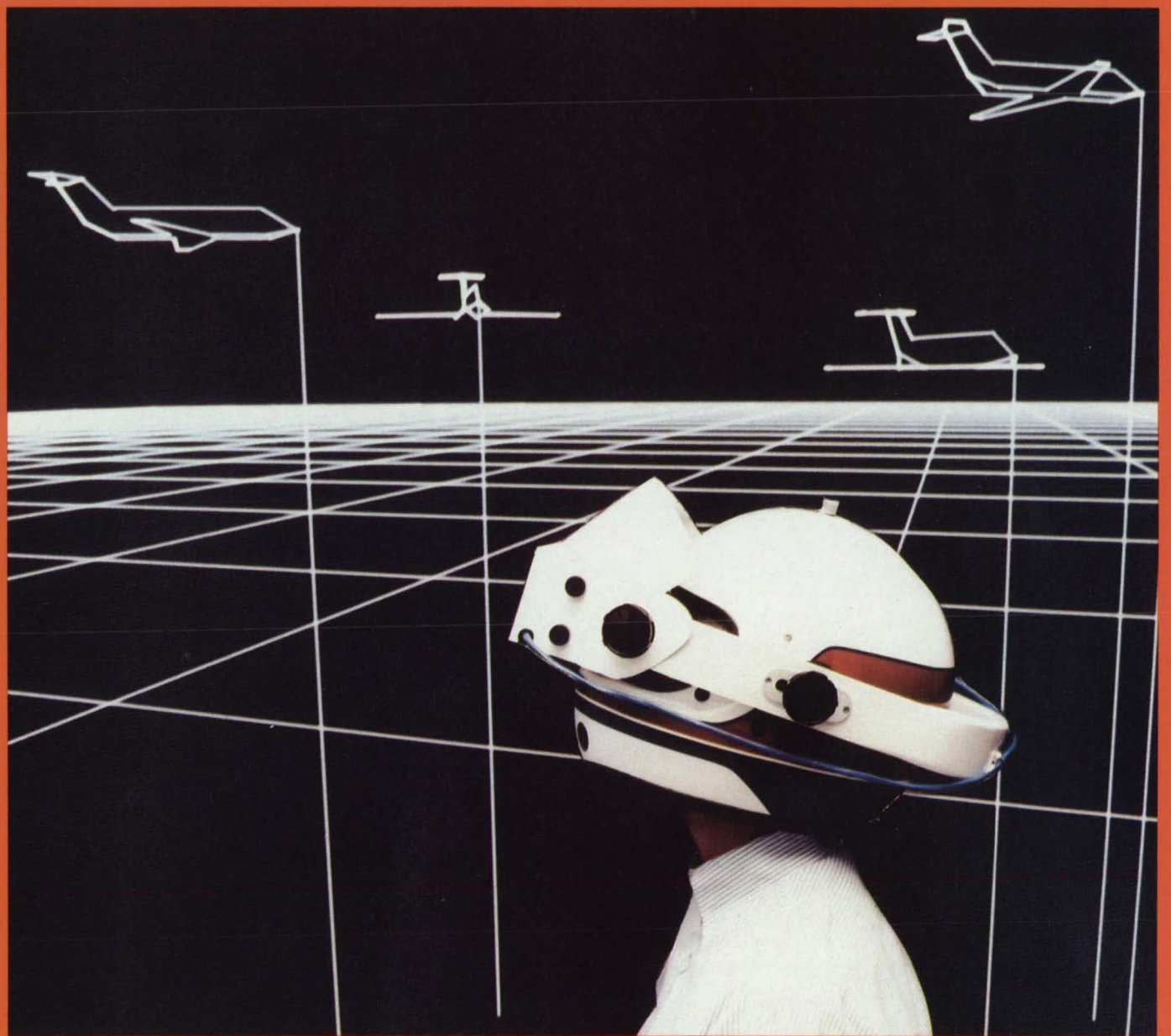


NASA Tech Briefs

Transferring Technology to
American Industry and Government

July/August 1988
