array of indium antimonide detectors.

The spectral calibration determined the wavelength distribution of light falling on each detector element to an accuracy within 2.1 nm, which is less than the 5-nm maximum allowable by design. The paper describes the steps required: calibrating a laboratory monochromator, aligning the monochromator with the AVIRIS, and recording the scan of a narrow spectral bandwidth of light from the monochromator across the AVIRIS detectors. Also included are a diagram of the laboratory apparatus and a graph showing the spectral response determined for one of the detector elements. A table lists the following spectral calibration parameters for each spectrometer: average bandwidth, spectral sampling interval per detector element, standard deviation of the linearity measurement, the uncertainty in the calibration of the monochromator, and the accuracy of the spectral calibration.

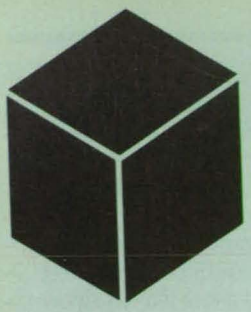
The radiometric calibration achieved an absolute accuracy of 7.3 percent (traceable to a National Bureau of Standards lamp), which is within the 10-percent design requirement. The steps described are the following: calibration of a spectroradiometer; calibration of the AVIRIS radiance source, an integrating sphere 40 in. (1 m) in diameter, with the spectroradiometer; acquisition of digital readings of the output of the integrating sphere from the AVIRIS detectors; and, finally, the calculation of a table of multipliers used to convert raw detector readings directly to radiance. A diagram shows the apparatus used in calibrating the spectroradiometer and integrating sphere.

The paper includes an error-budget analysis of the accuracy of the radiometric calibration, which takes into account the following: the accuracy of calibration of the integrating sphere, the temporal stability of the AVIRIS, the radiometric effect of uncertainty in the spectral calibration, sensitivity to polarization, and the effect of spectral and spatial stray light. Instrumental effects that limit temporal stability include thermally induced drift and vibrationally induced fluctuations in output levels.

Future plans for improving the stability and calibration accuracy of AVIRIS include the following: realignment of the foreoptics to eliminate vignetting, substitution of preamplifier and clock-driver circuit boards less vulnerable to vibration, reconfiguration of the spectrometer heaters, installation of kinematic mounts to reduce the transmission of vibration to the instrument and of heat from the instrument, and improvements in the built-in calibrator.

This work was done by G. A. Vane, T. G. Chrien, E. A. Miller, and J. H. Reimer of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Spectral and Radiometric Calibration of the Airborne Visible/Infrared Imaging Spectrometer," Circle 91 on the TSP Request Card.*

NPO-17582



Materials

Tough, Microcracking-Resistant, High-Temperature Polymer

Simultaneous synthesis from thermosetting and thermoplastic components yields a polyimide with outstanding properties.

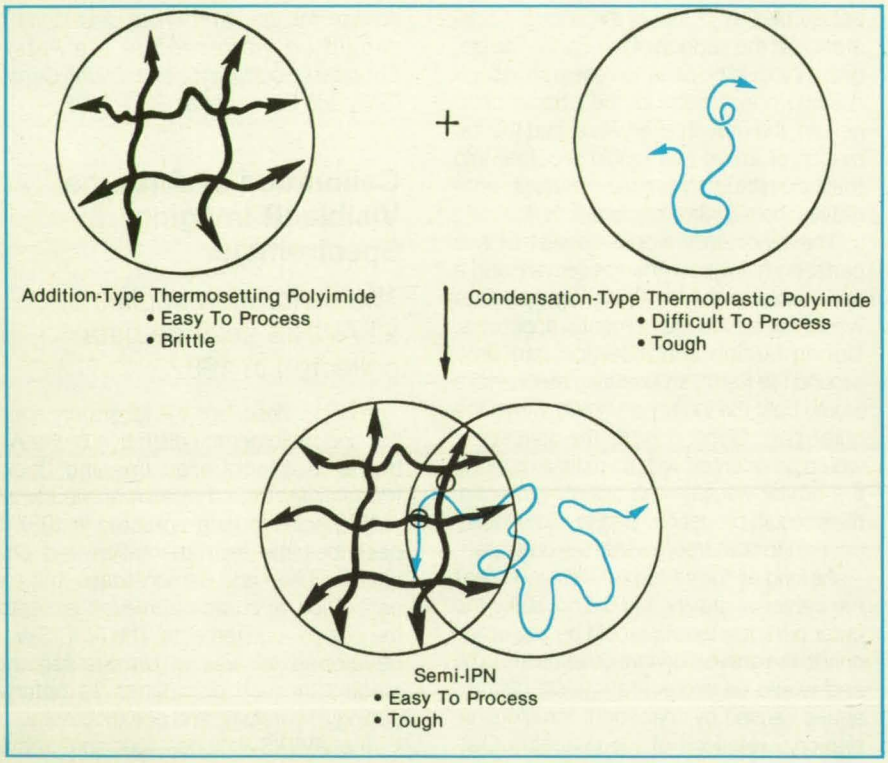
Langley Research Center, Hampton, Virginia

For the last few years, there has been an active search for an improved high-temperature matrix resin capable of performing at a temperature of 316 °C in air for several hundred hours. Some of the desired properties for this material are significantly increased toughness, increased resistance to microcracking, good processability, and good mechanical performance. A new approach to the production of this material involves the simultaneous synthesis of a semi-interpenetrating network (semi-IPN) polyimide, consisting of an easy-to-process but brittle thermosetting polyimide and a tough but difficult-to-process thermoplastic polyimide. The synthesis is illustrated schematically in the figure.

Unlike previous sequential syntheses, the "simultaneous method" involves a process in which one polymer is crosslinked in the immediate presence of the other, undergoing simultaneous linear chain extension. This synthesis can lead to a network in which one polymer interlocks with the other, forming permanent entanglements in certain regions of the network system. The resulting physical crosslinking can provide synergistic properties that are nonadditive and are greatly improved over the properties of the constituents.

The new material, LaRC-RP40, was synthesized from the current leading commercially available high-temperature thermosetting imide prepolymer (chosen primarily because of its easy processability and relative low cost compared to those of other high-temperature materials) and from a leading thermoplastic monomer (selected because of its outstanding thermo-oxidative stability, toughness, and resistance to microcracking).

The physical and mechanical properties of the neat LaRC-RP40 resin and of a graphite-fiber-reinforced composite made with it were compared with those of the commercially available resin used under identical conditions. The comparison showed three significantly improved properties: (1) toughness (322 percent increase, 368 vs. 87 J/m^2), (2) resistance to microcracking (0 vs. 58 microcracks/in., and (3) glass-transition temperature (369 vs. 339 °C). These improvements in properties were achieved without significantly compromising processability (curing temperature of 316 °C for both materials), mechanical performance at high temperature (at 316 °C, flexural strength 1,199 MPa compared to 1,096 MPa), and cost-effectiveness.

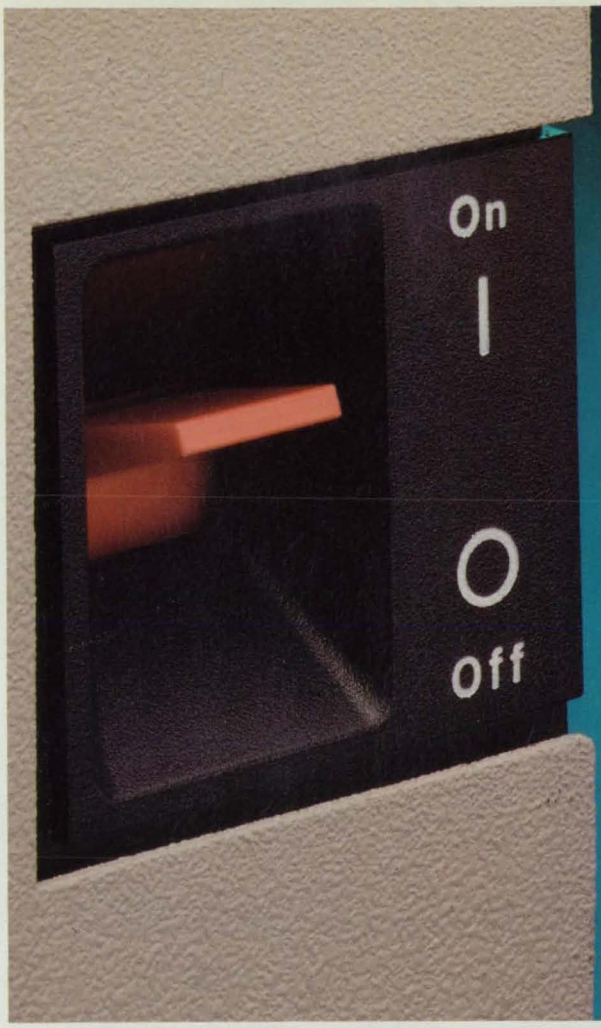


The **Interpenetrating Polymer Network** (IPN) is obtained in simultaneous syntheses of two polymers.

LaRC-RP40 clearly shows considerable promise as a high-temperature matrix resin for a variety of components of aircraft engines and for use in other aerospace structures. The development of LaRC-RP40 has also demonstrated that simultaneous improvements in both toughness characteristics and glass-transition temperature, which are very difficult to achieve by conventional polymer syntheses, are technically feasible and are an attractive feature of the current semi-IPN synthesis.

This work was done by Ruth H. Pater, Pert Razon, Ricky Smith, and Dennis Working of **Langley Research Center** *and Alice Chang and Margaret Gerber of PRC. For further information, Circle 3 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 25]. Refer to LAR-13925.



When you're looking for

- digital ICs
- linear ICs
- interface ICs
- microprocessor ICs
- memory ICs
- optoelectronic devices
- transistors
- diodes or
- thyristors

flipping a PC switch is faster than thumbing through catalogs.

That's why the IC/Discrete Parameter Database is on CD-ROM!

Now do component research a new way. Software for your IBM® AT® compatible and a database on CD-ROM provide fingertip access to over 1.1 million ICs and discrete semiconductors from 1,100 manufacturers.

- Search for active *and* discontinued devices, commercial and mil/high rel.
- Locate devices by component characteristic, IC generic number, manufacturer part number, Mil/883 part number, Mil slash sheet number, NSN or DESC drawing number.
- Access over 272,000 manufacturers' datasheets and 19,000 Mil spec/QPL 38510 and 19500 slash sheets. *Exact* images of the hardcopy version! And, all the text, application notes, mechanical data, outline drawings, packaging and ordering information can be printed in seconds.

All the critical information you need at the flip of a switch!

The results? Time saving searching—and time is money.

Circle Reader Action No. 546

For a free demo diskette return the coupon below or call toll-free:

800-241-7824

In Colorado and outside the U.S.A.: 303-790-0600 ext. 59
Telex: 4322083 IHS UI
Fax: 303-799-4085 (U.S.A.); 303-799-4097 (outside the U.S.A.)

Yes! Please send me a FREE DEMO DISKETTE and more information.

Name _____

Dept./Title _____

Organization _____

Address _____

City _____ State _____ Zip _____

Phone (___) _____

Information Handling Services®
15 Inverness Way East; Englewood, Colorado 80150

Reinforcing Liner for Composite Cryogenic Tank

The liner would prevent detachment of antileakage foil from the shell.

Marshall Space Flight Center, Alabama

A proposed fiber-reinforced liner for a graphite/epoxy fuel tank would prevent a metal-foil leakage barrier from detaching at low temperatures. The thin metal-foil barrier is necessary to prevent such fuels as liquid hydrogen and liquid methane from gradually oozing through the wall of the tank. However, when the tank is filled, the temperature inside drops well below room temperature, causing the foil to contract while the graphite/epoxy composite shrinks very little. As a result, the foil tends to pull away from the composite wall.

The tank would be made of an outer layer of graphite/epoxy plies to which double layers of foil and a single layer of the liner would be attached by adhesive films (see figure). The sheets of foil would be placed on the inside of the tank. The edges of the sheets of foil would be resistance-welded to form leakproof seams.

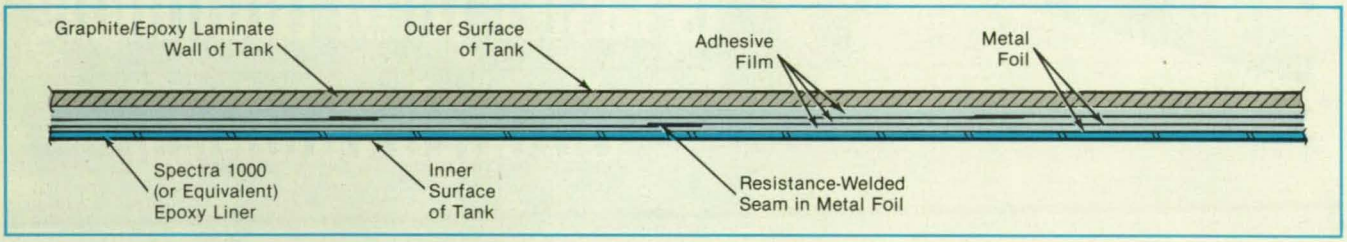
The new liner would consist of epoxy containing fibers of Spectra 1000 (or equivalent), a high-strength, high-modulus material that expands with decreases of temperature in the temperature range in which the tank is to be used. However, in the same temperature range, the graphite/epoxy composite wall neither expands nor contracts significantly. As the temperature decreased in a tank of circular cross section, the liner would therefore compress the foil against the wall, preventing it from pulling away. Possible choices for the foil material include stainless steel, titanium, aluminum, copper, or bronze.

Because the liner would have to create a hoop stress in the foil, the thickness of the liner would have to be chosen in consideration of the tension properties of the foil — yield stress, ultimate stress, elongation, and modulus of elasticity. However, because the foil would be relatively thin, the liner could also be made thin in comparison with the wall.

The lined composite tank could be used to hold liquids from room temperature to cryogenic temperatures. For example, it could hold liquid helium at −452 °F (−269 °C). It is not suitable for oxygen, however, because the organic materials in the liner could be oxidized quickly.

This work was done by John E. Burgeson of General Dynamics for **Marshall Space Flight Center**. *For further information, Circle 10 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-28399.



The **Graphite/Epoxy Wall of the Tank** would hold inner layers of foil, adhesive, and the proposed liner. The liner would be much thinner than the shell, would add little weight, and would subtract little volume.

Preparation of High-Temperature Reactive Oligomers

Very reactive materials form very-heat-stable polymers.

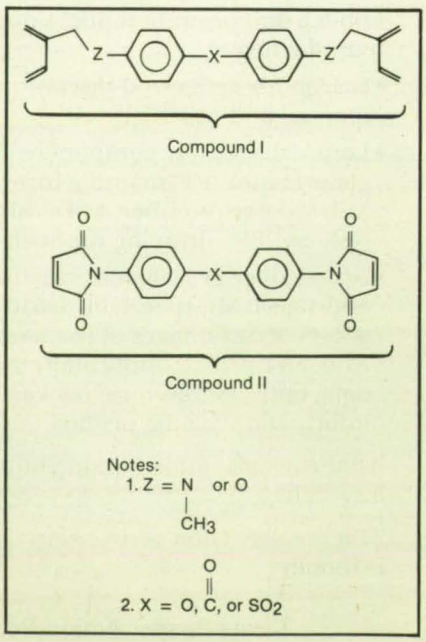
Langley Research Center, Hampton, Virginia

A major goal in the field of high-temperature polymers is the preparation of aromatic polyimides that can be easily fabricated into parts that have thermal and physical properties required in aerospace applications. Recent research has been directed toward the synthesis of polyimides that are soluble in common organic solvents, melt-processable, and thermally curable without the evolution of volatile byproducts. Melt-processability can be enhanced by lowering the flow temperature via synthesis by such techniques as the incorporation of aryl ether and meta-phenylene linkages in the backbone of a polymer.

A previous approach to obtaining phenylated polyimides involved the Diels-Alder polymerization of phenylated biscyclopentadienones with bismaleimides. One disadvantage of this process is that during the reaction, carbon monoxide is produced after the Diels-Alder addition. Furthermore, at temperatures >300 °C, dehydrogenation and other decomposition processes occur, yielding polymers of poor solubility. Consequently, research was conducted to prepare, by Diels-Alder polymerization, high-temperature polymeric materials that will maintain their integrities and toughnesses during long exposure times at elevated temperatures.

A unique monomer, N-phenyl-3,4-dimethylene-pyrrolidine can be modified to form a bis(exocyclodiene) (compound I in the figure) for the preparation of polyimides by the Diels-Alder process. This bis(exocyclodiene) undergoes Diels-Alder reaction with a bismaleimide (compound II in the figure) without the evolution of gaseous byproducts. Dimerization, which can result from a Diels-Alder reaction between two exocyclic dienes, was observed in the

Diels-Alder Polymerization yields compounds that maintain their integrities and toughnesses during long exposure times at high temperatures.



case of N-phenyl-3,4-dimethylene-pyrrolidine. However, it was observed that bis [4-(3,4-dimethylene-pyrrolidyl)-phenyl] methane reacts very rapidly with bismaleimide by Diels-Alder addition. This polymerization was followed by ^1H nuclear magnetic resonance (NMR) spectroscopy. At a temperature of 50 °C in trifluoroacetic acid, complete polymerization could be achieved within 48 hours. The polymerization yield was estimated to be 92 percent, based on the integration of the ^1H NMR spectrum.

A polymer powder was prepared from the prepolymer solution, which contained equimolar amounts of bis[4-(3,4-dimethylene-pyrrolidyl)-phenyl] methane (as compound I) and bismaleimide (as compound II) in solution. Good, flexible films were prepared by casting the prepolymer solution onto a clean glass surface. However, the original polymer film was insoluble in organic solvents.

The thermal stability and decomposition temperature of the polymer films were analyzed by thermogravimetric analysis (TGA). The measurements were carried out in nitrogen and in air, respectively. In nitrogen, the polymer film was thermally stable, with only 10 percent weight loss at 357 °C and 20 percent weight loss at 413 °C. On the other hand, TGA plots in air showed different behavior. The first moderate weight loss occurred at a much lower temperature, 239 °C. The second rapid weight loss occurred above 400 °C and was indicative of total decomposition of the polymer backbone.

High-temperature polymers can be synthesized by use of this technique. Films and perhaps fibers can be fabricated from the prepolymer in solution. The major potential at this stage of the research appears to be limited to aerospace applications.

This work was done by Raphael M. Ottenbrite of Virginia Commonwealth University for **Langley Research Center**. *For further information, Circle 156 on the TSP Request Card.*

This invention is owned by NASA (U.S. Patent No. 4,851,544). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 25]. Refer to LAR-13965.

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.

Friction and Wear of Silicon Ceramics

A variety of ceramics are tested in friction against a nickel alloy.

A report presents the results of an experimental study of friction and wear in unlubricated sliding of silicon-based ceramics on Inconel* 718 nickel-based alloy. Both monolithic and fiber-reinforced ceramics were tested at temperatures from 25 to 800 °C.

The study was done to evaluate the ceramic materials for potential use as cylinder liners, piston caps, and other engine parts subjected to sliding or rubbing. Silicon carbide (SiC), fused silica (SiO_2), syalon (a combination of silicon, yttrium, aluminum, oxygen, and nitrogen), silicon nitride (Si_3N_4) with tungsten and magnesium additives, and Si_3N_4 with yttria (Y_2O_3) additive were tested. Also tested were reaction-bonded Si_3N_4 reinforced with SiC fibers and borosilicate glass reinforced with crossed layers (0°, 90°) of unidirectional carbon fibers.

Samples of the materials were rubbed against the edge of a rotating disk of Inconel* 718. Friction and wear were measured, and the worn surfaces were examined under a scanning electron microscope and by energy-dispersive x-ray analysis.

At a temperature of 25 °C, the carbon-fiber/borosilicate glass exhibited a coefficient of friction of 0.18, which was the lowest of all. The total wear of this material was about 100 times as small as that of monolithic fused silica. The silicon carbide exhibited the lowest total wear (rub block + disk) at 25 °C. At a temperature of 800 °C, syalon had the lowest coefficient of friction, while sialon and Si_3N_4 (with W and Mg) had the lowest wear. At temperatures of 550 °C and above, the oxidation products of the Inconel* 718 alloy transfer to the ceramic rub block, where they form a thin, lubricating glaze that reduces friction and wear in both the monolithic and reinforced materials.

*"Inconel" is a registered trademark of the Inco family of companies.

This work was done by Daniel L. Deadmore and Harold E. Sliney of **Lewis Research Center**. *Further information may be found in NASA TM-100294 [N88-17796], "Friction and Wear of Monolithic and Fiber Reinforced Silicon-Ceramics Sliding Against IN-718 Alloy at 25 to 800 °C in Atmospheric Air at Ambient Pressure."*

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-14835

Computer Programs

COSMIC: Transferring NASA Software

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

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.

Mathematics and Information Sciences

Computing Mass Properties From AutoCAD

Mass properties of structures are computed from data in drawings.

The AutoCAD to Mass Properties (ACTOMP) computer program was developed to facilitate quick calculations of the mass properties of structures that contain many simple elements in such complex configurations as trusses or sheet-metal containers. The calculation of the mass properties of structures of this type can be tedious and repetitive, but ACTOMP helps automate the calculations. A structure can be mathematically modeled in AutoCAD or a compatible computer-aided design (CAD) system in minutes by use of the three-dimensional elements. The resulting model provides all the geometric data necessary to calculate the mass properties of the structure.

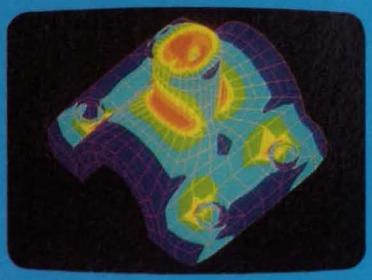
ACTOMP reads the geometric data of a drawing from the Drawing Interchange File (DXF) used in AutoCAD. The geometric entities recognized by ACTOMP include POINTs, 3DLINEs, and 3DFACEs. ACTOMP requests mass, linear density, or area density of the elements for each layer, sums all the elements, and calculates the total mass, the center of mass (CM), and the mass moments of inertia (MOI).

AutoCAD uses layers to define separate drawing planes. ACTOMP uses layers to differentiate between multiple types of similar elements. For example, if a structure is made of various types of beams, modeled as 3DLINEs, each with a different linear density, the beams can be grouped by linear density, and each group placed on a separate layer. The program requests the mass information of 3DLINEs for each new layer it finds as it processes the drawing information. The same is true with POINTs and 3DFACEs.

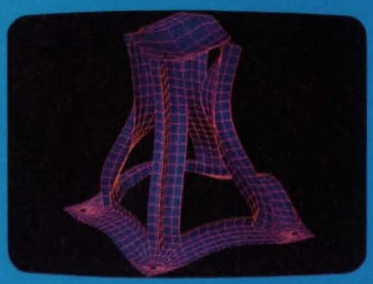
By using layers this way, a very complex model can be created. POINTs are used for point masses like bolts, small machine

ALGOR®

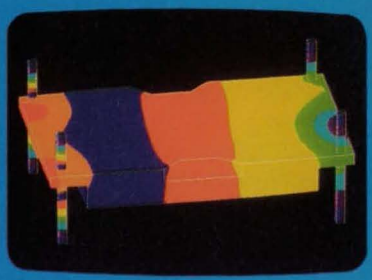
Finite Element Analysis Software for 286, 386 & 486 Desktop Computers



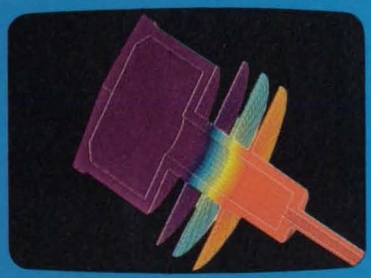
Linear stress analysis with ViziCad Plus modeling and postprocessing.
Part 94 $889



Frequency, mode shape (modal), and dynamic stress analysis with ViziCad Plus modeling and postprocessing. **Part 100 $1290**

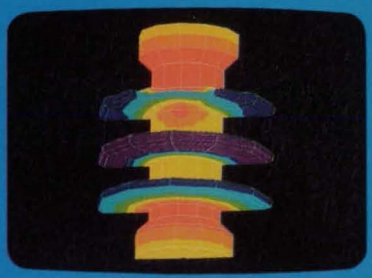


Steady-state heat transfer for temperature, heat flux; feedback to stress analysis; includes modeling and postprocessing. **Part 101 $1090**



Transient heat transfer by direct integration—2D and 3D elements; animated contours.
Part 106 adds to Part 101 or 102 $300

AccuPak processor set for nonlinear material properties and large deformation.
Part 110 adds to Part 100 or 102 $895



Electrostatic analysis for fields, currents, and electric potential; includes modeling and postprocessing. **Part 109 $995**

ViziCad Plus—FEA modeling and postprocessing is included with all analysis part numbers. Also calculates engineering properties for line or polygon cross-sections.

Algor's FEA "Hands-On" Interactive Demo.
Part 3102 $29

ElectroStat "Hands-On" Interactive Demo.
Part 3106 $19

PipePlus "Hands-On" Interactive Demo.
Part 150D $19

Algor's detailed FEA Product Catalog.
Part 3101

Part No.	-S Price	-3H Price
94 – Stress Analysis	$ 889	$ 1290
100 – Stress+Dynamics	$ 1290	$ 1689
101 – Heat Transfer	$ 1090	$ 1489
102 – 100+101	$ 1690	$ 2089
106 – Transient H.T.*	$ 300	$ 495
110 – AccuPak Nonlinear**	$ 895	$ 1295
109 – ElectroStat	$ 995	***
3102 – FEA Demo	$ 29	***
3106 – ElectroStat Demo	$ 19	***
150D – PipePlus Demo	$ 19	***
3101 – Algor Catalog	N/C	***

* Adds to part 101 or 102.
** Adds to part 100 or 102.
*** "-3H" version not necessary.
Prices subject to change without notice.

"-S" Versions operate on 286, 386, or 486 computers running under DOS.

"-3H" Versions for 386 or 486 systems; directly utilize extended memory.

Weitek coprocessor support add $50 per Part No.

GSA Contract #GS00K89AGS6270PS01

Other packages available:

- Random Vibration Analysis
- Composite Element Analysis
- Buckling Analysis for Beam and Plate/Shell Elements
- Dynamic Analysis with Load Stiffening
- Nonlinear Gap Analysis
- PipePlus ASME Piping Analysis
- Beam Design Editor
- Paragen–Parametric Modeling
- SuperCap–Computer-Aided Presentation and Animation
- Education Seminars, held monthly at various locations

Algor's Element Library Includes:

Truss, Beam, Membrane, 2D Solid Elasticity, 3D Solid, 3D Plate/Shell, Pipe, Boundary, Rigid Link, Nonlinear Gap, Thin and Sandwich Composite; Nonlinear Truss, 2D and 3D Nonlinear Solid; Temperature Boundary, 2D and 3D Thermal Conductivity; 2D Planar, 2D Axisymmetric, 3D Solid, and Voltage Boundary Elements.

Separate CAD package not needed.
No artificial node or element limits.

Thousands of engineers use Algor FEA in 49 states and 42 countries.

To place your order
PHONE
412-967-2700

FEA Since 1977

ALGOR®
Algor Interactive Systems, Inc.
260 Alpha Drive • Pittsburgh PA • 15238
Fax: 412-967-2781

Circle Reader Action No. 361

parts, or small electronic boxes. 3DLINEs are used for beams, bars, rods, cables, and other similarly slender elements. 3DFACEs are used for planar elements. 3DFACEs can be created as three- or four-point faces. Some examples of elements that might be modeled by use of 3DFACEs are plates, sheet metal, fabric, boxes, large-diameter hollow cylinders, and evenly distributed masses.

ACTOMP was written in Microsoft QuickBasic (Version 2.0). It was developed for the IBM PC microcomputer and has been implemented on an IBM PC-compatible computer under DOS 3.21. ACTOMP was developed in 1988.

This program was written by A. Jones for **Goddard Space Flight Center**. *For further information, Circle 64 on the TSP Request Card.*
GSC-13228

Flight Dynamics Analysis System

This software assists in the development of software for for research in flight dynamics.

The Flight Dynamics Analysis System (FDAS) collection of computer programs provides an environment for the configuration and study of Ada software. This program is designed to support flight-dynamics research and analysis activities concerning software models, algorithms, and techniques used within the flight Dynamics Division at the Goddard Space Flight Center.

The purpose of FDAS is to assist analysts and programmers in building, testing, and evaluating applications software by providing an integrated support system for the modification and reconfiguration of software. This includes the capability of assembling reusable software components into applications programs, as well as the capability of reconfiguring an assembled program after it has been partially or fully completed.

The stand-alone FDAS system-manager utility program creates, deletes, and maintains the user-information data base, and creates and/or sets up directory data bases for each new user. A directory data base contains a user's application-software components and program "trees" constructed from these components.

The installation utility program enables application programmers to install their developed Ada software components into their directory data bases under FDAS, thus making their code available to others working on the project. Upon invocation of the utility, the identity of a given user is validated against the information contained in the user-information data base.

The FDAS executive system program provides analysts and programmers with the ability to configure, test, and reconfigure program trees of their application-software components through the use of a window-based interface. This interface uses the user-information data base to validate the identities of users and to gain access to the application-software data bases.

It is anticipated that all of the software placed in the central FDAS library will be written in Ada. However, individual users will have the option of importing modified FORTRAN software via the Ada "import" pragma.

Future developments of FDAS are planned to combine the system-manager and installation utility functions into the executive program as well as provide access to the VAX Ada compiler and editors.

The system is developed in Ada for use on a DEC VAX computer operating under VMS 4.3 or higher and version 1.3 or higher of the VAX Ada Compilation System (ACS). FDAS has a central-memory requirement of approximately 360,000 bytes. This program was released in 1988.

This program was written by Keiji Tasaki, Lenda Jun and Ed Seidewitz for **Goddard Space Flight Center**. *For further information, Circle 69 on the TSP Request Card.*
GSC-13163

Mechanics

Crash-Resistant Shield

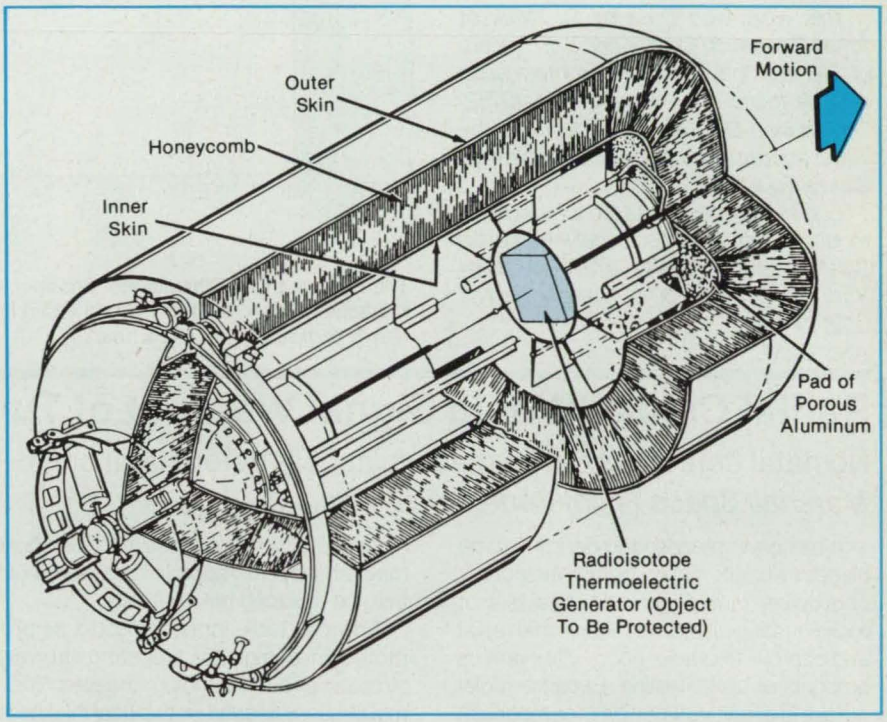
Thick aluminum honeycomb provides protection with low weight.

NASA's Jet Propulsion Laboratory, Pasadena, California

An impact-resistant shield has been designed to consist of an aluminum honeycomb structure sandwiched between inner and outer aluminum skins. The shield, 6.275 in. (15.94 cm) thick, is intended to protect the radioisotope thermoelectric generator of a spacecraft from impact with ground or water after free fall from the upper atmosphere. The honeycomb is designed to absorb impact energy by buckling, while the inner and outer skins — 0.15 and 0.125 in. (0.38 and 0.32 cm, respectively) — are designed to protect against shrapnel, overpressure, and impact loads. The concept of the shield may be applicable to crashproof compartments for ground vehicles and aircraft.

The shield is configured as a domed cylinder that surrounds the radioisotope thermoelectric generator (see figure). Pieces of honeycomb are to be welded together into a single unit. The outer skin is to be made in lapped sections and bonded to the core by adhesive. A pad of porous aluminum between the inner skin and the radioisotope thermoelectric generator at the front end gives extra protection against head-on impact.

The shield is 59.95 in. (152.3 cm) long and 30.35 in. (77.09 cm) in diameter. The density of the honeycomb is 38 lb/ft^3 (609 kg/m^3). The overall weight of the shield is 629 lb (285 kg).



The **Crushable Aluminum Honeycomb Surrounds** a thermoelectric generator. The honeycomb is intended to keep the generator intact in a crash or explosion.

This work was done by Charles H. Bixler of General Electric Co. for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 12 on the TSP Request Card.*
NPO-17616

Combination of Techniques for Computing Incompressible Flow

Pseudocompressibility, upwind differencing, and other techniques are used to solve the Navier-Stokes equations.

Ames Research Center, Moffett Field, California

A scheme for the finite-difference numerical solution of the two-dimensional Navier-Stokes equations of incompressible flow combines several recently developed methods, each of which was developed to increase the speed and/or accuracy of computations of this kind. Notable among the methods incorporated into this scheme is that of pseudocompressibility, in which the incompressible fluid is considered to have a small artificial compressibility.

The Navier-Stokes equations are written in the form of conservation laws in nondimensional variables. A derivative of pressure with respect to pseudotime is added to the equation of continuity to couple the pressure directly to the velocity. Iterations are performed to obtain the divergence-free velocity field that satisfies the equation of continuity. The equations are then advanced to the next step in physical time, and the iterations are performed in pseudotime until a divergence-free velocity field is obtained again.

An upwind-differencing scheme based on flux-difference splitting is used to compute the convective terms. Upwind differencing increases the speed of computation by making the numerical process more stable. The upwind differencing is biased on the basis of the sign of the local eigenvalue of the Jacobian matrix. Third- or fifth-order spatial accuracy is maintained throughout the interior points of the grid.

Equations are solved in an implicit line relaxation scheme. This scheme is stable

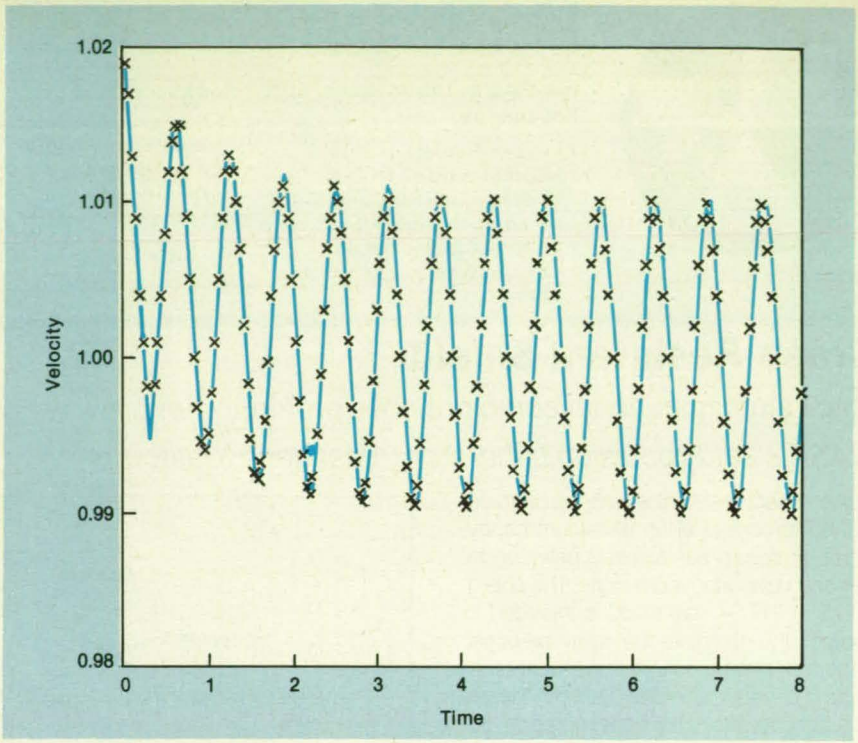
and can accommodate large steps in pseudotime, leading to fast convergence at each step in physical time. Implicit, nonreflective boundary conditions based on the method of characteristics enable the placement of the boundary relatively close to the body about which the flow is computed.

The scheme has been verified by application to several flows, ranging from very simple ones for which analytical solutions are available (see figure) to more complex flows that include the shedding of vortices and for which experimental data and other computational data are available. The predictions of the new scheme agree well with the previously obtained analytical, experimental, and numerical results.

This work was done by D. Kwak of **Ames Research Center** *and S. E. Rogers of Sterling Software. Further information may be found in AIAA paper 88A-40752, "An Upwind Differencing Scheme for the Time-Accurate Incompressible Navier-Stokes Equations."*

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

ARC-12257



The **Flow in a One-Dimensional Channel** with oscillating back pressure was computed by the scheme described in the text (solid lines) and by the exact analytical solution to the Navier-Stokes equations (× marks).

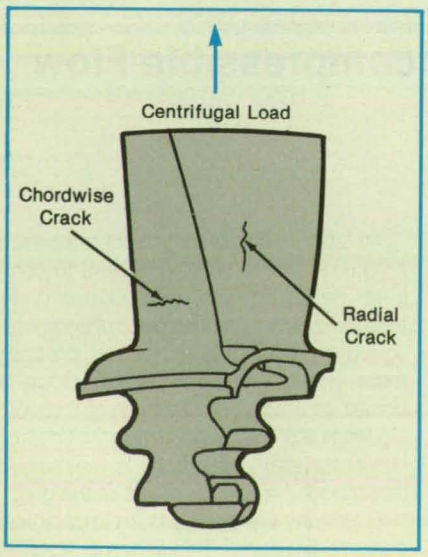
Radial Cracks Would Signal Wearout of Turbine Blades

Nonfatal defects would be made to appear before fatal ones.

Marshall Space Flight Center, Alabama

It has been proposed to design turbine blades to crack radially before they crack chordwise (see Figure 1). Analysis of rocket turbine blades has shown that radial and chordwise cracks occur after various amounts of cyclic testing. Because radial cracks are relatively benign in comparison with chordwise cracks, the prior appearance of a radial crack or cracks in a used blade could serve as a warning that a more-threatening chordwise crack or cracks may subsequently appear. The blade could then be replaced before it fails.

Figure 1. A **Turbine Blade** develops cracks as a result of cyclic stresses in operation.



Advance radial cracking could be promoted in design by adjusting thermal stresses and net bending stresses. Thermal stresses depend on the local thickness of the wall. By judicious distribution of the thicknesses on the concave and convex surfaces, the radial- and chordwise-crack lives could be adjusted.

Net bending stresses are the sums of gas bending and tilt bending stresses. Gas bending stresses are caused by gas loads imparted to the blade in the turning of the mainstream flow. Tilt bending stresses are

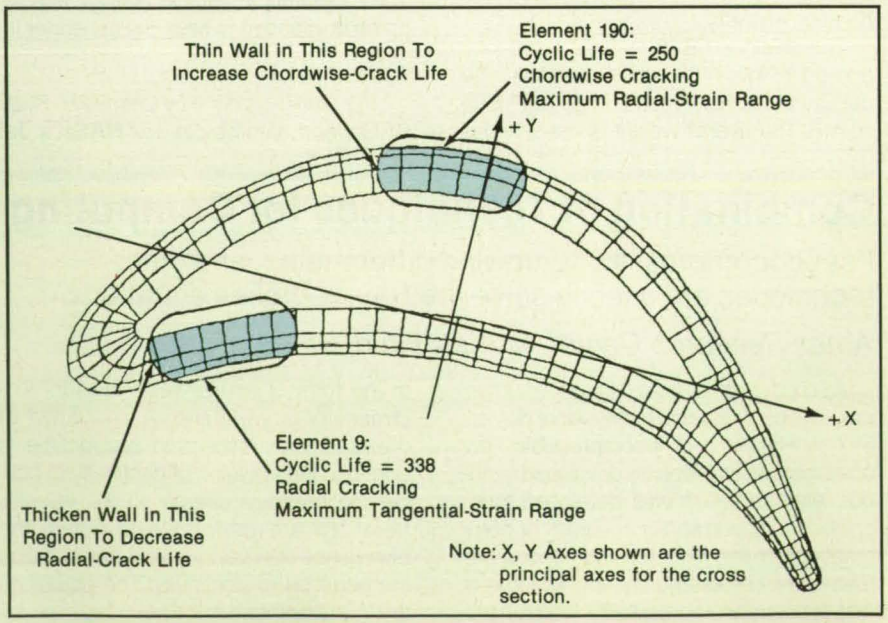


Figure 2. This is a **Blade-Root Cross Section** in a finite-element mathematical model of a turbine blade. The wall could be thinned and thickened as shown to increase the chordwise-crack life and decrease the radial-crack life, respectively.

caused by the centrifugal bending of a blade that has its cross-sectional centers of gravity offset from a radial line. Tilt bending stresses are normally designed to cancel the gas bending stresses at full power. By adjusting tilt bending, the resultant net bending stresses could be tailored to change the chordwise-crack life.