Volume 12 Number 7

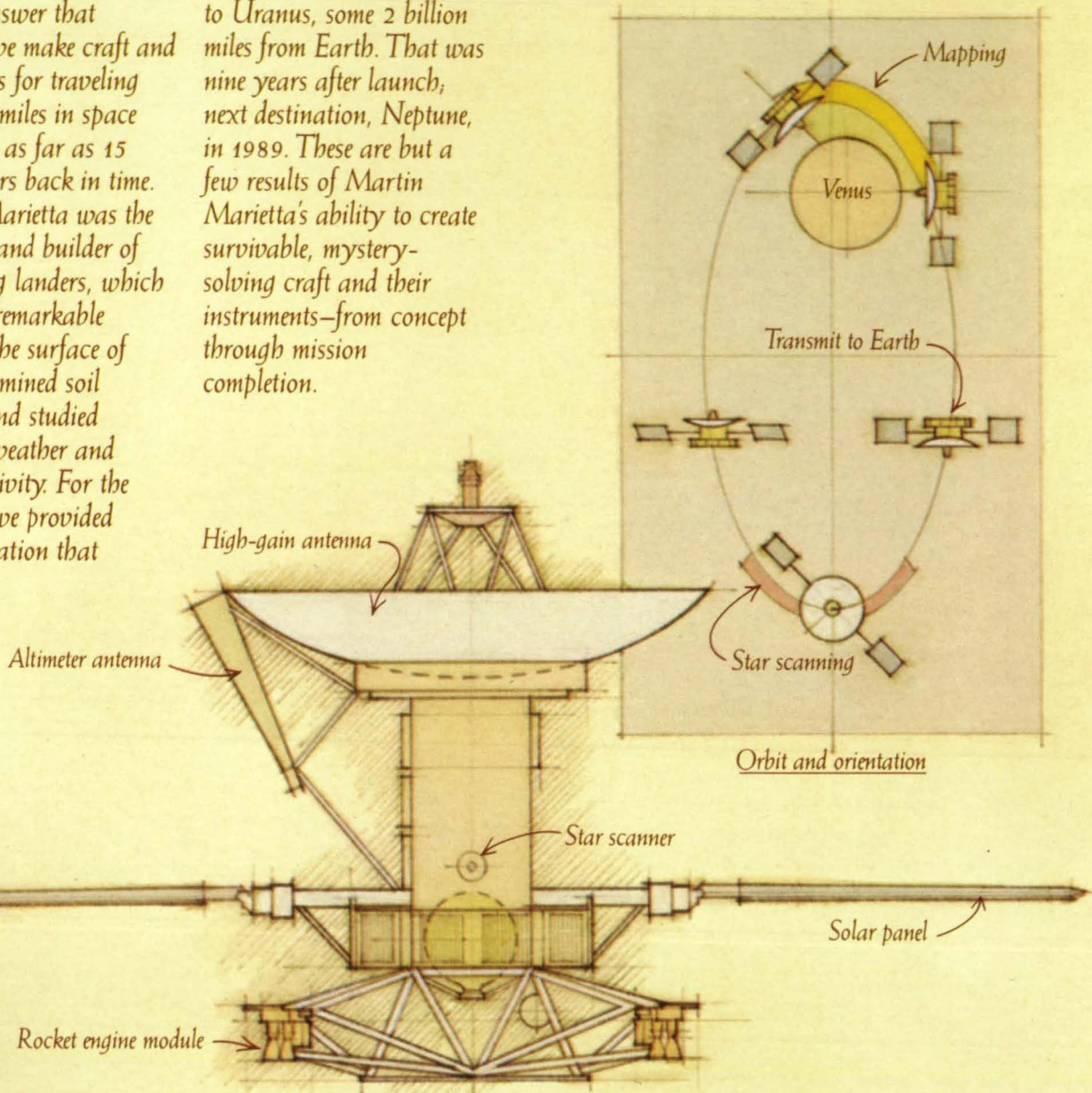


NASA's Virtual Workstation Shapes A VIVED Reality

In space: looking back to look forward.