The analysis of thermal and bending stresses and the resulting effects upon crack lives could be performed with the help of MARC, a three-dimensional finite-element computer program. One should start with a design, the cracking sequence of which is the opposite of the desired sequence, then proceed as follows:

1. Decrease the local thickness of the wall in the region shown on the upper surface in Figure 2 to reduce the local thermal stresses and increase the chordwise-crack life.
2. Locally thicken the wall in the region shown on the lower surface in Figure 2 to increase local thermal stresses and decrease the radial-crack life.
3. Increase the net bending about the $-X$ principal axis to increase the chordwise-crack life of element 190.

This work was done by Donald E. Paulus of United Technologies Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 25]. Refer to MFS-28363

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.

Numerical Simulation of Buckling in Waffle Panels

Accurate results are obtained when fillet radii are considered.

Two reports describe a numerical and experimental study of the application of the PASCO and WAFFLE computer programs to the analysis of buckling in an integrally machined, biaxially stiffened panel (which resembles a waffle). The waffle pockets of such panels are machined with rounded fillets, the radii of which were not taken into account in previous applications of PASCO. As a result, previous panel designs were overconservative; that is, the structures were designed to be heavier than they had to be to withstand the anticipated buckling loads.

PASCO (Panel Analysis and Sizing Code) is a finite-element stress-and-strain code written for analysis and sizing of uniaxially stiffened panels. The mathematical model of the panel includes skin elements and assemblies of thin, flat, rectangular plate elements that represent the stiffening ribs. The loads on each plate element are calculated under the assumption of uniform longitudinal strain. The transverse load is assumed to be carried by the skin elements. In this application, a fillet is approximated by a stack of thin plate elements, the widths of which increase at the transition from the rib to the skin. This provides a stepped-cross-section approximation to the rounded cross section of the real fillet.

A biaxially stiffened panel can be analyzed by treating it as an assembly of uniaxially stiffened panels, the interfaces between which are the locations of the transverse stiffeners. However, PASCO alone cannot account for the boundary conditions (other than the simply-supported-beam condition) at the interfaces. Therefore, the WAFFLE program, which provides a comprehensive stress analysis of a waffle panel, can be used to determine bending moments at the interfaces.

The experiments consisted of buckling tests of waffle panels, which were instrumented with strain gauges. Stress readings taken in the buckled regions were compared, where applicable, with the predictions of WAFFLE, of PASCO without the fillet approximation, and of PASCO with the

fillet approximation. The predictions of PASCO with the fillet approximation agreed with the experimental values within a few percent.

This work was done by Dah N. Yin and Vu M. Tran of Rockwell International Corp. for **Johnson Space Center**. *To obtain a copy of the reports, "Modeling Buckling by Special PASCO Technique" and "Local Stiffener and Skin Pocket Buckling Prediction by Special PASCO Modeling Technique: Correlation to Test Data," Circle 33 on the TSP Request Card.*
MSC-21599

Aerothermodynamic Heating of a Transatmospheric Vehicle

The vehicle would be heated more severely during ascent than during descent.

A report describes calculations of the aerothermodynamic heating of a conceptual transatmospheric vehicle (a vehicle with characteristics of both an airplane and a space shuttle, intended to take off and land at ordinary airports and to fly along trajectories that take it briefly into low orbits above the atmosphere). These calculations are important to future design studies because it is necessary to determine the need for cooling by transpiration or ablation of the most-severely heated surfaces.

Even approximate previous calculations had shown that the requirements for thermal protection would be determined by the conditions during ascent. This is because the vehicle would use primarily an air-breathing engine or engines, and consequently the ascent trajectory would have to involve a long flight through the atmosphere at up to nearly orbital speeds. The severe aerodynamic heat fluxes and total heat loads of such hypervelocity ascent through the atmosphere would be more severe than those to be encountered during entry and descent.

The calculations begin with the study of trajectories likely to be used, so that trajectories can be varied parametrically to obtain a range of realistic heating conditions. Rates of heating, temperatures of the walls, and total heat loads were calculated for laminar flow at the stagnation point and for laminar, transitional, and turbulent flows along the leading edge of a postulated wing, and on the centerline of the windward bottom surface. Calculated rates of heating were compared with data from flights of the Space Shuttle.

The numerical results of the calculations show that the combination of the high heating rates experienced by surfaces with small curvatures and the long ascent times would result in severe heating and large total heat loads. The peak equilibrium temperatures of the walls at the leading edge of the wing and at the stagnation point during ascent could reach values of 3,000 and 4,000 K, respectively, in trajectories of high dynamic pressure. Therefore active cooling, such as transpiration or ablation, may be required in these regions of the vehicle. (The corresponding temperatures during entry would be about 1,500 K lower.)

However, the temperature on the windward centerline would be lower, with peak values of about 1,500 K. Therefore, radiative cooling should be effective over large areas of the vehicle. In contrast with the heat loads at the stagnation point and at the leading edge of the wing, the heat loads on the windward centerline would be relatively insensitive to the dynamic pressure of the ascent trajectory. The heat loads for the windward surface during entry would be much lower but would depend strongly on the flightpath.

This work was done by Michael E. Tauber of **Ames Research Center** *and Henry G. Adelman of the National Resarch Council. To obtain a copy of the report, "The Thermal Environment of Transatmospheric Vehicles," Circle 157 on the TSP Request Card.*
ARC-11854

Machinery

Hardware, Techniques, and Processes

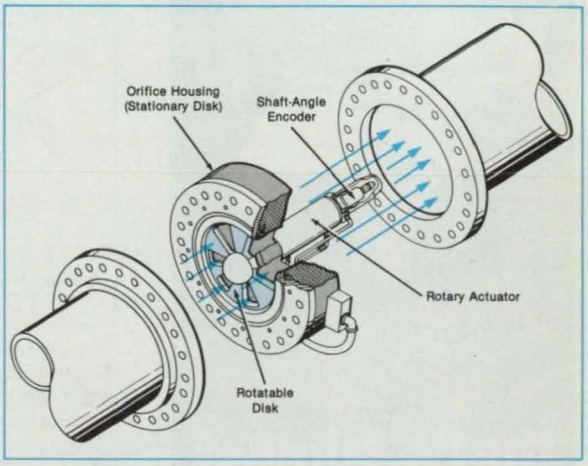
Remotely-Controlled Variable-Orifice Valve

Features include compactness and reduction of perturbation.

Marshall Space Flight Center, Alabama

A remotely-controlled variable-orifice valve is used to adjust the back pressure in tests of the flow of air in a duct. Although fixed orifices of similar configuration could be used, adjustments of the back pressure would require time-consuming removals and installations of different orifices. Adjustable valves of different configurations (e.g., gate and globe valves) that could handle the mass flows and pressures of the tests are too expensive and bulky, and they divert the flow away from straight streamlines to an extent that is undesirable for the purposes of the tests.

The valve includes an orifice housing, which is essentially a thick, stationary disk with six sectoral holes. Immediately upstream of the fixed disk is a rotatable disk with a similar pattern of holes. The angular position of the rotatable disk determines the area of overlap of the holes in the two disks; that is, the cross-sectional area open to the flow. As can be seen in the figure, the overlapping holes lie along or near most streamlines, so that the variable orifices effect minimal diversion of the flow.



A **Disk With Holes** is rotated on a fixed disk with similiar holes to adjust the cross sectional area available to the flow.

The rotatable disk is turned by a hydraulic rotary actuator. The angular position of the actuator and rotatable disk is measured by a shaft-angle encoder. The valve can be calibrated in terms of angle or open flow area versus back pressure, so that the valve can be preset at the angle necessary to obtain the desired back pressure.

The remotely-controlled variable-orifice valve is small in comparison with other types of valves designed to control similar flows and pressures. The valve can be moved easily from one flow-test facility to another. It can be sandwiched between two 18-in. (46-cm) flanges and requires an axial gap of only 5 in. (13 cm) between the flanges once it is installed.

This work was done by Olen E. Hill of **Marshall Space Flight Center**. *For further information, Circle 93 on the TSP Request Card.*
MFS-28369

Heteropolar Magnetic Suspension

A compact permanent-magnet/electromagnet actuator has six degrees of freedom.

Marshall Space Flight Center, Alabama

A heteropolar magnetic actuator has been conceived for use as an actively controlled vibration-isolating suspension device. The actuator would exert forces along, and torques about, all three principal coordinate axes to resist all three components of translational vibration and all three components of rotational vibration.

The actuator has a cylindrically symmetrical design partly reminiscent of both a loudspeaker voice coil and an electric motor. An outer cylinder holds several four-pole sets of sectors of cylindrically symmetrical permanent magnets, which generate radial magnetic fields. An inner cylinder, which moves freely with respect to the outer cylinder, includes a magnetic return path (see Figure 1). Mounted on the inner cylinder in the airgap between the permanent magnets and the magnetic return path are six layers of electromagnet coils oriented variously along the principal Cartesian and cylindrical coordinate axes (see Figure 2).

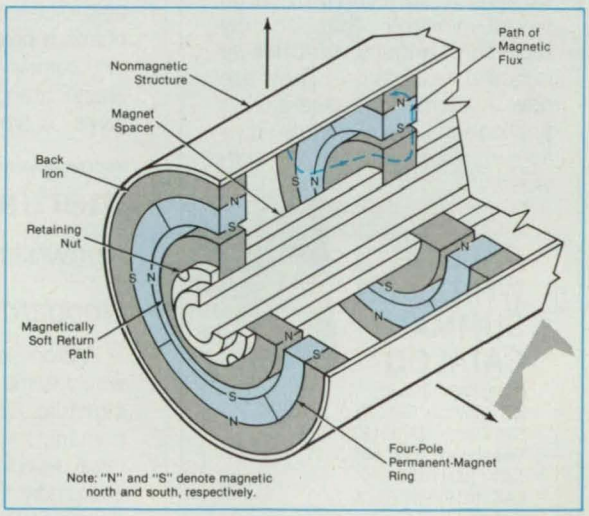


Figure 1. The **Inner Cylinder** is suspended magnetically within the outer cylinder. Electro-magnet coils (shown in Figure 2) interact with the fields of the permanent magnets to provide active control of the suspending force and torque.

Because the interaction of a radial magnetic field with an electric current does not produce a radial force, the use of the radial magnetic fields eliminates undesired radial decentering forces. Furthermore, there is no spurious force produced by the interac-

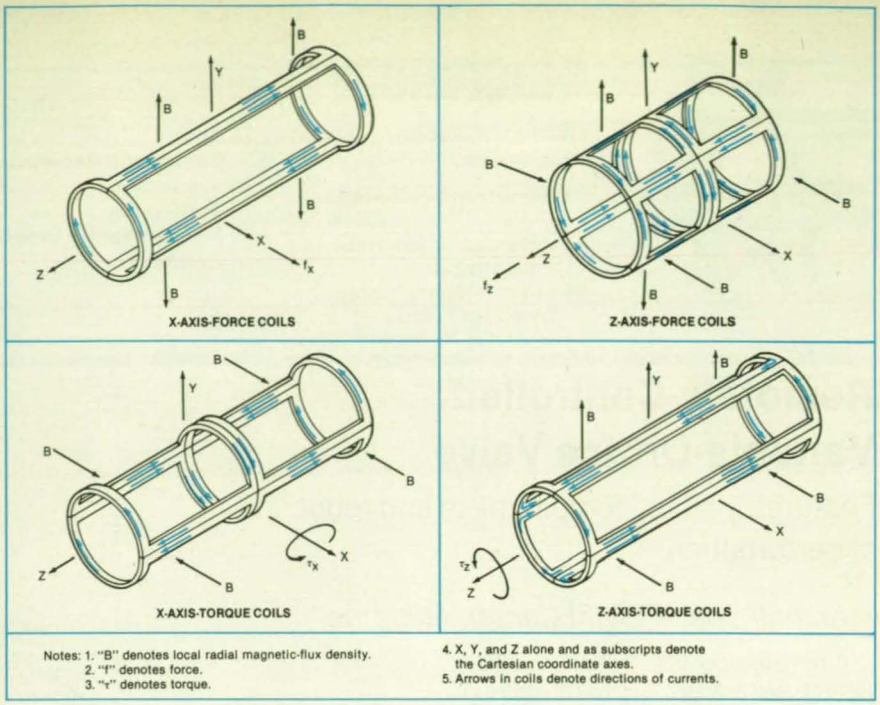


Figure 2. **Sets of Electromagnet Coils** are shaped and oriented on the inner cylinder to produce the Cartesian components of suspending force and torque. The coils for the Y force and torque, which are not shown, are simliar to those for the X and Z force and torque.

tion of the radial magnetic field with radial currents (such as those in connecting wires).

Each of the six layers of electromagnet coils is designed so that the current in it interacts with the local radial magnetic fields to produce the desired Cartesian component to force or torque. For example, in the coil shown in the top left part of Figure 2, the currents flowing along the Z axis produce a force along the X axis, while the currents flowing azimuthally produce zero net force along the Z axis.

The design of the actuator is based in part on the requirement that it produce a specified force with an airgap large enough to allow the required stroke. The design is also dictated by the magnetic and mechanical properties of the magnetic core and permanent-magnet materials and the electrical and mechanical properties of the wires. A typical core material would be 1018 cold-rolled steel. Nonmagnetic parts could be made of lightweight materials like aluminum. Coils could be made of copper wire. A typical permanent-magnet material would be Sm_2Co_{17}; the use of permanent magnets not only helps make the actuator compact but also eliminates the consumption of power in ohmic heating of conventional field windings.

This work was done by Kathleen Misovec, Bruce Johnson, James Downer, David Eisenhaure, and Richard Hockney of SatCon Technology Corp. for **Marshall Space Flight Center**. *For further information, Circle 30 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-26096

Inertia-Wheel Vibration-Damping System

Known vibrational modes would be damped sequentially.

Goddard Space Flight Center, Greenbelt, Maryland

A proposed electromechanical system would damp vibrations in a large, flexible structure. Although the system is intended primarily for use in a spacecraft that has large, flexible solar panels and a science-instrument truss assembly, it embodies a principle of control that is interesting in its own right and may be adaptable to terrestrial structures, vehicles, and instrument platforms.

In the example of Figure 1, the structure includes three main flexible appendages connected to a rigid module. The rigid module and the tips of the appendages are instrumented with accelerometers in all three coordinate axes. Rate gyroscopes and accelerometers normally carried by the spacecraft attitude-control and propulsion systems can also be utilized. The tips of the appendages are also equipped with reaction wheels driven by dc motors in all three coordinate axes. The appendage tips are an ideal place to locate sensing and torquing elements because the tips are never in a vibration mode.

The vibrational velocity of the tip of each

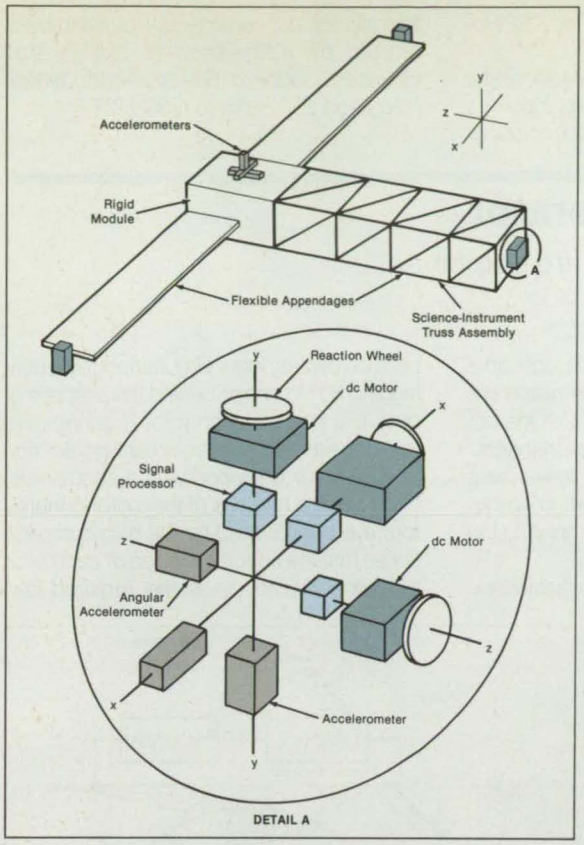
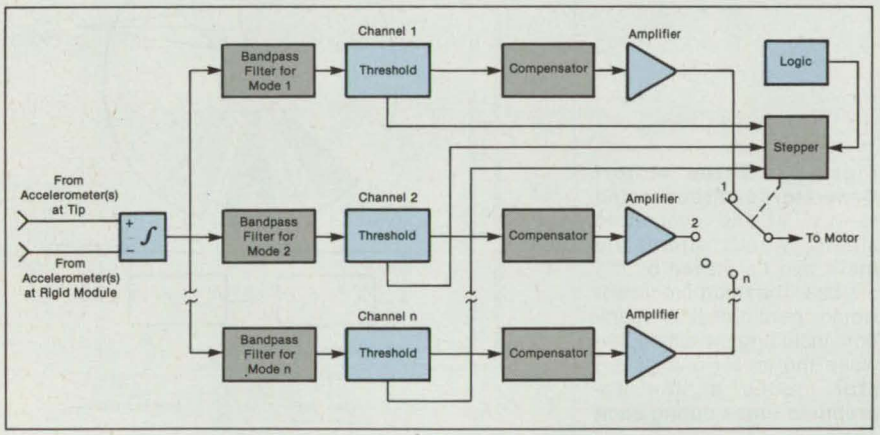


Figure 1. In the **Active Vibration-Damping System** motors and reaction wheels at the tips of appendages would apply reaction torques in response to signals from accelerometers.

Figure 2. The **Velocity Signal for Vibrations About One Axis** would be processed into a control signal to oppose each of *n* vibrational modes. The various modes would be suppressed one at a time.



appendage would be computed by integrating the difference between the outputs of the accelerometers at the tip and the accelerometers in the rigid module. To a first approximation, the motor and reaction wheel dedicated to damping vibrations about a given axis would produce reaction torques that oppose those vibrations when the motor is excited by an opposing voltage proportional to the corresponding component of linear/angular velocity.

Figure 2 illustrates, in greater detail, the processing of accelerometer outputs into motor-control signals for one axis. The differential-acceleration signals would first be integrated to obtain the velocity signal, then simultaneously band-pass filtered at the frequencies of *n* known modes of vibration of the particular structure about the particular axis. When the velocity signal in each modal channel exceeded a predetermined threshold, it would be fed to a compensation network, which would condition it for proper phasing for use by the motor. After conditioning, the signal would be amplified by an amount appropriate for each mode.

The amplified signal for each modal channel would be fed to the motor through a stepping switch. Once the velocity signal in each modal channel was reduced below the threshold, the switch would step to another channel. The switch could be controlled by either sequential stepping logic or by highest-modal-vibration-energy logic. Thus, a single accelerometer-inertia wheel could be used to damp several vibration modes about one axis sequentially. If a three-axis damper (two orthogonal directions for bending and a third axis for torsion) is on each of the major appendages of the spacecraft (see Figure 1), with ap-

propriate logic coordinating the dampers, then all of the significant system vibration modes can be damped.

This work was done by Joseph V. Fedor of **Goddard Space Flight Center**. *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, Goddard Space Flight Center [see page 25]. Refer to GSC-13077

Rotary Stirling-Cycle Engine and Generator

Advanced heat-engine and motor/generator concepts are combined.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed electric-power generator would comprise three motor generators coordinated by a microprocessor and driven by a rotary Stirling-cycle heat engine. This combination of state-of-the-art components would offer the thermodynamic efficiency of the Stirling cycle, relatively low vibration, and automatic adjustment of operating parameters to suit the changing load on the generator.

Figure 1 is a partially schematic axial view of the inside of the rotary Stirling engine. Three rotors are mounted on concentric shafts in the cylindrical engine chamber. Each rotor is a pair of diametrically opposite, paddlelike sectors of cylinders that act as rotary pistons. Heat from an external source enters the working gas of the engine (for example, helium) through the right heat exchanger at the top of the engine. Exhaust heat from the engine leaves through the left heat exchanger at the bottom.

Each rotor moves clockwise at a speed that varies semisinusoidally with its angular position so that it alternately almost catches up with and then falls behind the rotor that moves in front of it. The motions of the rotors are coordinated in such a way that the following combination of compression and expansion cycles occurs:

1. Cool working gas is drawn into the chamber through the lower left port as the rotary piston ahead of the valve races ahead of the piston behind the valve.
2. The piston ahead slows down, the piston behind races ahead, and the cool gas is compressed between the two pistons as they move toward the upper left port.
3. As the space enclosed by the two rotary pistons passes the upper left port, the compressed gas flows through the upper left heat exchanger, where it receives recycled heat, then flows through the upper right heat exchanger, where it receives heat from the external source.
4. The compressed, heated gas enters the space between two rotary pistons through the upper right port. This gas expands as the piston in front races ahead of the piston behind.
5. The piston ahead passes the lower right valve, allowing the expanded, hot gas to start escaping through the lower right heat exchanger, which recyles some of its heat to the upper left heat exchanger, then continues through the lower left heat exchanger, which rejects the unusable heat to the environment. The piston behind catches up, helping to push the hot gas through the lower heat exchangers.
6. The cooled gas leaves the lower heat exchangers and reenters the chamber through the lower left port, completing the cycle.

Of course, six such compression/expansion cycles occur simultaneously, each lagging 60° in phase behind the preceding one. The shaft of each rotor is connected to a permanent-magnet, brushless dc motor/generator equipped with a shaft-angle encoder. The motions of the motor/generators are coordinated by the microprocessor so that the angular position of each as a function of time yields the required de-

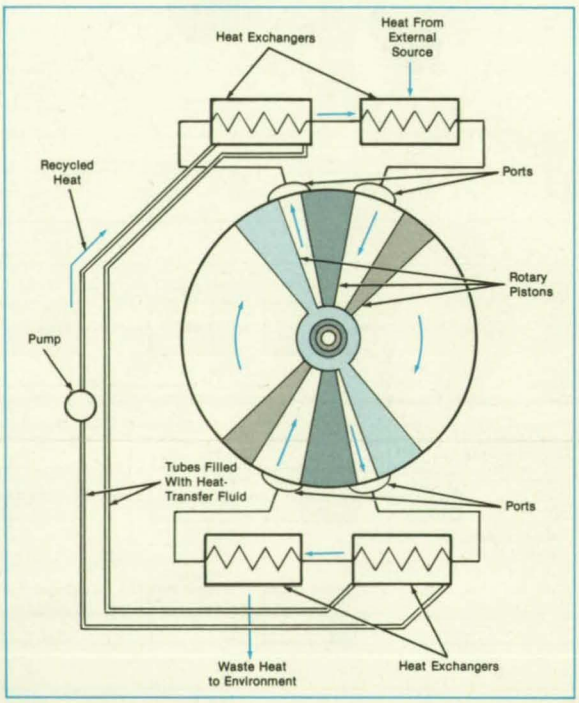
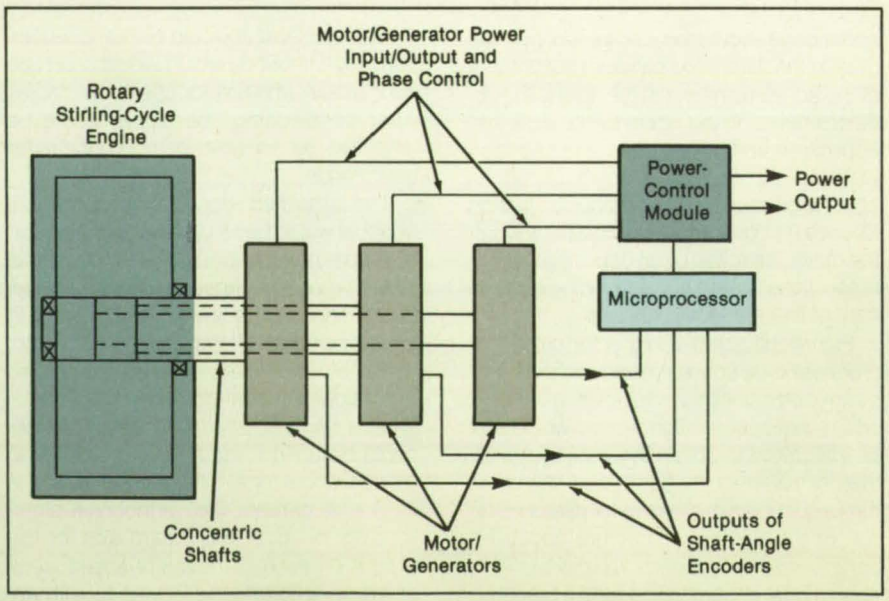


Figure 1. The **Rotary Stirling Cycle Engine** would convert heat to power via compression and expansion of a working gas between three pairs of rotary pistons on three concentric shafts in phased motion.

Figure 2. **Three Motor/Generators** each connected to one of the concentric shafts, would alternately move and be moved by the pistons. The microprocessor would coordinate their operation, including switching between the motor and generator modes at the appropriate times during each cycle.



pendence of speed on angular position to obtain the properly phased compression and expansion cycles.

The microprocessor switches each motor/generator between the motor and generator modes at the angular positions that define the boundaries between net expenditure and net generation of energy for the affected rotor. Although the motor/generators expend energy in compressing the gas, they generate energy during the expansion phases, and over the complete cycle there is a net conversion of heat to electrical energy. If the microprocessor is suitably programmed and supplied with such additional sensor inputs as the inlet and heat-exchanger temperatures and the electrical load on the motor generators, it can optimize the compression/expansion cycles.

This work was done by Joseph A. Chandler of **Johnson Space Center**. *For further information, Circle 70 on the TSP Request Card. MSC-21530*

Securing Bearing Races to Turbopump Shafts

Tension bands would prevent races from loosening caused by differential thermal contraction.

Marshall Space Flight Center, Alabama

A proposed method of attaching the inner race of a roller bearing to a shaft would prevent loosening that is now caused by the difference between the coefficients of thermal expansion of the race and shaft materials. The method is intended for a cryogenic turbopump in which the race is made of 440C stainless-steel alloy and the shaft is made of Inconel* 100 nickel alloy. The stainless-steel race material is chosen for its hardenability. The coefficient of thermal expansion of the stainless steel is more than 15 percent less than that of the nickel alloy. Therefore, as the cryogenic liquid cools the pump, the race loosens on the shaft because the shaft shrinks more than the race. The centrifugal force at the high rotational speed of the turbopump adds to the loosening of the race.

If the race were allowed to loosen enough to slip on the shaft, it would wear and gall the shaft. Accordingly, the practice has been to shrink-fit the race when it is installed on the shaft. But this creates tensile stresses in the race that can cause stress-corrosion cracking while the turbopump is stored at room temperature before use.

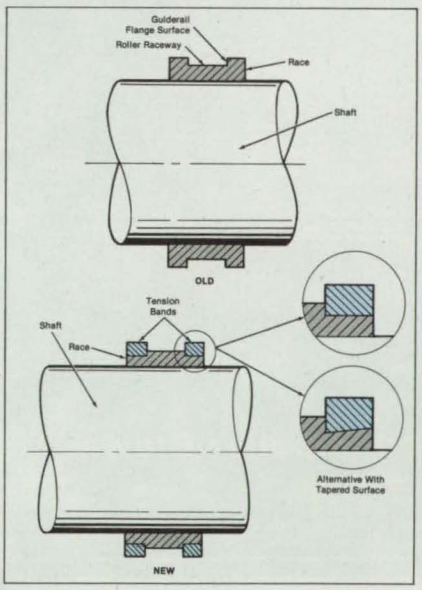
In the proposed new method of attaching the race, the guiderail flanges of the race, which guide the rollers, would be replaced by tension bands of a strong material that has a coefficient of thermal expansion greater than that of the 440C alloy. One such material is Waspalloy, which has a coefficient substantially larger than those of both the stainless-steel and nickel alloys. As the assembly would cool, the Waspalloy tension bands would shrink more than would the race or shaft, so that the tension bands would hold the race firmly on the shaft.

Like the stainless-steel alloy, Waspalloy is strong and resistant to corrosion. It cannot be hardened as much as the 440C alloy, but it is tougher. Inasmuch as the rollers make contact with the flanges only intermittently, the tougher, slightly softer flange material may prove to be superior.

*Inconel is a registered trademark of the INCO family of companies.

This work was done by Dale H. Blount of **Marshall Space Flight Center**. *For further information, Circle 66 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-28384



The **Roller Bearing Race** is press-fit customarily onto the turbopump shaft (top). In the proposed version (bottom), the flanges of the race would be replaced by tension bands that shrink faster as they are cooled. A tension band in the alternative configuration shown in the inset would engage the race on a slightly sloping surface so that axial forces would not dislodge it.

Mechanism for Guided Release

A shield would be thrown off a protected object.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed mechanism would retain a protective shield until it is no longer needed, then release the shield and guide it away for safe ejection from a vehicle (a spacecraft, according to the original concept). The mechanism is intended for use with a shield like the one described in the preceding article "Crash-Resistant Shield" (NPO-17616).

The mechanism would include a segmented-band device that would hold the shield on a base on which the equipment to be protected is mounted (see Figure 1). An electrically actuated explosive separator would hold the band together. On command, the separator would release the segments of the band from each other (see Figure 2).

At separation, a pair of springs would push the shield away from the base. Rollers on the inside wall of the shield would ride in a pair of diametrically opposed tracks. The tracks would guide the shield along its entire length until it separates from, and is safely clear of, the object to be protected and the rest of the vehicle. A truss would be connected to the shield for support during maneuvers before ejection. Explosively retractable pins would join the truss to the shield. The command to jettison would cause the retraction of the pins so that the shield could move freely.

This work was done by Richard A. Kull of General Electric Co. for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 11 on the TSP Request Card.*
NPO-17617

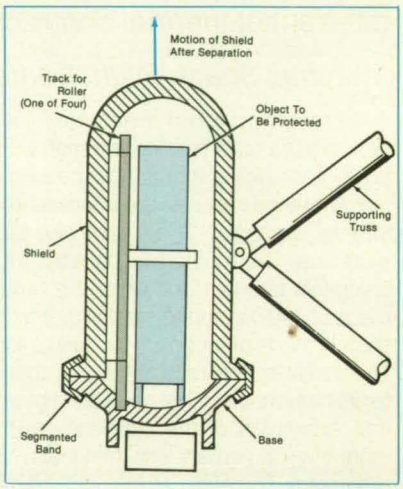


Figure 1. The **Mechanism for Guided Release** would separate the shield from the base and from a supporting truss on command.

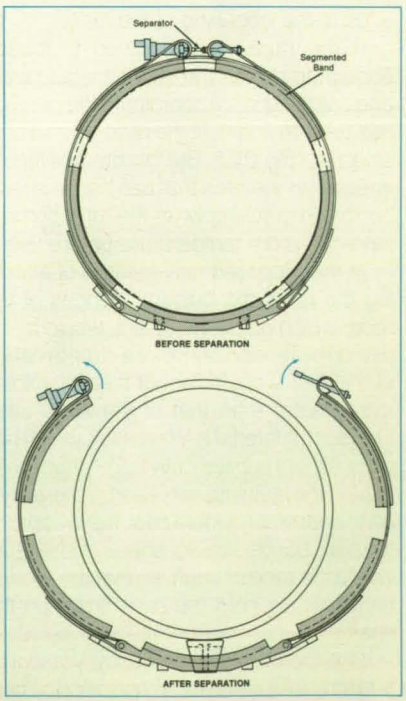


Figure 2. The **Band That Holds the Shield on the Base** would be released by an explosive separator.

Fabrication Technology

Spot-Welding Gun With Adjustable Pneumatic Spring

Controlled force would be applied at any position within the stroke.

Marshall Space Flight Center, Alabama

A proposed spot-welding gun would be equipped with a pneumatic spring instead of a conventional elastic spring. The pneumatic spring, which could be a bellows or a piston and cylinder, would exert a force independent of position along its stroke. Thus, the gun could apply an accurately controlled force to the joint to be welded, without precise positioning at a critical position within the stroke.

A conventional spot-welding gun includes a spring-loaded welding tip and a switch set at a tripping point within the stroke of the tip and spring, corresponding to a preset welding contact force. When the tip is pressed against the workpiece with the preset force, the switch initiates the pulse of welding current. However, once the welding current is initiated, the force can deviate from the preset value because it depends on how far the spring is subsequently compressed beyond the tripping point.

In the proposed spot-welding gun, the static contact force would depend only on the atmospheric pressure and the pressure inside the pneumatic spring. The tripping force could be adjusted easily and accurately by adjusting a pressure sensor and/or a pressure regulator that would feed the pneumatic spring. As an additional benefit, during the typical short duration of the welding pulse, the pressure in the pneumatic spring could momentarily be increased substantially to apply a welding contact force greater than the technician could exert by pushing against the weld. This mode of operation would rely on the mass of the gun and the technician to minimize recoil, in a manner similar to that of a firearm.

This work was done by Richard K. Burley of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.* *MFS-29569*

Moving Large Wiring-Harness Boards

A rolling carrier makes the transfer of heavy boards easy and safe.

Marshall Space Flight Center, Alabama

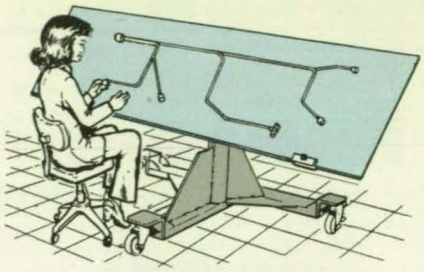
A carrier for wiring-harness fabrication boards enables a lone operator to move a board easily and safely. The carrier holds the harness while the operator is fabricating it, while it is being stored, and while it is being transported to an equipment frame for mounting. Previously, three people were needed to move the board, which measures 8 by 5 ft (2.4 by 1.5 m) and weighs 54 lb (24 kg), exclusive of the harness.

The operator assembles the harness on the board while the carrier holds the board in locking channels and supports it at a convenient height and angle (see figure). When the work is complete, the operator removes a safety lockpin from the carrier and lifts the right side of the board, tilting it to a vertical orientation. The operator locks a safety arm to maintain the board in the vertical orientation and presses an electrical switch on the carrier to lower the board onto a roller track on the base of the carrier. The operator unlocks the casters on the base and rolls the carrier and board to a cabinet for storage. At the cabinet, the operator pushes the board along the roller track forward into a vertical storage slot.

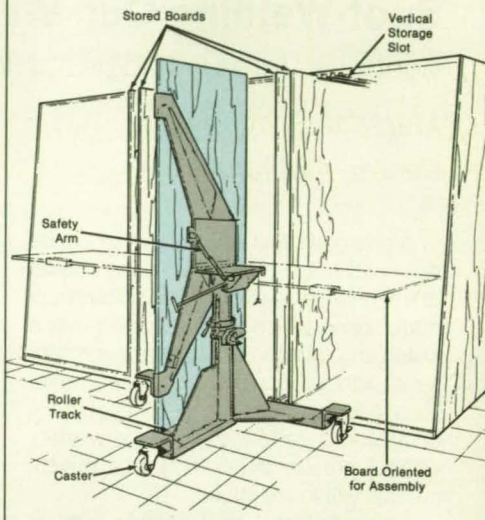
When the time comes to take out the harness again, the operator reverses the procedure, sliding the board back onto the roller track on the carrier. For fabrication, the carrier can be adjusted so that the board is at an angle of 30°, 45°, or 60°. Similarly, the board can be raised or lowered by the switch-operated motor on the carrier.

This work was done by Samuel D. Shepherd and Isaac Gurman of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 8 on the TSP Request Card.*
MFS-29510

When Positioned for Assembly of the Wiring Harness, the board and carrier give an operator easy and convenient access to wires and cables, when positioned for transfer of the wiring harness to or from a storage area, the carrier holds the board securely while it is moved by one person.



ASSEMBLY OF HARNESS ON BOARD



BOARD IN POSITION FOR TRANSFER OR STORAGE

Impact Wire Dislodges Obstructions

Inaccessible debris are broken or shaken loose by impact.

Marshall Space Flight Center, Alabama

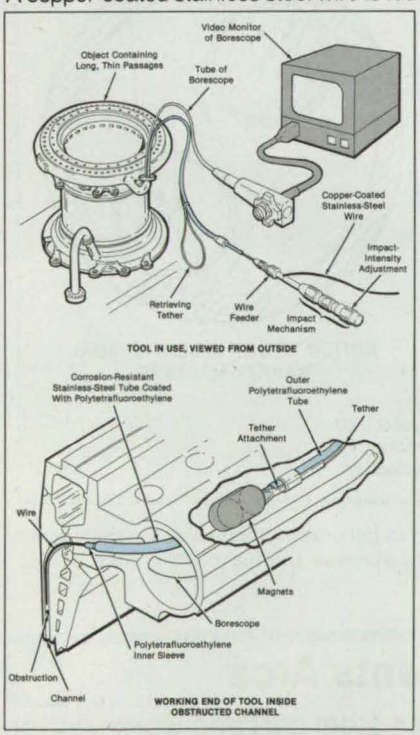
A snakelike tool loosens trapped debris that obstruct narrow passages in normally inaccessible locations. The tool is designed for use in the narrow, intricate coolant channels of a rocket engine. The tool lends itself readily to modification for use in engine blocks, heat exchangers, general plumbing, and the like.

The tool includes a long polytetrafluoroethylene outer tube that contains a corrosion-resistant stainless-steel inner tube covered with polytetrafluoroethylene. The working end of the inner tube may have to be bent to fit the narrow space in which it is to be used. The inside of the inner tube is lined with polytetrafluoroethylene.

The obstruction is located by a radiographic, infrared, or other suitable inspection technique. Together with a borescope, the tool is threaded into the blocked channel until the working end approaches the obstruction. Magnets can be attached to the working end of the outer tube to enable it to be pulled along the channel from outside. If the outer tube is prevented by the size of the channel from moving farther, the inner tube can be pushed farther in through the outer tube.

A manual impact mechanism is attached to the outer end of the stainless-steel tube. A copper-coated stainless-steel wire is fed through the impact mechanism into and along the inner tube until it emerges at the working end. The working end of the wire is capped with polytetrafluoroethylene to keep it from scratching the wall of the channel.

With the help of the borescope, the tip of the wire is guided into contact with the obstruction. The impact mechanism is then used to apply an impact load to the wire; and the wire, in turn, strikes the obstruction, hopefully breaking it loose. The dislodgement of the obstruction should be visible through the borescope. The removal of debris is completed by flushing the passage at a high rate of flow and verified by radiographic or other suitable inspection.



The **Flexible Tool** is threaded into the obstructed channel, much like a common plumbing snake. The wire is fed along the inner tube of the tool until its tip reaches the obstruction. The wire delivers an impact from the impact tool to the obstruction.

This work was done by Steven K. Ricklefs and Jeffrey E. Anders of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 118 on the TSP Request Card.*
MFS-29513

Centrifugal Barrel Finishing of Turbine-Blade "Fir Trees"

Residual compressive stresses and smooth surfaces are obtained simultaneously.

Marshall Space Flight Center, Alabama

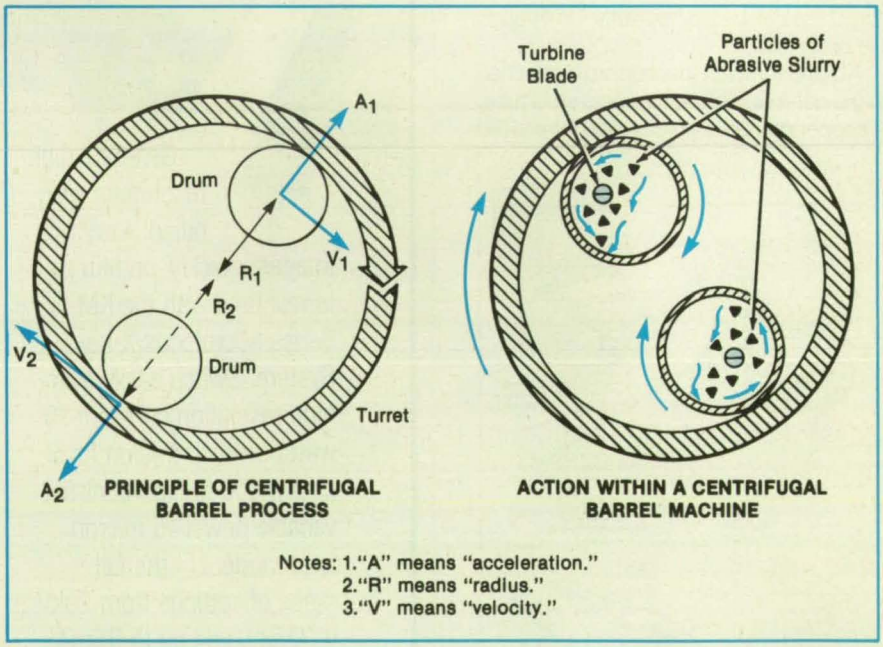
A modified centrifugal barrel-finishing machine (see figure) imparts desired residual compressive stresses to the "fir trees" of turbine blades — the wavy, keywaylike surfaces by which the roots of the blades are gripped by turbine disks. The use of the modified barrel finisher eliminates the need for shot peening (the conventional way to impart compressive stresses). It therefore eliminates the rounding of edges and burrs caused by shot peening and, consequently, the need for mass finishing operations to remove the burrs. In addition, the modified barrel finisher improves the surface finish of the "fir trees."