What can the nature and origin of the universe tell us about the future of Earth? To help answer that question, we make craft and instruments for traveling billions of miles in space and seeing as far as 15 billion years back in time. Martin Marietta was the integrator and builder of two Viking landers, which sent back remarkable photos of the surface of Mars, examined soil samples, and studied Martian weather and seismic activity. For the Voyagers we provided instrumentation that

reported on electromagnetic activity near Jupiter and Saturn—Voyager 2 went on to Uranus, some 2 billion miles from Earth. That was nine years after launch; next destination, Neptune, in 1989. These are but a few results of Martin Marietta's ability to create survivable, mystery-solving craft and their instruments—from concept through mission completion.



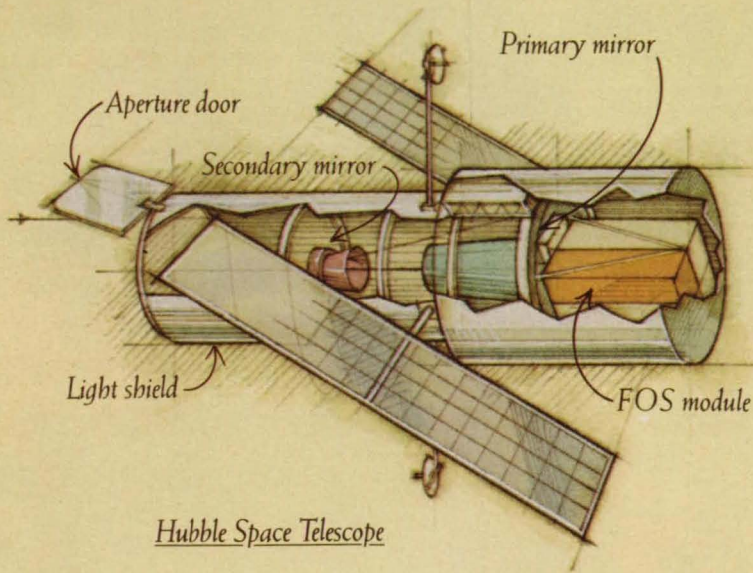
Magellan Spacecraft

Mission: map Venus.

From orbit, Magellan's radar will penetrate the planet's thick, gaseous cloud cover and send back photo-like images of nearly 90% of its surface. Our role: design, integrate, build and test the craft.

Viewing the infant universe.

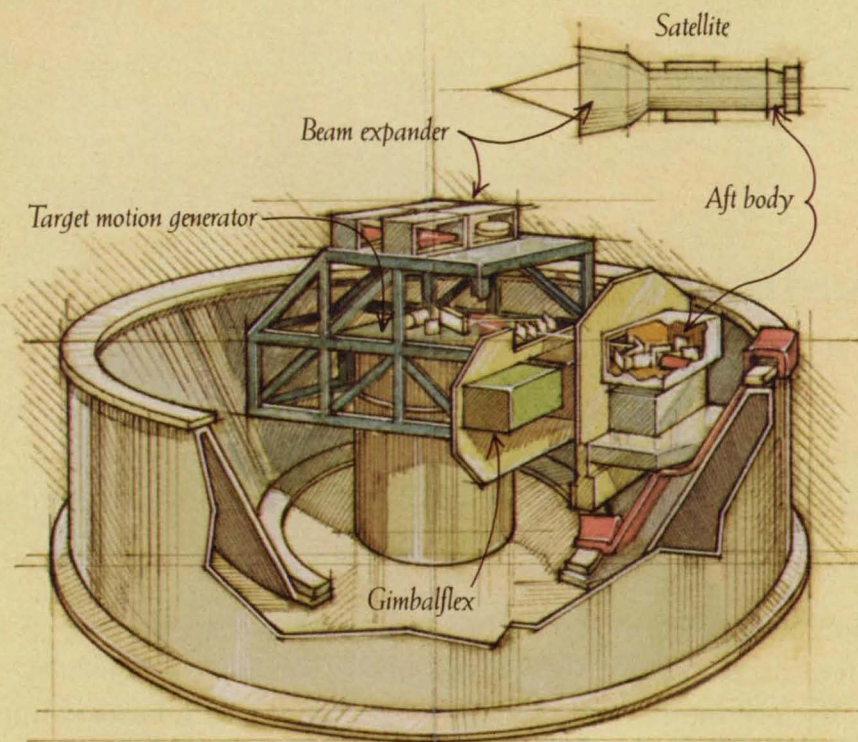
For the Hubble Space Telescope we are providing the Faint Object Spectrograph (FOS), which will see objects up to 15 billion light-years away. Since the universe is estimated to be 18-20 billion years old, astronomers will witness events close to its birth.