The turbine blades are suspended in a ceramic-based abrasive slurry that is contained along the periphery of the barrel finisher. The barrel finisher is rotated very rapidly to generate extremely high centrifugal loads, which are distributed evenly over the surfaces of the blades by the slurry. These loads generate the residual compressive stresses.

Those portions of the surfaces of the blades that are not to undergo compressive loading are masked with urethane or epoxy before insertion in the barrel finisher. The barrel-finishing process removes only about 10^{-5} in. (0.25 μm) of material from the surfaces of the blades, yielding highly polished surfaces.

This work was done by Johnny L. Mandel 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 25]. Refer to MFS-29553



Notes: 1. "A" means "acceleration."
2. "R" means "radius."
3. "V" means "velocity."

In the **Centrifugal Barrel Finisher**, centrifugal forces generate compressive stresses, which are transmitted to the turbine blades through the abrasive slurries in which they are suspended.

Etching Electrode Prevents Arcs

A wooden part replaces a stainless-steel part and works better.

Marshall Space Flight Center, Alabama

A disposable electrode for etching Inco* 625 (or equivalent) alloy works better than does the previous, more expensive version. The size and shape of the electrode make it easier than before to etch in narrow grooves and other confined spaces

(see Figure 1). The electrode is designed to prevent arcing, which damages the metal workpiece.

The old version of the electrode includes a stainless-steel rod, the end of which is wrapped in cotton and fiberglass. The cotton and fiberglass are imbued with the etching solution. The positive side of a dc power supply is connected to the workpiece, and the negative side to the electrode. The electrical circuit is completed, and etching occurs at the contact between the workpiece and the electrode. If particular care is not taken, the cotton and fiberglass rapidly break down, causing the rod to break through and arc to the workpiece, causing damage.

In the new version, the stainless-steel rod is replaced with a piece of wood — for example, a tongue depressor (see Figure 2). The wood is wrapped with a piece of copper wire, which provides the necessary electrical conduction. The wire is covered with cotton, then fiberglass. (The fiberglass and cotton must make contact with the wire to complete the circuit.) Plater's tape is wrapped around most of the electrode assembly, excepting only the portion that is to do the etching. As in the old version, the electrode is imbued with etching solution and connected to the dc power supply. The new version etches without drawing arcs between the wire and the workpiece.

*"Inco" is a registered trademark of the Inco family of companies.

This work was done by Michael J. Trost and Carl V. Yanagihara 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 25]. Refer to MFS-29508

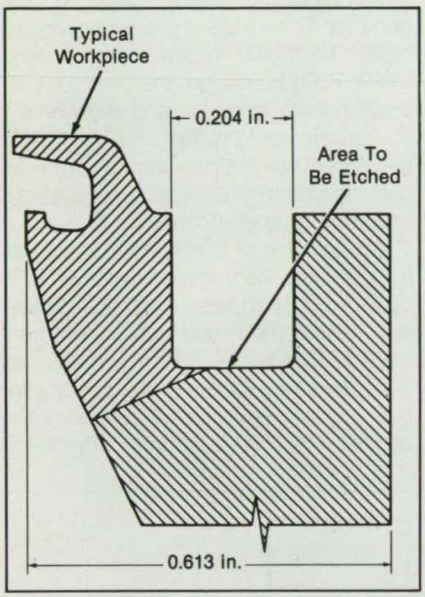


Figure 1. **Etching Can Be Performed in Grooves** by use of etching electrodes of the types described here. Each electrode carries a small supply of the etching solution.

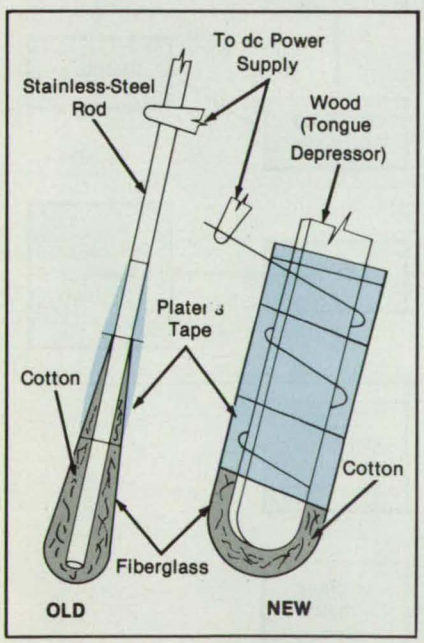


Figure 2. The **Old and New Versions of the Etching Electrode** have similar functional parts. However, the new version costs less and is less likely to damage the workpiece by arcing.

Mathematics and Information Sciences

Software for Development of Expert Systems

A modular software system helps to create efficient artificial-intelligence computer programs.

NASA's Jet Propulsion Laboratory, Pasadena, California

The STAR*TOOL system is a set of high-level software tools that assist programers in the creation of efficient knowledge-based (expert) software systems. STAR*TOOL provides the language and capabilities for the compilation of application programs written in the Common LISP programming language. Unlike other expert-system "shell" programs, STAR*TOOL features modularity that enables the elimination of unnecessary capabilities from the final application program and thereby achieves greater computing performance.

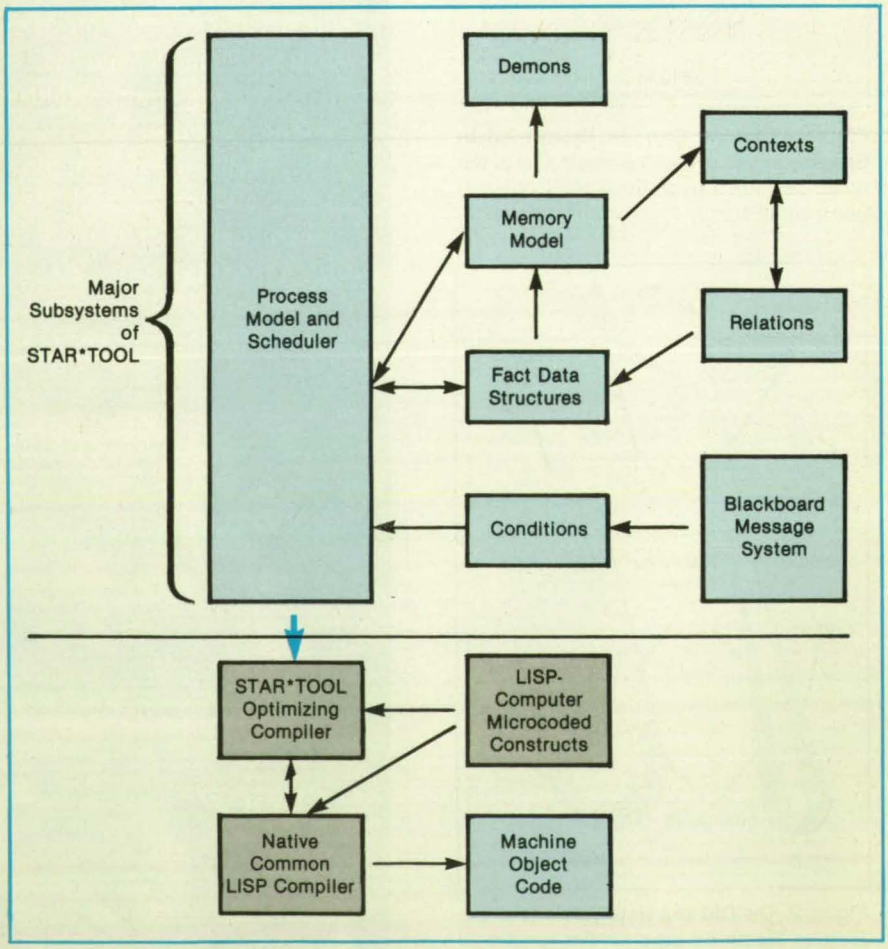
The unique approach of STAR*TOOL to the creation of knowledge-based systems is based in part on the use of sophisticated compiler techniques. STAR*TOOL can be run on any computer that supports Common LISP and that has sufficient memory.

STAR*TOOL provides the programmer with the necessary software tools to build a wide variety of reasoning and inference engines for such applications as planning, diagnosis and analysis, and simulation. The high efficiency of STAR*TOOL's implementation also enables the building of real-time systems, including those for monitoring real-time processes. When STAR*TOOL is run in an environment that supports multiple programming languages, STAR*TOOL's capabilities can be utilized via local and remote procedure calls and through shared data structures. This enables portions of the application system to be developed in the most suitable programming language and allows such portions to be connected to the Common LISP STAR*TOOL application in a straightforward, natural way.

STAR*TOOL enables and encourages the development of embedded expert systems. Thus, STAR*TOOL could be a supervisor of many other systems written in either STAR*TOOL or conventional programming languages. Most of the software tools provided by STAR*TOOL, such the blackboard, memory model, process model, and process scheduler, can operate independently of one another (see figure). However, when operated in combination, they form a fully integrated synergistic set of software tools. Since the user is able to choose only those portions of STAR*TOOL that are applicable to a given application, the computational overhead of including unnecessary excess software is avoided, resulting in greater application efficiency. Thus, the resulting application program can run on a smaller computer than the one on which it was developed.

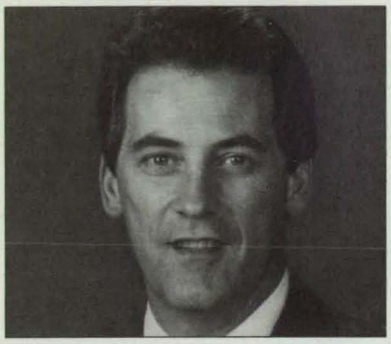
When an application program is developed in STAR*TOOL, STAR*TOOL first translates the program to Common LISP code. It can then optionally pass the resulting Common LISP code through an extensive source-to-source LISP code optimizing compiler. STAR*TOOL generates code that is custom-tailored for each application. There are no intermediate levels of interpretation for execution, unlike many other knowledge-based system software shells. STAR*TOOL programs are executed directly by Common LISP interpreter and compiled directly by Common LISP compiler. This results in greater speed and better portability to other computers. STAR*TOOL builds upon the Common LISP programming language and environment so that programs written in STAR*TOOL have direct use of all the features of the underlying Common LISP software systems and computing environment.

A single line of STAR*TOOL code can translate into many lines of Common LISP code. To support ease in application system development and subsequent software maintenance, all error messages generated from the STAR*TOOL compiler and run-time environment reference the original STAR*TOOL source code. In the



The **STAR*TOOL Software System** comprises eight major subsystems that act in concert to produce Common LISP computer code tailored to specific applications.

WE COULDN'T PAY PEOPLE TO WRITE COPY THIS CONVINCING.

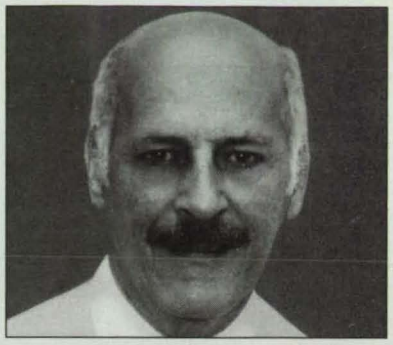


"NASA Tech Briefs is the winner! It generated 45% more reader inquiries than any other publication and telephone inquiries amounted to 50% more than the nearest competitor."

Gary Kerr, Marketing Communications Manager
The Ioline Corporation

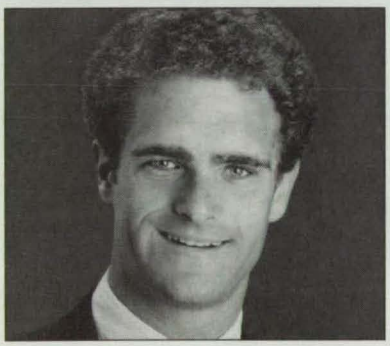
"We rely on advertisements in NASA Tech Briefs to guide our purchasing. It's an unspoken thought on my part; if they advertise in the NASA publication, there must be something to it."

Dr. T.F. Korenowski, President
TFK Company, Inc.



"NASA Tech Briefs is the single most important technical publication relating to aerospace, commercialization of space and technology transfer. Thanks for a great magazine!"

Jac B. Kadar, Senior Staff Engineer, Advanced Robotics Section, United Technologies—USBI



"NASA Tech Briefs helped make our product a best-seller. It not only generates a good number of leads, but more importantly, an extremely high percentage of those leads are turned into sales."

Alex Wellins, Director of Marketing
The Visionics Corporation

"Articles in NASA Tech Briefs help keep me abreast of many new developments. If I had to give up all my magazines except one, NASA Tech Briefs would be the one I'd keep."

Perry D. Campbell, Jr., Engineer, Advanced Robotics
Lockheed Engineering and Sciences Company

"Through NASA Tech Briefs we 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 Corporation

Discover NASA Tech Briefs, your secret weapon in the high-tech media wars.

There are literally *thousands* of similar testimonials. From readers who can't do without NASA Tech Briefs; from advertisers who wish they'd discovered us sooner.

Our engineer subscribers react to the most timely editorial in the business press. Because all findings from NASA programs are published in NASA Tech Briefs first, *before anyone.* While advertisers applaud our book and their agencies for making such a low cost, high impact media buy. NASA Tech Briefs works because it's engineered for results, pure and simple.

You haven't heard of us? Here's a quick study: In just a little over five years our circulation has more than doubled, from 83,000 to 183,000. Our readers not only have the power to specify advertised products, but also personally sign for their subscriptions. And—proof that the word is getting out—pages are up more than 30% for the third consecutive year. That's a decidedly dynamic performance, in a static magazine market.

If you're targeting design engineers, here's a little secret: A schedule in NASA Tech Briefs is bound to make everyone heroes. Because it'll work wonders, without breaking the budget.

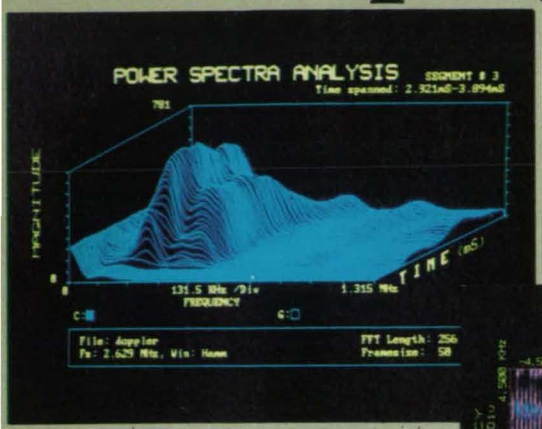
For a revealing media kit, call toll-free (800) 258-0201 today; in New York (212) 490-3999; FAX (212) 986-7864.

NASA Tech Briefs

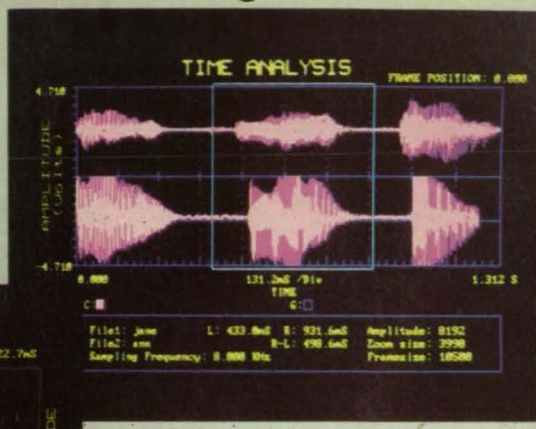
ENGINEERED FOR RESULTS

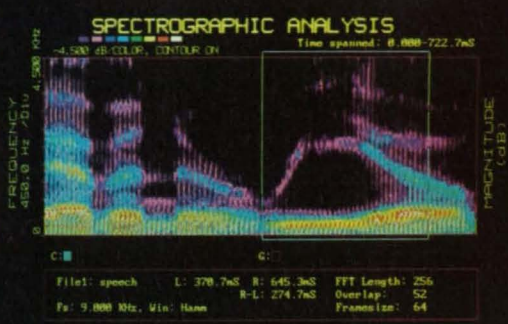
41 East 42nd Street, Suite 921, New York, New York 10017

Display the beauty...



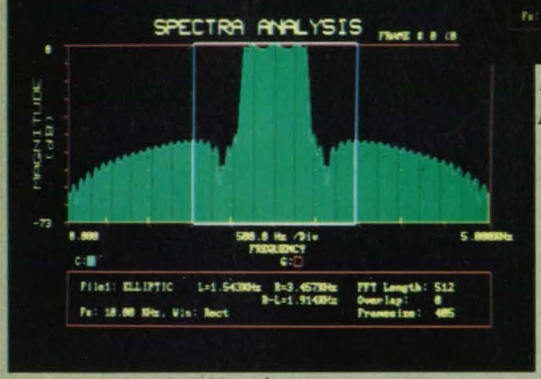
Complete, integrated DSP environment with true menu selection, frame-based waveform analysis with full zoom, pan, and random-access capability in time and frequency domains





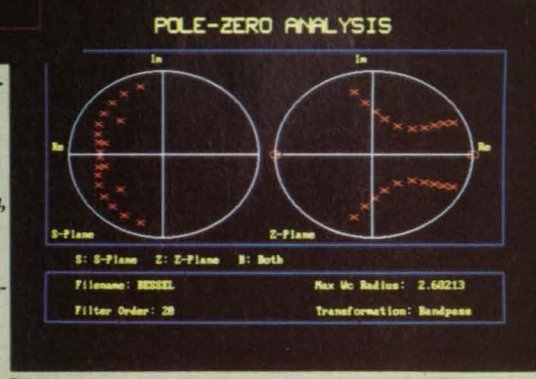
Over 300 screens of context-sensitive, on-line help, 375+ page Users Manual

User options include mouse interface, color/mono displays and hardcopy



Popular board manufacturers supported, including:

- *Acrosystems*
- *Ariel*
- *Burr-Brown®*
- *CAC (Communications, Automation, and Control)*
- *Data Translation®*
- *Motorola®*
- *Spectrum Signal Processing (Loughborough Sound Images)*
- *Texas Instruments®*



...and tame the beast in your DSP problems with Hypersignal-Workstation™ DSP software.

Hypersignal-Workstation has become an industry standard in DSP and PC-based instrumentation software, supporting more analog/DSP boards, more DSP chips, and more DSP functions, algorithm design tools, and analysis tools than any other software available. Before you end up with a shelf full of packages that won't talk to each other, consist of separate "modules" (with separate prices), or worse yet, weren't designed for real DSP problems, consider what more and more customers worldwide already have:

REAL-TIME SUPPORT

- Integrates 320C25/C30, DSP32C, DSP56000, ADSP-2100, Data Translation®, Acrosystems™, and Burr-Brown® analog/DSP hardware
- Continuous hard disk acquisition/playback up to 150 KHz
- Instrumentation sampling rates as high as 1 MHz
- Accelerated FFT processing
- DSP chip source code interface for algorithm simulation/test
- Dual-channel digital oscilloscope and spectrum analyzer

ANALYSIS

- Time waveform display, editing, and D/A playback
- FFT processing, including window, framesize, and overlap control
- 3-D spectrogram, 2-D spectrographic analysis and D/A playback
- Power spectra estimation
- Convolution, recursive filtering
- LPC autocorrelation, including window, framesize, and overlap control
- Pole-zero, unwrapped phase, group-delay, linear/log magnitude, etc.

DESIGN & SIMULATION

- Classical, arbitrary FIR/IIR filter design, including graphical filter editor and log or linear axes
- Comprehensive difference equations, with math functions, signal arithmetic, and signal calculus
- Arbitrary function generation
- Code generation and quantization simulation for Texas Instruments® TMS320xx, AT&T WE® DSPxx, Motorola® DSP5600x, Analog Devices ADSP-2100. Selectable IIR structure and quantization.

North American Pricing:

Hypersignal-Plus DEMO	FREE
Hypersignal-Plus	$489
Hypersignal-Workstation	$989
DSP Workstation-25 MHz	$9995
DSP Workstation-33 MHz	CALL

Hyperception

Hyperception Inc, 9550 Skillman LB125, Dallas, TX 75243 TEL 214-343-8525, FAX 214-343-245

WEST GERMANY - Electronic Tools, phone: (02102) 841013, TLX 1631+BTX 02102841013 1+,fax: (02102) 841000 • UK, IRELAND - Loughborough Sound Images, LTD., phone: (0509) 231843, TLX 341409 LUFBR G. fax: (0509) 262433 • FINLAND - ITT, phone: (90) 739 100, TLX 121450 MultiKomponent, fax: (90) 712 414 • FRANCE - BORES Technical Sales, phone: CC44 (0483) 740138, fax: (0483) 740136 • ITALY - Mon Ingegneri & Consulenti, phone: (172) 422577-422531, fax: (172) 431243 • JAPAN - CADTECHS, INC., phone: 3-813-8222, TLX: 23528, fax: 3-818-7888 • DENMARK - Assentoft Electronics, phone: (06) 16 29 26, fa (86) 16 20 12 • ISRAEL - IES Ltd., phone: (03) 7526333, fax: (03) 7510927

Circle Reader Action No. 445

case of run-time errors, the resulting Common LISP translation is also referenced.

This work was done by Mark L. James and David J. Atkinson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 5 on the TSP Request Card.*

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

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

Refer to NPO-17536, volume and number of this NASA Tech Briefs *issue, and the page number.*

Connection Protocol for Mobile/Satellite Communications

Throughput is increased by better resolution of competing simultaneous requests for connections.

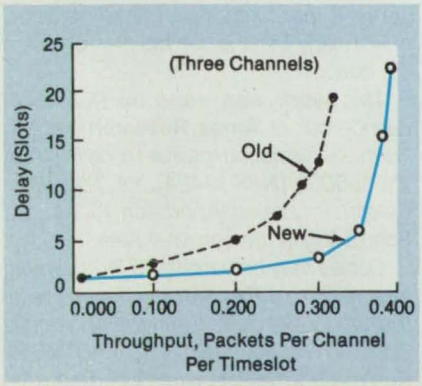
NASA's Jet Propulsion Laboratory, Pasadena, California

An improved protocol sorts out simultaneous competing requests by message-originating stations for connection to the satellite transmission link of a land-mobile/satellite digital communication system. The protocol applies to a multiple-channel packet-message system with synchronous timeslots on all channels. During each timeslot it is possible to transmit only one packet of data on each channel. Simultaneous requests from two or more originating stations for connection to the transmission medium can result in "collisions" between packets on a channel. The problem in devising a protocol is to resolve such collisions in a manner that is stable, prevents deadlocks, and provides for efficient utilization of channels and timeslots.

The communication system has Q channels. Transmissions of packets are allowed to begin only at the beginnings of the timeslots. The system provides, to all users, binary feedback information on the state of the channel — namely, whether or not there is a collision — during each timeslot. When the round-trip propagation delay is negligible in comparison with the packet-transmission time, the feedback information is known to the users immediately at the end of each timeslot.

Then the protocol is as follows:

1. An attempt is made to transmit a new packet immediately at the start of the first timeslot that follows its arrival by independently selecting one of the Q channels with probability $1/Q$.
2. Collisions in the channels during a timeslot are resolved on a channel-by-channel basis. That is, the collisions (if any) in channel 1 during that timeslot are re-



The **New Collision-Resolution Protocol** results in decreased delay and increased throughput.

solved first, followed by the collisions (if any) in channel 2 during that timeslot, and so on.

3. The next attempt to transmit the packets that collide in channel i will be made during a timeslot in which all collisions in channels 1 through $i-1$ shall have been resolved. This attempt will be made by independently selecting one of the Q channels with probability Q. When the round-trip propagation delay is equal to d slots, the feedback information is known to the user $d+1$ slots later. In this case, $d+1$ interleaved copies of the above protocol are employed.

The throughput performance of the new protocol was derived analytically and the delay performance obtained by computer simulations, assuming an infinite number of users and a Poisson distribution of arrival times of packets at a rate of λ packets per timeslot. As measured in terms of the average delay per packet necessitated by retransmission of colliding packets in a three-channel system, the new protocol is superior to a previous collision-resolution protocol (see figure). The maximum stable throughput of the new protocol is 0.402 packets per channel per timeslot, while that of the older protocol is 0.368 packets per channel per timeslot.

This work was done by Harry H. Tan and Tsun-Yee Yan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 6 on the TSP Request Card.*
NPO-17735

Algorithm Schedules Airplane Landings

The average landing delay is reduced.

Ames Research Center, Moffett Field, California

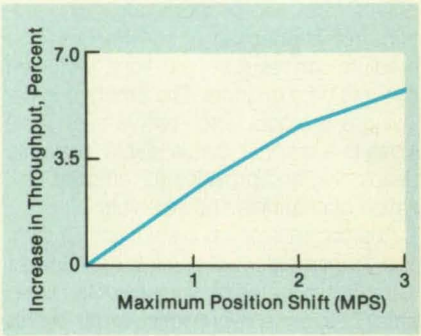
An algorithm schedules the arrivals of airplanes to reduce the average or overall landing delay. In computer simulations, the algorithm increased the number of landings by 3 to 5 percent at a representative airport, Stapleton at Denver.

The algorithm rearranges the order of landing according to the weight class of each airplane. For example, inasmuch as a lighter airplane must follow a heavier one at a relatively large distance to avoid a dangerous wake, landings could be speeded if a group of heavy aircraft were made to follow a group of lighter ones. Of course, the algorithm limits the extent of one rearrangement to avoid penalizing any airplane or category of airplanes.

The algorithm is a version of a well-known algorithm for the "traveling-salesman" problem, which selects an efficient itinerary for sales calls. The object of the aircraft-scheduling algorithm is to minimize the time in which the last airplane in a string of arriving airplanes is allowed to land. It observes the following rules:

- The first airplane must still be scheduled first in the revised schedule.
- An airplane must be scheduled within a preset number of landing slots of its original position.
- Airplanes following the same incoming route may not pass one another.

The algorithm takes the original order of arrival as the initial schedule and computes the time to land all airplanes. It then randomly selects adjacent airplanes and interchanges their landing order. It generates a new schedule, but one that is still feasible according to the rules. Starting with the new schedule, the algorithm considers all feasible repositionings of a given airplane and the associated time to land the aircraft. It selects the best repositionings. The algorithm does this for each aircraft to arrive at the solution — a nearly optimum schedule (see figure).



The **Increase in Throughput** of an airport is increased in a simulation in which the order of landing of any airplane in the queue is permitted to shift by a number of positions up to the maximum position shift (MPS). The resulting new schedule is a suboptimum solution to the scheduling problem and approaches the optimum as the MPS increases.

In simulations, the time required to schedule a queue of 40 aircraft on a VAX computer ranged from 10 to 30 seconds. In general, the computation time increases only linearly with the number of airplanes in the queue.

This work was done by Robert A. Luenberger of **Ames Research Center**. *Further information may be found in NASA TM-100062 [N88-19424], "A Traveling-Salesman Based Approach to Aircraft Scheduling in the Terminal Area."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12197

Multivariable PID Controller for Robotic Manipulator

Gains are updated during operation to cope with changes in characteristics and loads.

NASA's Jet Propulsion Laboratory, Pasadena, California

A conceptual multivariable controller for a robotic manipulator includes a proportional/derivative (PD) controller in an inner feedback loop, and a proportional/integral/derivative (PID) controller in an outer feedback loop. The PD controller places the poles of the transfer function (in Laplace-transform space) of the control system for the linearized mathematical model of the dynamics of the robot. The PID controller tracks the trajectory and decouples the input from the output.

The mathematical model of the dynamics of an n-joint robotic manipulator can be represented by a set of coupled nonlinear differential equations of the general form

$$M(\theta)\ddot{\theta} + N(\theta,\dot{\theta}) + G(\theta) + H(\dot{\theta}) = \mathrm{T}$$

where t = time; $\theta(t)$,$\dot{\theta}(t)$ and $\ddot{\theta}(t)$ are the $n \times 1$ vectors of joint angles, velocities, and accelerations respectively; $\mathrm{T}(t)$ is the $n \times 1$ vector of joint torques; $M(\theta)$ is the $n \times n$ inertia matrix, $N(\theta,\dot{\theta})$ is the $n \times 1$ Coriolis-and-centrifugal-torque vector; $G(\theta)$ is the $n \times 1$ gravity-loading vector; and $H(\dot{\theta})$ is the $n \times 1$ frictional-torque vector. This set of equations is highly nonlinear in $\theta(t)$, $\dot{\theta}(t)$, and $\ddot{\theta}(t)$.

The problem is to obtain a control scheme that generates the joint torques $\mathrm{T}(t)$ required to ensure that the joint angles $\theta(t)$ track the reference trajectories $\theta_r(t)$ as closely as possible. The multivariable controller, which is designed to do this, is based on linear multivariable control theory. The theory, in turn, requires a linearized mathematical model of the dynamics of the robot. The model is, in effect, piecewise-linear because the equations of motion are treated as linear for small perturbations during small intervals of time.

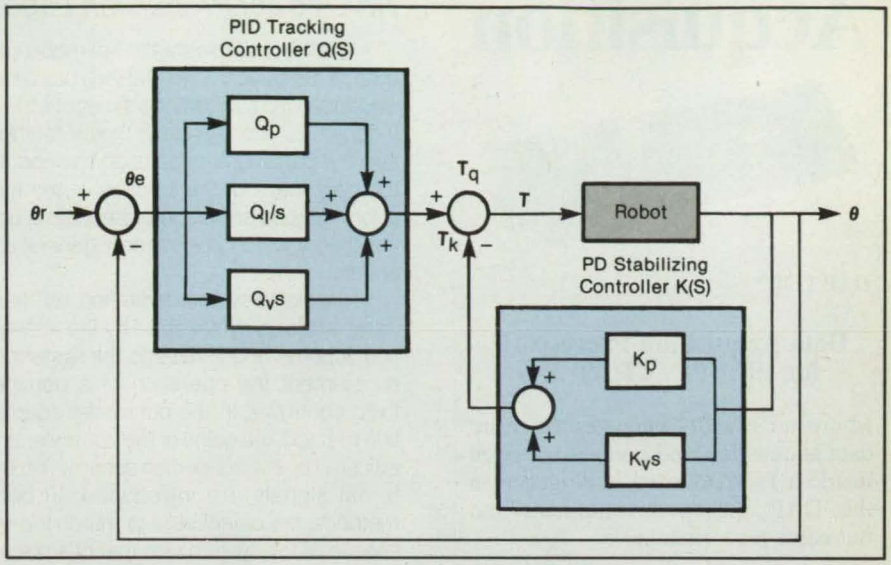
The controller derived from the linearized equations (see figure) includes the stabilizing (inner-loop) controller $K(s)$ and the tracking (outer-loop) controller $Q(s)$ where K and Q are transfer-function matrices and s is the Laplace-transform complex frequency. The stabilizing controller implements the PD feedback control law

$$T(t) = T_q(t) - K_p\theta(t) - K_v\omega(t)$$

or, taking the Laplace transform,

$$T(s) = T_q(s) - [K_p + K_v s]\theta(s)$$
$$= T_q(s) - K(s)\theta(s)$$

where T is the torque applied to the robotic manipulator, T_q is the torque due to the tracking controller, K_p and K_v are constant $n \times n$ position- and velocity-feedback gain matrices respectively, and $K(s) = K_p + K_v s$ is the $n \times n$ transfer-function matrix of the multivariable PD controller. This control law provides, in effect, full state feedback for the linearized mathematical model, and it is therefore both necessary and sufficient for placement of all $2n$ poles of the transfer function of the system at arbitrary locations in the complex plane. To stabilize the robot and obtain acceptable transient responses, the feedback gains K_p and K_v are chosen to place the closed-loop poles at some desired locations in the left half of the complex plane.



The **Multivariable PID Controller** consists of a PD stabilizing controller in the inner loop and a PID tracking controller in the outer loop.

By providing for decoupling of inputs from outputs, the tracking controller ensures that the reference trajectory for each joint angle will affect only that joint angle and that there will be robust steady-state tracking for a class of reference trajectories and torque disturbances. The tracking controller implements the control law

$$T_q(t) = Q_p\theta_e(t) + Q_I\int_o^t \theta_e(t)dt + Q_v\dot{\theta}_e$$

or

$$T_q(s) = Q(s)\theta_e(s)$$
$$= [Q_p + \frac{Q_I}{s} + Q_v s]\theta_e(s)$$

where $\theta_e(t) = \theta_r(t) - \theta(t)$ is the $n \times 1$ joint-angle error vector; and Q_p, Q_I, and Q_v are proportional, integral, and derivative gain matrices, respectively, and are related to the dynamics by a set of equations.

Two approaches to the tuning of the conceptual controller have been proposed. In the first approach, the matrices of the controller are updated during operation to compensate for the variations in the matrices of the mathematical model of the robot during gross motion or changes in the payload. In the second approach, high controller gains are used to obtain desirable performance during gross motion and changes in the payload. In the high-gain approach, uncertainties in the mathematical model of the dynamics of the robot have negligible effect on the performance of the closed-loop system.

The results of the numerical simulation of a controller for a two-link manipulator show that satisfactory performance is obtained even when the robot is subjected to large changes in payload and torque disturbances. High controller gains do not produce excessive torques or saturation.

This work was done by Homayoun Seraji of Caltech and Mahmoud Tarokh of the University of California at San Diego for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 2 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 25]. Refer to NPO-17647

Method for Model-Reference Adaptive Control

Synthesis of signals and adaptation of parameters are combined in a unified theory.

NASA's Jet Propulsion Laboratory, Pasadena, California

A relatively simple method of model-reference adaptive control (MRAC) has been developed from two prior classes of MRAC techniques: the signal-synthesis method and the parameter-adaptation method. In the new method, the theories of the two prior methods are incorporated into a unified theory, which yields a more general adaptation scheme.

In the signal-synthesis method, an "auxiliary" signal is synthesized by the adaptation scheme and is fed into the system to supplement the operation of a nominal fixed controller. In the parameter-adaptation method, the gains of the controller are adjusted by the adaptation scheme; no external signals are introduced. In both methods, the objective is to match the response of the system with that of a predefined reference model.

The new method applies to an MRAC system that includes both an adjustable system and a reference model (see figure). The adjustable system contains both the plant to be controlled, which is fixed, and the controller, which can be adjusted. For instance, given the multivariable plant

$$M(t)\mathbf{y}(t) + N(t)\dot{\mathbf{y}}(t) = \mathbf{v}(t)$$

with the control law

$$\mathbf{v}(t) = \mathbf{f}(t) + K(t)[\mathbf{y}_r(t) - \mathbf{y}(t)] + Q(t)\mathbf{y}_r(t)$$

the adjustable system is obtained as

$$\dot{\mathbf{y}}(t) = [-M^{-1}(N+K)]\mathbf{y}(t) + [M^{-1}(K+Q)]\,\mathbf{y}_r(t) + [M^{-1}\mathbf{f}(t)]$$

where t = time, $\mathbf{v}$ is the $m \times 1$ control vector, $\mathbf{y}$ and $\mathbf{y}_r$ are the $m \times 1$ actual and reference output vectors, M and N are the $m \times m$ plant matrices with $|M| \neq 0$, $\mathbf{f}$ is the $m \times 1$ auxiliary input vector, and K and Q are the $m \times m$ controller-gain matrices.

In general, the adjustable system can be represented by the state model

$$\dot{\mathbf{x}}(t) = A(t)\mathbf{x}(t) + B(t)\mathbf{u}(t) + \mathbf{w}(t)$$

where $\mathbf{x}(t)$ is the $n \times 1$ state vector, $\mathbf{u}(t)$ is the $m \times 1$ reference input vector, $\mathbf{w}(t)$ is the $n \times 1$ auxiliary input vector to be synthesized, and A and B are $n \times n$ and $n \times m$ time-varying matrices that contain adjustable parameters, and all entries of A, B, and $\mathbf{w}$ can be adjusted independently. The reference model expresses the desired performance of the system specified by the designer as

$$\dot{\mathbf{x}}_m(t) = A_m\mathbf{x}_m(t) + B_m\mathbf{u}(t)$$

where $\mathbf{x}_m(t)$ is the $n \times 1$ model state vector, and A_m and B_m are constant prespecified $n \times n$ and $n \times m$ matrices. The reference model is stable. The MRAC problem is to adjust the parameters of $A(t)$ and $B(t)$ and to synthesize the signal $\mathbf{w}(t)$ in such a way that for any arbitrary input $\mathbf{u}(t)$, the state $\mathbf{x}(t)$ of the system approaches the model state $\mathbf{x}_m(t)$ asymptotically.

The laws of the adaptation scheme are derived from the dynamics of the adaptation-error vector $\mathbf{e}(t) = \mathbf{x}_m(t) - \mathbf{x}(t)$. The derivation involves the use of an improved Lyapunov function. The results are given by

$$\mathbf{w}(t) = \mathbf{w}(0) + Q_0^* P\mathbf{e}(t) + Q_0^{-1}P\int_0^t \mathbf{e}(t)dt$$

$$A(t) = A(0) + Q_1^* P[\mathbf{e}(t)\mathbf{x}'(t)](S_0^2)^{-1} + Q_1^{-1}P\int_0^t [\mathbf{e}(t)\mathbf{x}'(t)]dt(S^2)^{-1}$$

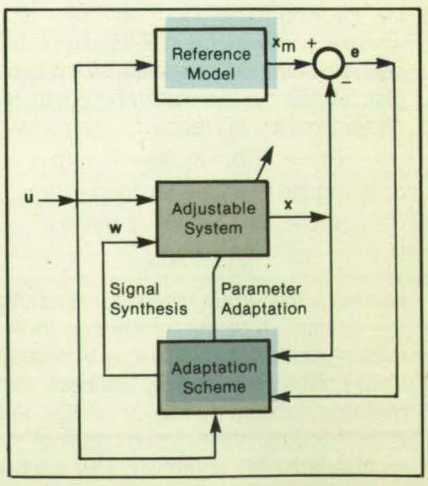
and

$$B(t) = B(0) + Q_2^* P[\mathbf{e}(t)\mathbf{u}'(t)](R_0^2)^{-1} + Q_2^{-1}P\int_0^t [\mathbf{e}(t)\mathbf{u}'(t)]dt(R^2)^{-1}$$

where the Q's, R's, and S's denote constant weighting matrices and P is the solution of the Lyapunov equation for the reference model.

It is interesting to note that the auxiliary signal $\mathbf{w}(t)$ can be generated by a proportional-integral (PI) controller with constant gains $K_p = Q_0^* P$ and $K_I = Q_0^{-1}P$ driven by the adaptation error $\mathbf{e}(t)$. The addition of the auxiliary signal to the parameter-adaptation laws results in improved transient performance and faster convergence. The auxiliary signal also provides more flexibility in the design without increasing the computational time of the adaptation scheme.

This work was done by Homayoun Seraji of Caltech for ***NASA's Jet Propulsion Laboratory****. For further information, Circle 138 on the TSP Request Card.*
NPO-17717



The **New Method of Model-Reference Adaptive Control** combines elements of the signal-synthesis and parameter-estimation methods in a unified adaptation scheme.

Life Sciences

Affinity Electrophoresis Using Ligands Attached to Polymers

Polymer molecules enhance electrophoretic separabilities.

Marshall Space Flight Center, Alabama

Experiments have shown that neutral, hydrophilic polymer molecules can be covalently coupled to affinity ligand molecules to reduce the electrophoretic mobilities of cells in a specific and dose-dependent manner. Polyethylene glycol was used in the experiments, but it is expected that other neutral, hydrophilic polymers like polyvinyl alcohol and copolymers of ethylene glycol and propylene glycol could also be used.

The objective is to electrophoretically separate specific macromolecules, cells, or other particles on the basis of their specific interactions with immunoglobulins (immuno-affinity electrophoresis), alkyl hydrophobic molecules (hydrophobic-affinity electrophoresis), or other ligands (ligand-affinity electrophoresis). In a precursor to the new technique, reported in 1981, polyethylene-glycol-linked dyes that have specific affinities for certain types of nucleic acids were used to carry out ligand-affinity electrophoresis of fragments of deoxyribonucleic acid molecules.

In the new technique, the reduction of electrophoretic mobilities by the addition of polyethylene glycol to the ligands increases the electrophoretic separabilities. In immuno-affinity electrophoresis, this modification of the ligands extends the specificity of electrophoretic separation to particles that have surface electric-charge structures that would otherwise make them electrophoretically inseparable. Furthermore, the modification of the antibodies by polyethylene glycol greatly reduces their ability to aggregate while enhancing their ability to affect the electrophoretic mobilities of cells. In hydrophobic-affinity electrophoresis, the addition of polyethylene glycol also reduces the tendency toward the aggregation of cells or macromolecules.

This work was done by James M. Van Alstine, Robert S. Snyder, J. M. Harris, and D. E. Brooks of Universities Space Research Association for **Marshall Space Flight Center**. *For further information, Circle 68 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 25]. Refer to MFS-26049.