Hubble Space Telescope

The fine points of fine pointing.

Precisely controlled, space-spanning energy delivery and collection systems create difficult pointing and retargeting challenges, which we can now simulate. This new lab is working toward the precision to zero in on a football-size object 3,000 miles away, in support of the Strategic Defense Initiative research program.



Fine Pointing Simulator

Masterminding tomorrow's technologies

MARTIN MARIETTA

6801 Rockledge Drive, Bethesda, Maryland 20817, USA

Before he pushes the edge, IBM takes you beyond it.

From miles away and thousands of feet below, you know exactly what he's feeling. Using an IBM 3090 with supercomputer power, you've pushed your design through relentless iterations of finite element modeling and fluid dynamics analysis. You've defined the edge.

The IBM 3090 with Vector Facility, for its part, has redefined supercomputer performance, combining up to six vector processors with one of the industry's fastest scalar processors and most efficient memory management systems, parallel processing capabilities, and full IBM System /370 compatibility.

The result is balanced supercomputer performance that can improve your job turnaround by eliminating data bottlenecks, and save the added expense of a separate



front-end processor. Plus, the IBM Vector Facility's modular design lets you start with just the computer power you need today, and make economical in-field upgrades as your needs grow. And that gives the IBM 3090VF a big edge over more expensive and less flexible vector processors.

IBM's integrated system approach combines the power of the IBM 3090VF with the advantages of a single operating environment, low entry cost, low software and maintenance costs, a wide variety of application programs, and IBM support to create a winner in total cost-of-computing.

To find out more, or to arrange to have your IBM Marketing Representative contact you, simply call 1-800-IBM-2468, ext. 20.



The Bigger Picture

Cray X-MP, 2
IBM 3090/VF
Amdahl
VP Series

Convex
NAS
BBN
TXSI

DEC VAX
Gould NPL
Multiflow

CDC Cyber
Ardent-Titan
Stellar-GS Series

Prime MXCL
Cydrome-Cydra

ETA
Alliant
FX Series
IBM 30X

ONLY ONE MATHEMATICS LIBRARY GIVES YOU ACCESS TO THE GREAT WORKS AND THE BEST SELLERS.

*
Masscomp
Intergraph
Gould PN
Series

IBM 4300, 9370
Data General
MV Series

IBM PC
Concurrent

Apollo
Prime 50 Series,
PXCL Series

DEC MicroVAX,
VAX station
HP 9000 Series

Only Math Advantage® runs the same 260 hard-math subroutines on supercomputers, minicomputers, and workstations. Including Cray,™ Cyber,™ IBM™ Vector Facility,™ VAX,™ Apollo,™ Sun,™ IBM PC/AT,™ and more. Only Math Advantage is *optimized* for so many high-performance systems, and is so compatible.

The Math Advantage library is identical across hosts. So you can develop on a workstation and execute on a supercomputer, with no recoding. And enjoy a single, consistent user interface.

Math Advantage is optimized for both vector and parallel architectures. It's designed for high-performance applications—signal,

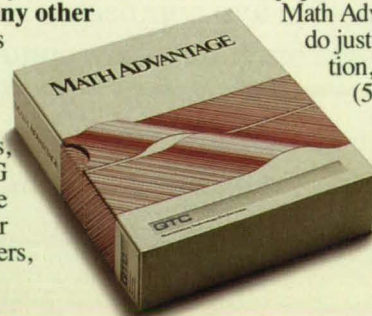
seismic, and image processing, simulation—where CPU time is at a premium. Development is faster too, with its ready-to-use vector operations, eigensolvers, BLAS, matrix operations, and FFTs. And it's available in FORTRAN, C, and Ada.

Now in version 3.0, Math Advantage gives you more compatibility than any other math library. It's compatible with the FPS™ and Numerix™ array processor libraries, as well as the SEG seismic subroutine standard. And, for Vector Facility users,

it complements and builds upon the content of ESSL.