Hollow-Fiber Clinostat

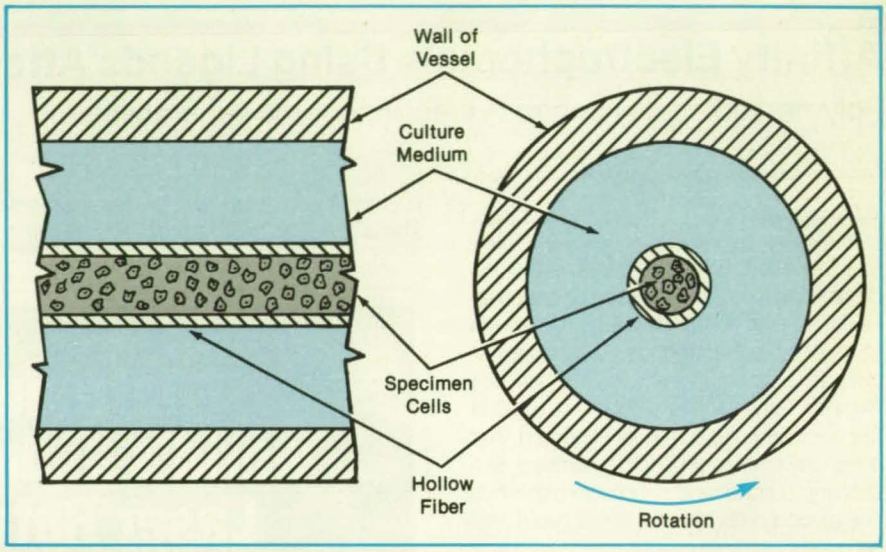
Cells are grown in an environment that simulates some of the effects of microgravity.

Marshall Space Flight Center, Alabama

The hollow-fiber clinostat is a bioreactor used to study the growth and other behavior of cells in simulated microgravity. The cells under study are contained in a porous hollow fiber immersed in the culture medium inside a vessel. The pores in the hollow fiber allow exchange of gases, nutrients, and metabolic waste products between the living cells and the external culture media. The hollow fiber lies on the axis of the vessel (see figure), which is rotated by a motor equipped with torque and speed controls. The desired temperature is maintained by operating the clinostat in a standard tissue-culture incubator. The axis of rotation can be made horizontal or vertical.

Cells are injected into the lumen of the fiber through a hypodermic needle. The ends of the fiber are then sealed by hot wax or by heat alone, and the fiber is mounted in a fiber holder under spring tension, which keeps it aligned with the axis. The holder is mounted in the vessel, the vessel is filled with the culture medium, and the vessel is sealed. Ports in the vessel provide access for exchange and sampling of the culture medium and for the injection of biochemical agents. The clinostat is designed for use with conventional methods of sterilization and sanitation to prevent contamination of the specimen. It is also designed for asepsis in assembly, injection of the specimen, and exchange of the medium.

Depending on the difference between the densities of the cells (or particles to which the cells are attached) and the liquid in which they are suspended, the particles may settle down to motion within circular trails about a horizontal axis of rotation. When the rotation is sufficiently rapid, microgravity is simulated in the sense that the particles cease to move vertically. The simulation approaches 100 percent for particles in suspensions in which the centrifugal forces and Brownian motions offset each other. Operation with rotation about a vertical axis provides the motional condition for a control experiment in the sense that the gravitation is then constant along the axis. Another control condition is provided by nonrotational operation with the axis horizontal.



In the **Hollow-Fiber Clinostat**, shown here in simplified schematic form, specimen cells are suspended in liquid inside a hollow fiber on the axis of a culture vessel. The vessel and fiber rotate about the axis to simulate some of the effects of microgravity.

The hollow-fiber-clinostat concept also embraces several alternative designs. Suspension cultures of cells or organisms can be studied by selecting speeds of rotation that maintain the positions of the cells within the fiber. Larger quantitites of cells or organisms can be tested by lengthening the fiber, fiber holder, and culture vessel. Slip-type connectors and tubing can be added for continual circulation of the culture medium to enable monitoring and/or control of the concentrations of substances in the medium. Cells or organisms dependent on anchorage could be grown on beads injected into the hollow fiber. This would facilitate removal of samples of cells from the fiber.

This work was done by Percy H. Rhodes, Teresa Y. Miller, and Robert S. Snyder of **Marshall Space Flight Center**. *For further information, Circle 89 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-28370

Self-Calibrating Respiratory-Flowmeter Combination

Dual flowmeters ensure accuracy over the full range of human respiratory flow rates.

Lyndon B. Johnson Space Center, Houston, Texas

A system for the measurement of respiratory flow employs two flowmeters, which are complementary: one compensates for the deficiencies of the other. The combination yields an easily calibrated system that is accurate over a wide range of gas flow.

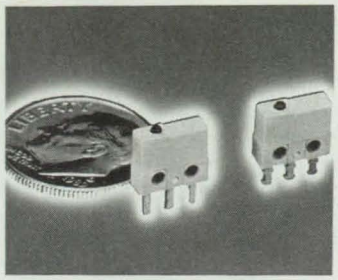
The flowmeters are in series in the flow path. A vortex flowmeter has stable characteristics, so that it rarely needs calibration. Its accuracy is independent of the composition, pressure, and temperature of the gas. However, it is not accurate over the entire range of flow rates from rest to maximum exercise. A pneumotach flowmeter provides a linear output over the complete range of flow, but it tends to drift and needs frequent calibration. It also needs compensation for changes in the composition of the gas.

The vortex flowmeter, which can go for years without calibration, even in rugged duty, is therefore used as a calibration standard for the pneumotach flowmeter whenever the flow through the vortex flowmeter exceeds its lower operating threshold. During each breath, the outputs of both flowmeters are stored in arrays of data. At the end of each breath, if enough data are recorded and if the peak flow was high enough, a linear regression between the two flowmeter signals is calculated, and the regression coefficient is used to calibrate the pneumotach.

This work was done by Dwayne R. Westenskow and Joseph A. Orr of the University of Utah for **Johnson Space Center**. *For further information, Circle 124 on the TSP Request Card.* *MSC-21430*

New on the Market

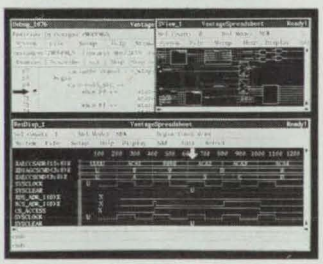
A new sub-subminiature **snap-action switch** from the Otto Controls Division of Otto Engineering, Carpentersville, IL, boasts a 2 ampere capacity for a minimum of 25,000 cycles, and can also switch low-level logic signals reliably. The B1 Series switch is designed to meet MIL-S-8805/94 specifications and is available with either solder or PC pin molded-in terminals.
Circle Reader Action Number 770.



Designed to reduce clean room contamination caused by traditional telephones, the **Model 295 Clean Phone** from GAI-Tronics Corp., Reading, PA, features a smooth, crevice-free front panel and an integral speaker/microphone. The microprocessor-based phone offers remote programming for two autodial numbers, call time-out, and auto answering and is available in flush- or wall-mount styles.
Circle Reader Action Number 796.

Designed for vibration test engineers, the CASIO FX 730P **personal computer** from Ling Dynamic Systems Inc., Yalesville, CT, features ten random profile calculations as well as computations of parameters relating to sine and shock testing. Other functions include calculation of PSD in g2/Hz for a flat random spectrum; sweep rate for swept sine test; decibel/level relationships; and peak velocity and displacement predictions for a defined shock pulse. The handheld computer also serves as a scientific calculator with 61 functions, a 24-character display, and a function memory for additional formulas.
Circle Reader Action Number 774.

Debug 1076™, a menu-driven **VHDL debugger** from Vantage Analysis Systems Inc., Fremont, CA, provides the designer with a highly interactive graphical interface to track the execution of and debug parallel models in large simulations. The debugger supports design concurrency: breakpoints can be set for subprocesses, subprograms, source code line numbers, or for simulation time points generated by the main simulation. Debug 1076's operations also include an understanding of simulation time and simulation delta times (internal model processing timesteps in VHDL) which are clearly displayed by the debugger.
Circle Reader Action Number 792.



A new handheld **noncontact infrared thermometer** from Capintec Instruments Inc., Ramsey, NJ, offers accurate readings across a 50° to 1000°F temperature range, with 0.1° resolution and a 0.5 second response time. The HR-1 digital thermometer is available in a general purpose model for reading targets up to 20 feet away, and a close-up configuration for measuring targets as small as 0.16 inches in diameter.
Circle Reader Action Number 776.

The compact S5 **O-ring face seal** from the Calnevar Seal Company, Oxnard, CA, is designed for applications in which using a standard seal is not possible. Besides aircraft, engines, and missiles, the seal can be used in construction equipment, gear boxes, transmissions, machine tools, industrial pumps and turbines, and grinders. While the standard S5 seal can withstand pressure up to 250 psi and temperatures from -65° to 400° F, it can be designed for special applications to work up to 2000 psi and to 600° F. The seal can also handle speeds ranging from 0 to 20,000 fpm.
Circle Reader Action Number 772.

The Elenco electronic temperature control **soldering station** permits a user to change the tip temperature from 150°C to 480°C without changing the tip or heating element. A temperature sensor located near the tip enables rapid response and excellent temperature stability. Electronic switching completely protects voltage- and current-sensitive components.
Circle Reader Action Number 798.

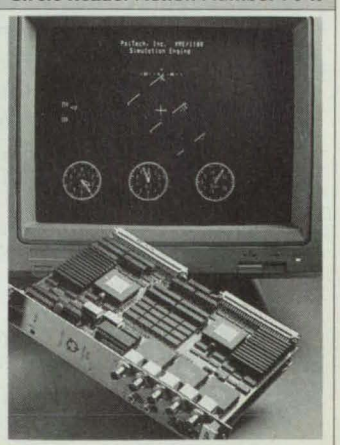
Tefzel HT-2127 **wire and cable insulation** from the Du Pont Company, Wilmington, DE, combines the tensile strength and abrasion resistance of Du Pont's Tefzel fluoropolymer with the flexibility and temperature tolerance of its Teflon fluorocarbon resin. The insulation is suited for use with cable constructions exposed to frigid weather, as well as in airframe components, including aircraft hook-ups, and in back panel circuitry for computers and electronic boxes. Tefzel HT-2127 can withstand temperatures up to 180°C and is easily processed onto wire.
Circle Reader Action Number 790.

A new **VMEbus simulation engine** from PsiTech Inc., Fountain Valley, CA, offers a real-time anti-aliasing solution to the "jaggies" and artifacts commonly found in simulation and training systems. Designated the VME/1100, the dual 6U graphics board set features a 24-bit frame buffer which is double buffered to display smooth animation of true color images. The extensive number of color shades available (16.7 million) is a key to the anti-aliasing performance. PsiTech uses four DSPs in parallel to achieve complete screen updates 60 times per second.
Circle Reader Action Number 766.

SermeTel® 1083, a high-temperature **polymeric coating** from Sermatech International Inc., Limerick, PA, provides excellent resistance to corrosion, abrasion, and heat when applied to aluminum, magnesium, and other light metals. The coating is applied as a spray coating over anodized or conversion coated surfaces, providing uniform thickness even on parts of complex geometry.
Circle Reader Action Number 800.

An innovative **metallurgy process** developed by Materials Innovation Inc. (MII), Gilford, NH, makes it economical to cool electronic packages with composite metal matrix materials. MII employs patented technology to blend elemental powders consisting of low-expansion, low-resistivity metals and nonmetals to yield new heterogeneous composite materials. MII can furnish fully dense parts molded to net or near-net shapes with industry-standard tolerances for electronic packaging applications.
Circle Reader Action Number 764.

IBM has introduced the SciBench, a general-purpose laboratory **data acquisition and analysis package** that allows a user to write simple data acquisition programs for displaying and plotting data on an OS/2 system. It offers a library of linkable software routines, including standard plotting, add, subtract, baseline smooth, differentiation, log, FFT, integral, and square root, as well as curve fitting routines such as least square, smooth, spline and polynomial fit. SciBench supports various industry-standard data acquisition boards, and allows for image acquisition and processing with 3D representation and wire frame drawing.
Circle Reader Action Number 794.



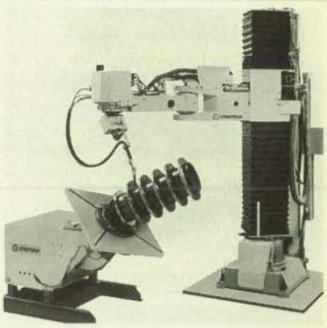
New on the Market

The E-Series Ultrajet, an environmentally-safe, non-abrasive **dust remover** from Chemtronics Inc., Kennesaw, GA, delivers powerful jet blasts for cleaning critical electronic systems and has variable pressure up to 120 psi for maximum cleaning efficiency. Ultra-filtered to less than 0.2 microns, Ultrajet is suited for dusting of close tolerance instruments, optical and photographic surfaces, clean room procedures, and other PCB, system, and component manufacturing applications.
Circle Reader Action Number 782.

Unlike other scanning electron microscopes which rely on a high-vacuum environment and require extensive specimen preparation, the **Environmental Scanning Electron Microscope (ESEM)** from ElectroScan, Wilmington, MA, allows researchers to view untreated wet samples, examine microstructures of biological specimens in their natural state, and watch the molecular dynamics of chemical change taking place. Applications include chemistry, biology, materials and laser research, pathology, petroleum and geology, coatings and catalysts, and semiconductors.
Circle Reader Action Number 780.

The **GripMaster™** from Exos Inc., Burlington, MA, tracks the motions of the wrist and measures the grip force of the hand. The sensor-lined device is worn on the hand and wrist and connects to a computer, which displays measurements in real time and stores them for later analysis. It shortens product development cycles and helps avoid costly redesigns by providing critical information on the comfort and ease-of-use of handheld products.
Circle Reader Action Number 784.

The HP 48SX **scientific expandable calculator** from Hewlett-Packard's Corvallis Division offers automatic unit management; a serial interface to IBM and Macintosh PCs for computer printer and disk drive sharing; and a two-way infrared interface for data transmission from one HP 48SX to another. It provides graphics integrated with calculus functions for finding roots, intersections, local extremes, derivatives, slopes and areas under a curve; and an EquationWriter application for entering and viewing equations in textbook format.
Circle Reader Action Number 778.



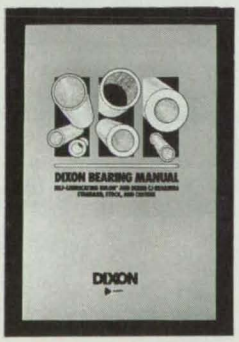
The Cybotech Series H80, a **jointed robot arm** from Automaker Inc., Stafford, TX, offers high-accuracy positioning and repeatability over large work envelopes. It reaches vertically from 3 to 35 feet and horizontally from 3 to 10 feet. The robot is controlled from a multi-tasking RC-10 controller that can coordinate up to 12 axes of motion. Applications include laser and waterjet cutting, welding, painting, plasma spraying, grit blasting, machining, NDT inspection, and palletizing.
Circle Reader Action Number 788.

E/M Corp., West Lafayette, IN, has introduced a **lubricant additive** called Kronaplate®Gear Saver that extends the life of the base oil, increases tool life, lowers operating temperatures, repairs wear scars on damaged metal surfaces, and reduces energy consumption. The additive consists of molybdenum disulfide dispersed in a high-grade mineral oil. Developed for use on gears, the product is equally effective on metal working equipment, bearings, and machine tools.
Circle Reader Action Number 786.

New Literature

A new 217-page catalog from Wavetek Corp., San Diego, CA, contains detailed descriptions and illustrations of the company's **signal sources and measurement equipment.** Product categories include VXI instruments, WaveTest development software, function and arbitrary waveform generators, frequency synthesizers, microwave signal and sweep generators, microwave CW and peak power meters, digital multimeters, calibrators, datalogger systems, signal processing filters, signal switching systems, CATV signal level meters, and radio frequency components.
Circle Reader Action Number 710.

The UniForum Association, Santa Clara, CA, has released the second edition of its **UNIX Resources Guide.** Designed as a reference guide to UNIX-oriented services, the publication includes updated listings of UNIX user groups, market research firms, periodicals, catalogs, directories, executive search firms, conferences and trade shows, book suppliers, and training organizations.
Circle Reader Action Number 706.



A 24-page manual from the Furon Company's Dixon Division, Bristol, R I, describes Dixon's line of **self-lubricating RULON® and CJ bearings.** The manual features technical data such as application guidelines, design criteria, and product properties. Performance charts, graphs, cut-away diagrams, and illustrations are also included.
Circle Reader Action Number 702.

A six-page brochure from Holometrix Inc., Cambridge, MA, discusses the expanded **research, testing, and consulting services** of its Thermatest Measurements Division. Thermatest Measurements specializes in thermal property evaluation of insulation materials and systems over a -180 to +1000°C temperature range, and in a variety of controlled environments, including vacuum. The brochure spotlights the division's capability for laser flash thermal diffusivity, field measurement strategies for insulated systems, and cryogenic property measurements.
Circle Reader Action Number 704.

A free report from Manufacturers Technologies, West Springfield, MA, examines the generic functions, features, and potential benefits of **computer-aided cost estimating (CACE) and process planning.** It outlines the manufacturing processes covered by state-of-the-art CACE— detailing how the technology increases estimating accuracy and shop productivity while reducing throughput time and direct labor.
Circle Reader Action Number 708.

Technology Access Report is a 16-page newsletter focused on **technology development, transfer, and management.** Published 18 times a year by Technology Access, Inverness, CA, the newsletter covers patents and licenses, strategic alliances, cooperative R&D agreements, university and state technology transfer activities, spinoffs, and major conferences and technical meetings.
Circle Reader Action Number 712.

A 60-page catalog from Baldor Electric Co., Fort Smith, AK, spotlights the company's line of **industrial DC motors and tachometers.** Available free of charge, the catalog features a variety of single- and three-phase motors, including explosion-proof, fan and blower, repulsion/induction, vacuum pump, irrigation drive, gear, right angle, automotive, and brake motors.
Circle Reader Action Number 714.

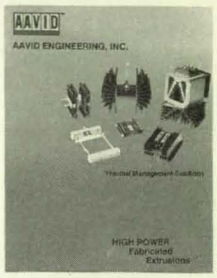
New Literature

A new design guide from Utitec Inc., Watertown, CT, spotlights its **high-speed deep-drawing process,** capable of producing miniature metal tubular components with extremely tight tolerances. Parts less than 2.5" in length, with outside diameters from 0.02" to 1.5" can be provided. The process enables length-to-diameter ratios as high as 42:1. The guide lists 35 copper-, aluminum-, iron-, and nickel-based alloys that can be used, in addition to exotic materials.
Circle Reader Action Number 720.

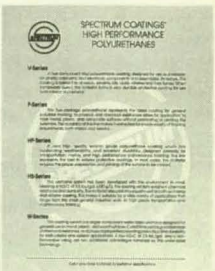
Technical descriptions, photographs, electrical specifications, block diagrams, and dimensional illustrations for more than 260 standard **power supply models** are provided in a new catalog from International Power Devices, Brighton, MA. Featured products offer output ranges from 1/2 to 120 watts; wide inputs; multiple outputs; and are encapsulated. Six-sided electromagnetic interference (EMI) shielding is standard.
Circle Reader Action Number 722.

A 200-page catalog from Z-Communications Inc., Ft. Lauderdale, FL, features more than 150 **VCO and synthesizer products** covering frequency ranges from 20 MHz to 3 GHz. The catalog provides specifications, such as voltage versus frequency data, power output, and phase noise. Application notes with recommended layout and schematic examples are also included.
Circle Reader Action Number 718.

Emphasizing a solutions approach to thermal management, a new catalog from Aavid Engineering Inc., Laconia, NH, describes the company's line of **fabricated extrusions** for cooling power semiconductors. The extrusions come in standard and custom styles for virtually all medium- and high-power devices, including power modules and stud mount devices, transistors, rectifiers, GTOs, and SCRs. Featured models are available in a variety of anodize and chromate finishes.
Circle Reader Action Number 724.



A new data sheet from Spectrum Coatings Laboratories Inc., Providence, RI, provides application criteria and recommends uses for the company's **high-performance polyurethane coatings,** and ranks each based upon its adhesion to metal or plastic; hardness; flexibility; chemical and water resistance; and weatherability.
Circle Reader Action Number 716.

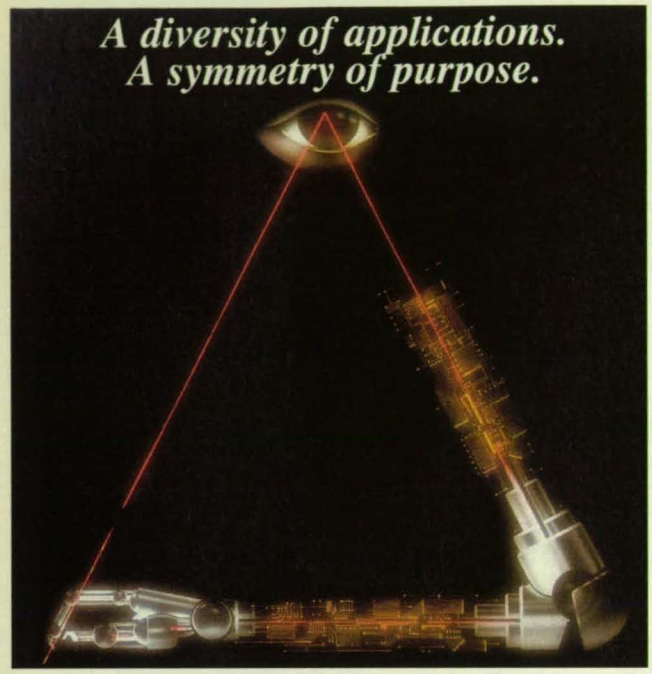


Molecular micromapping, as performed with the Spectra-Tech IRμs™ System, is described in a new brochure from Spectra-Tech Inc., Stamford, CT. The IRμs system, which incorporates research light and FT-IR spectroscopy with computer software and a precision micropositioning stage, enables a user to map thousands of points (in a linear or pattern sequence) to obtain a chemical profile of a sample. This provides molecular characterization of microscopic samples, even those smaller than the molecular vibrational wavelengths. The maps can be used to determine the composition of polymeric substances, biological tissues, inorganic biological by-products, coatings, and thin films.
Circle Reader Action Number 726.

Subject Index

YOU'LL FIND THE ANSWERS TO YOUR TOUGHEST SENSOR PROBLEMS IN CHICAGO, SEPTEMBER 11–13

And meet the industry's leading suppliers.



All-New Conference Program

SENSORS EXPO 90 will feature more than 25 expert presentations on a wide variety of current topics in sensing, including:

- Automotive applications
- Aerospace applications
- Data acquisition
- Pressure sensing
- Proximity and position
- Fiber-optic sensors
- Processing applications
- Large-array radiotelescopes
- Emerging technologies
- Electroacoustic sensing
- Sensors in manufacturing
- Chemical sensors
- Temperature sensing
- Extreme environments

***NEW!* Special Double Session on this important topic–**

Accelerometers: A Critical Comparison of Current Technologies (Roundtable)

- Silicon piezoresistive
- Silicon capcitive
- Quartz piezoelectric
- Polymer film
- Force sensing resistor

Practical solutions to real-life sensing problems

Bring your specs, bring your requirements, and bring your toughest problems! You're sure to find cost-effective solutions at SENSORS EXPO 90 in the O'Hare Exposition Center, September 11, 12, and 13 — easy to get to from anywhere in the country. With the high-quality conference program – plus the most comprehensive Exhibit Hall – SENSORS EXPO will give you the information you need to solve your toughest sensing problems, to fit your most intricate applications, to meet your most demanding requirements.

Leading-edge applications to shape the future

The SENSORS EXPO 90 Conference Program sessions will cover both the leading edge applications that are shaping the future of the industry plus practical solutions to real-life sensing problems. From proven everyday applications in the automotive and processing industries to the most advanced aerospace and environmental uses, your participation in this important professional education event will bring you up to the minute in the areas of sensing technology most important to your needs.

Get your FREE Conference Brochure

Whether you're an OEM or in-plant user, or both, SENSORS EXPO 90 will prove a valuable learning experience. Get your FREE Conference Brochure. Mail or FAX the coupon today.

YES! I'm interested in SENSORS EXPO 90.

☐ I want solutions to my toughest sensing needs and problems! Send me my FREE Conference Brochure.

☐ I'd like information on exhibiting. Please call me.

Name_____

Title_____

Company_____

Address_____

City_____ State____ Zip_____

Phone (_____)_____

FAX: 203/374-9667 Phone: 203/374-1411

Mail to: SENSORS EXPO, c/o Expocon, P.O. Box 1019, Trumbull, CT 06611 NA

SENSORS EXPO

THE FIFTH INTERNATIONAL CONFERENCE AND EXPOSITION OF MACHINE PERCEPTION TECHNOLOGY
O'HARE EXPOSITION CENTER
CHICAGO, ILLINOIS • SEPTEMBER 11-13, 1990

Sponsored by *Sensors* magazine and produced by Expocon Mangement Associates, Inc.

Circle Reader Action No. 589

Advertiser's Index

*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.

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 E. 42nd Street, New York, NY 10017-5391. Subscriptions 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 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 E. 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.

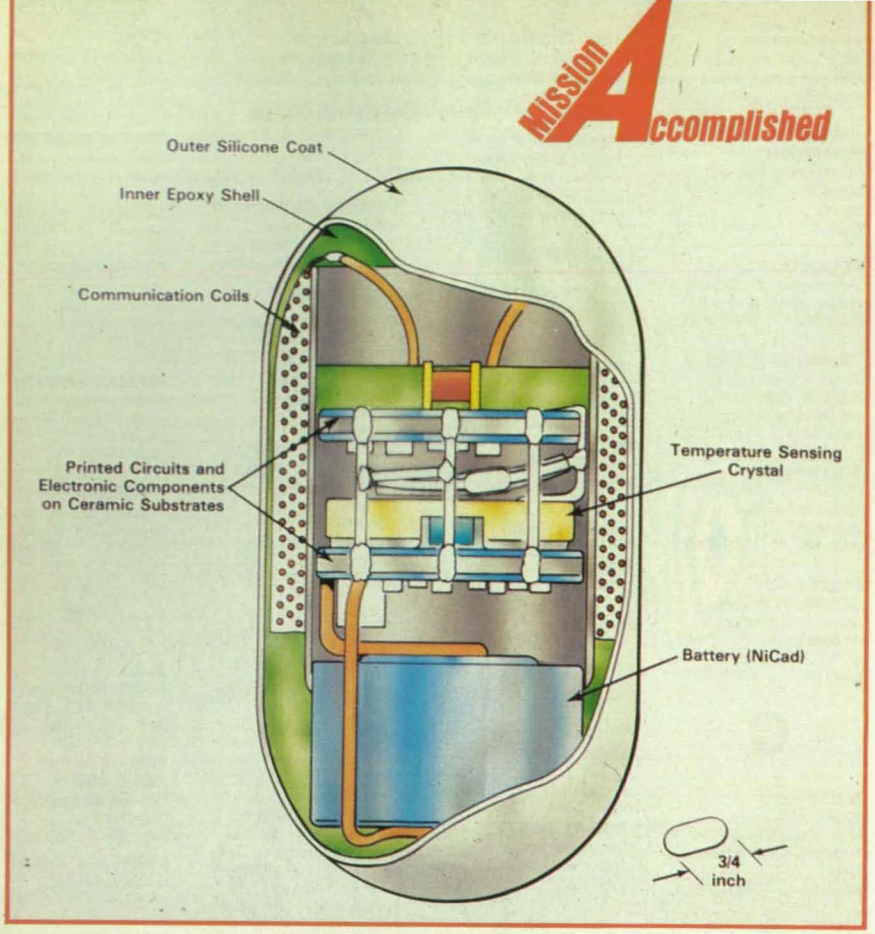


Illustration courtesy Johns Hopkins University Applied Physics Laboratory (APL)

The temperature pill incorporates such aerospace technologies as integrated circuit miniaturization, sensor and microbattery developments, and telemetry.

An ingestible pill capable of accurately measuring and relaying deep internal body temperatures has been developed by the Johns Hopkins University Applied Physics Laboratory (APL) in collaboration with NASA's Goddard Space Flight Center. Marketed under the trade name CorTemp by Human Technologies Inc. of St. Petersburg, Florida, the Ingestible Thermal Monitoring System (ITMS) enables improved patient care in hospitals and offers opportunities in medical experimentation.

The 0.6" x 0.4" silicone capsule contains a telemetry system, a microbattery, and a quartz crystal temperature sensor. When the capsule is ingested, its sensor resonates a frequency that varies according to body temperature. The oscillation drives a circuit with an "air" core coil, which responds by generating a magnetic field that passes harmlessly through the body and is detected by a coil connected to a remote receiver. The receiver amplifies the signal and sends it to a frequency counter, which converts the frequency into temperature. The receiver can be connected to a digital readout, or to a computer for data analysis. The ITMS monitors continuously during the 24 to 72 hours it takes the capsule to travel through the digestive system. Its receiving unit can record a patient's temperature every 30 seconds, and can be programmed to sound an alarm if the temperature exceeds preset limits. The unit can record and store 4500 temperature readings, requiring only battery replacement and the use of a series of capsules.

Researchers developed the ITMS to obtain internal temperature readings for treatment of such emergency conditions as dangerously low (hypothermia) and high (hyperthermia) body temperatures. Extremely accurate temperature readings are vital in treating such cases. Whereas the average thermometer is accurate to 0.1°C , the ITMS is off no more than 0.05°C, and provides the only means of gauging deep body temperature.

Although the concept for the temperature pill dates back to the 1950s, until now technology could not produce components small enough for an ingestible capsule, while meeting reliability, accuracy, and cost objectives. "Fitting the components compatibly in the smallest possible volume was probably the most difficult problem to solve," said Dr. Russell Eberhart, project director at APL. "Achieving the system's power, performance, and high-density packing requirements was possible only by incorporating NASA's recent technological advances."

The ITMS features such space-based technologies as miniaturized integrated circuits, a rechargeable microbattery, and telemetry techniques originally developed for transmission of coded data signals to Earth from orbiting satellites.

The capsule is listed with the Federal Drug Administration for one-time use. It can be reused for animal research, however, since its outermost silicon coating remains unaltered. This coating can be removed, the inner cylinder sterilized, the battery recharged, and the capsule recoated.

To date, the system has been used for research in areas such as reproductive endocrinology, substance abuse, obesity related to metabolism, gerontology (aging), and radiation treatments in oncology. "The ITMS is now being utilized to monitor high-risk ambulatory patients in wards, one of the ultimate applications of the system," said Arthur Gimpelson, director of production at Human Technologies. "It is also aiding in monitoring patients' temperatures prior to and during cardiac surgery, as well as in the post-operative recovery period."

In addition to these medical applications, the ITMS may be used to measure the internal temperature of food during processing, and to study the reaction of foods to heat. Further, the military wants to use the system to detect when personnel in extremely hot or cold environments are approaching life-threatening conditions.

APL researchers are working on an advanced, three-channel capsule that will simultaneously monitor temperature, heart rate, and inner body pressure. ❑

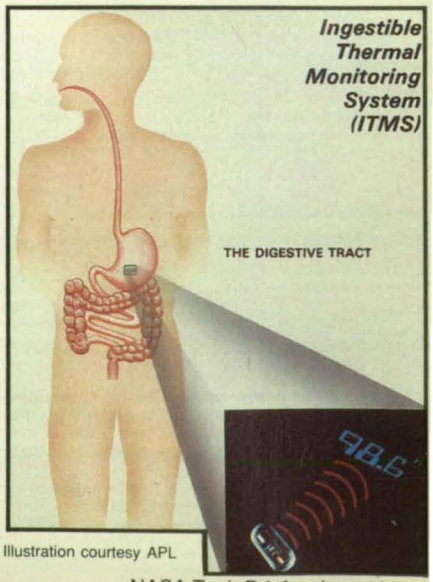
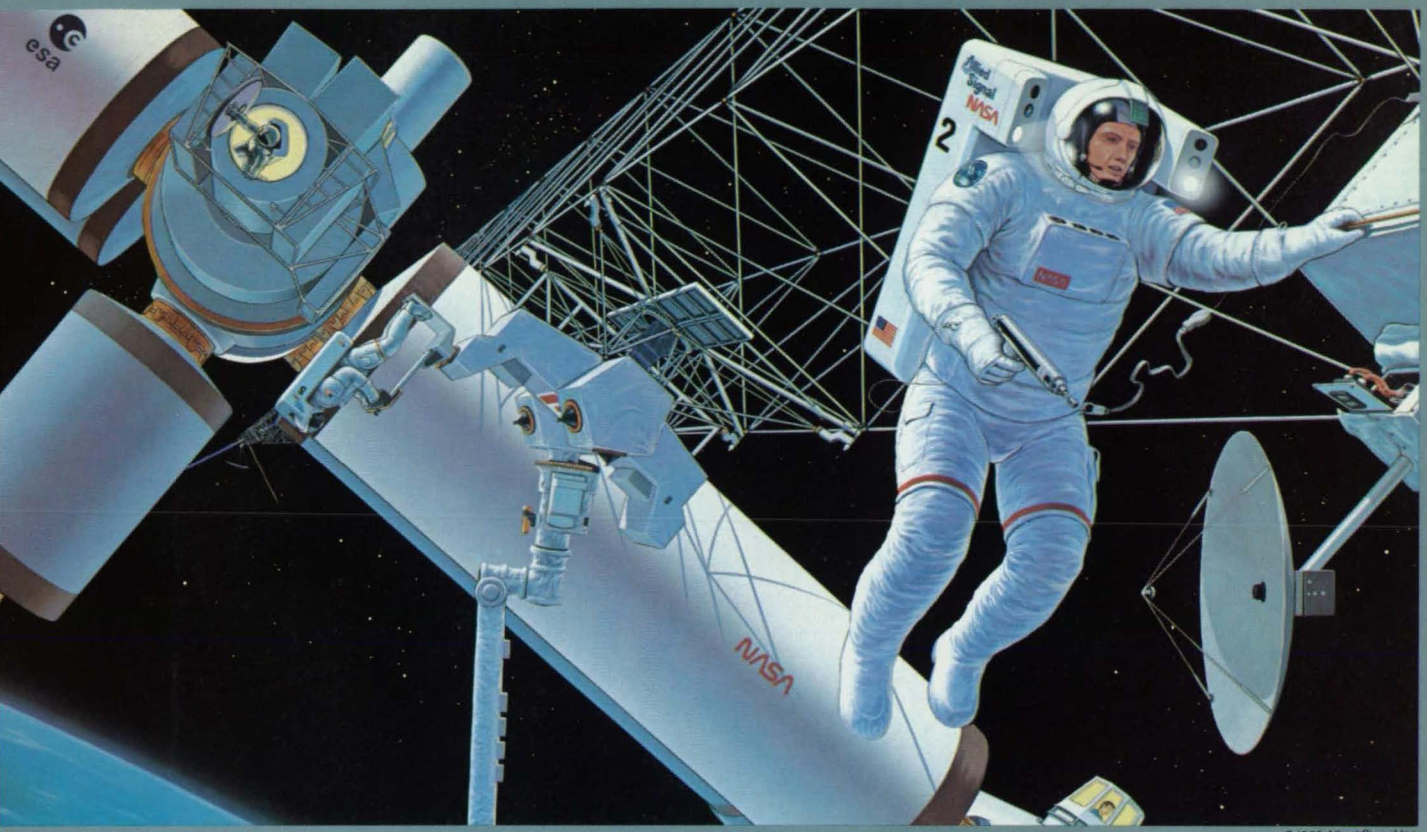


Illustration courtesy APL



EXTRAVEHICULAR ACTIVE WEAR.

WE'RE THE FIRST AND LAST WORD IN EXTRAVEHICULAR ACTIVITY. WITH A PIONEERING PAST AS NASA'S ORIGINAL PORTABLE LIFE SUPPORT SYSTEM SUPPLIER. AND CONTINUING LEADERSHIP IN ENVIRONMENTAL CONTROL/LIFE SUPPORT SYSTEM TECHNOLOGY.

WE'VE WON THREE SPACE STATION FREEDOM PORTABLE LIFE SUPPORT SYSTEM TECHNOLOGY CONTRACTS. DEVELOPING EFFICIENT NEW SUBSYSTEMS FOR VENTILATION, THERMAL CONTROL AND CO_2 REMOVAL.

NOT ONLY HAVE WE LIVED WITH THIS UNPRECEDENTED NEW TECHNOLOGY FOR SEVERAL YEARS, WE ARE THE PERFECT PARTNER TO TURN IT INTO HARDWARE.

AIRESEARCH LOS ANGELES DIVISION 2525 WEST 190TH STREET TORRANCE CA 90509 (213) 512-5488. WHERE THE ULTIMATE EFFICIENCY IS RELIABILITY.

Allied-Signal Aerospace Company

Circle Reader Action No. 415

Allied Signal

"The importance of the program cannot be overlooked ... it so fundamentally alters the mechanics of mathematics."

New York Times

"Mathematica has a real chance of replacing pencil and paper as the standard desktop environment for scientists and engineers."

William Press
Professor of Astrophysics,
Harvard University

"Mathematica will revolutionize the teaching and learning of math by focusing on the prose of mathematics, without getting lost in the grammar."

Steven Jobs
President,
NeXT, Inc.

Mathematica®

A System for Doing Mathematics by Computer

Some facts:

Function: Numerical, symbolic, graphical computation, interactive programming. Integrated technical computing environment.

Numerical Computation: Arbitrary precision arithmetic, complex numbers, special functions (hypergeometric, elliptic, etc.), combinatorial and integer functions. Matrix operations, root finding, function fitting, Fourier transforms, numerical integration, minimization, linear programming.

```
In[1]:=
3^70
Out[1]=
2503155504993241601315571986085849
In[2]:=
Hypergeometric2F1[7,5,4.1,3-I]
Out[2]=
-0.00403761 - 0.00295663 I
```

Numerical Computation

Symbolic Computation: Equation solving, symbolic integration, differentiation, power series, limits. Algebraic operations, polynomial expansion, factorization, simplification. Operations on matrices, tensors, lists.

Graphics: 2D, 3D plots of functions, data, geometrical objects. Contour, density plots. 3D rendering with intersecting surfaces, lighting models, symbolic descriptions. Color PostScript output, publication quality graphics, animation (most versions).

```
In[1]:=
Integrate[x/(a + Exp[x]), x]
Out[1]=
                    x
 2                 E
x      x Log[1 + --]
                   a
--- - ------------- -
2a          a
                            x
                           E
             PolyLog[2, -(--)]
                           a
             -----------------
                    a
```

Symbolic Computation

Programming: High-level, interactive, symbolic system. Full procedural language, functional programming constructs. General transformation rule paradigm based on pattern matching.

External Interface: Input from external files, programs. Output in TeX, C, FORTRAN, PostScript. Interactive external process control (most versions).

Graphics and Visualization

Macintosh User Interface: Notebook interactive documents mixing text, graphics, animations, *Mathematica* input, output. Macintosh front end can be used with kernels on other computers. Macintosh graphics standards used.

Documentation: "*Mathematica*: A System for Doing Mathematics by Computer" by Stephen Wolfram (Addison-Wesley, 1988) available at bookstores. Additional documentation supplied with specific versions. *Mathematica* Journal to be published in 1990.

Versions Now Available: Apple Macintosh: $495 (Plus, SE, etc.); $795 (II, IIx, IIcx, SE/30, etc.) • 386-based MS-DOS systems: $695 (no coprocessor); $995 (287/387); $1295 (Weitek) • Apollo DN 2500-4500, 10,000: from $2400 • Data General AViiON: $2,800 • DEC VAX VMS, ULTRIX, RISC-based systems: from $2400 • Hewlett-Packard 9000/300, 800: from $2400 • IBM AIX/RT: $2400 • MIPS: from $2800 • NeXT: bundled as standard system software • Silicon Graphics IRIS: from $2800 • Sony NEWS: from $2400 • Sun 3, 4, 386i: from $2250 • Supercomputer and other versions also available. • Educational, volume, reseller, and other discounts available • Now shipping Version 1.2.

```
log[1] = 0
log[E] = 1
log[x_ y_] := log[x] + log[y]
log[x_^n_] := n log[x]
log'[x_] = 1/x    (* derivative *)
log/: InverseFunction[log] = exp
log/:
Series[log[x_], {x_, 1, n_}] :=
  Sum[-(-1)^k (x-1)^k/k, {k,1,n}] +
                       O[x,1]^(n+1)
```

High-Level Programming

Implementation: 770 pre-defined *Mathematica* functions (C source 180,000 lines). Design, development led by Stephen Wolfram. Version 1.0 released June 1988.

Typical Applications: Research, engineering, education, mathematical modeling, publication graphics, data analysis, visualization, systems analysis, algorithm development.

Awards: Best 10 New Products, *Business Week* 1988 • Editor's Choice Award, *MacUser* 1989 • Award of Distinction, *BYTE* 1988.

Wolfram Research, Inc.

P.O. Box 6059, Champaign, IL 61826-6059, USA.
Information: 217-398-0700. Orders: 800-441-MATH.
Or visit your local software dealer.

Circle Reader Action No. 620