Math Advantage is from the experts in high-performance development tools—Quantitative Technology Corporation. So you can count on unmatched documentation, support, and technical excellence. Over a dozen computer equipment manufacturers offering Math Advantage on their systems do just that. For more information, contact QTC at (503) 626-3081 or Telex 910 240 2827.

Toolsmith Series®



QTC
Quantitative
Technology
Corporation

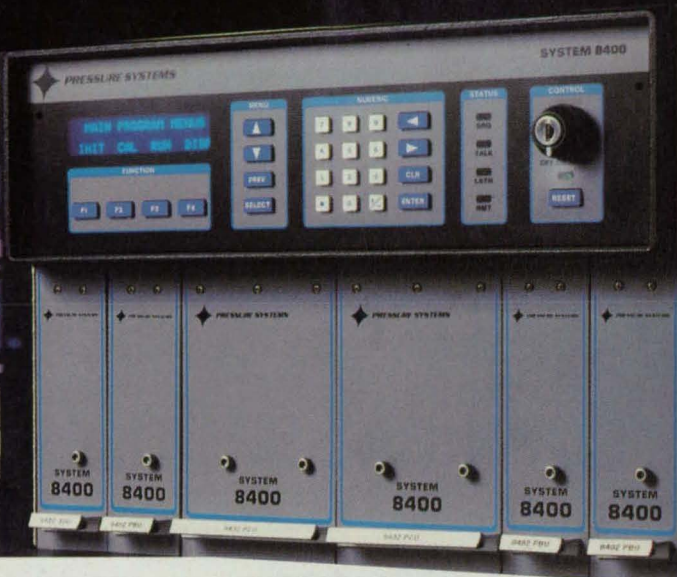
Quantitative Technology Corporation, 8700 Creekside Place, Beaverton, Oregon 97005.

Math Advantage and Toolsmith Series are registered trademarks of Quantitative Technology Corporation. Cray, Cyber, IBM, Vector Facility, and AT, VAX, Apollo, Sun, FPS, and Numerix are trademarks of Cray Research, Control Data Corp., International Business Machines Corp., Digital Equipment Corporation, Apollo Computers, Inc., Sun Microsystems, Inc., Floating Point Systems, Inc., and Numerix, respectively. Ada is a registered trademark of the U.S. Department of Defense (AJPO). Copyright © 1987 Quantitative Technology Corporation. Specifications and prices are subject to change without notice.

Circle Reader Action No. 570

Unleash The Power Of PARALLEL PROCESSING...

NEW MODULAR PRESSURE SCANNING SYSTEM



INTRODUCING THE MODEL 8400 PRESSURE SCANNING & ACQUISITION SYSTEM

- All Media Pressure Measurement
- Voltage, Frequency & Digital Inputs
- 100,000 + Measurements Per Second
- .05% Accuracy Full Scale

The 8400 system is a second generation approach to data acquisition. It frees the test engineer from technology of the past.

Parallel architecture lets you *simultaneously* acquire and correlate data from a variety of transducers. At high speed and high accuracy.

This acquisition system is fully integrated. So host computer software is substantially reduced. And cost of

ownership is far less compared to custom data acquisition systems.

The 8400 concept uses a 32-bit 68020 microprocessor for high speed data correlation and engineering unit conversion. The 68020 interfaces your host computer to as many as 64 measurement input units *each having its own microprocessor and acquisition personality card.*

Input units include pressure scanning, calibration, analog measurement, frequency measurement, and more — allowing input from virtually any signal source.

The 8400 system is ultimately flexible. It can be configured from a low cost entry

level system to ultra-high performance by your selection of modular subcomponents. This makes the 8400 specially suited for Turbine and Aerospace Testing.



The system 8400 is specially suited for Turbine & Aerospace Testing.

All backed by the company who built their reputation on *guaranteed measurement data*, Pressure Systems, the developer of electronic pressure scanning.

Call 1-800-678-SCAN for a brochure or exciting demonstration of the 8400's capabilities.



The typical measurement input unit has its own 8-bit microprocessor & acquisition personality card.
















PRESSURE SYSTEMS

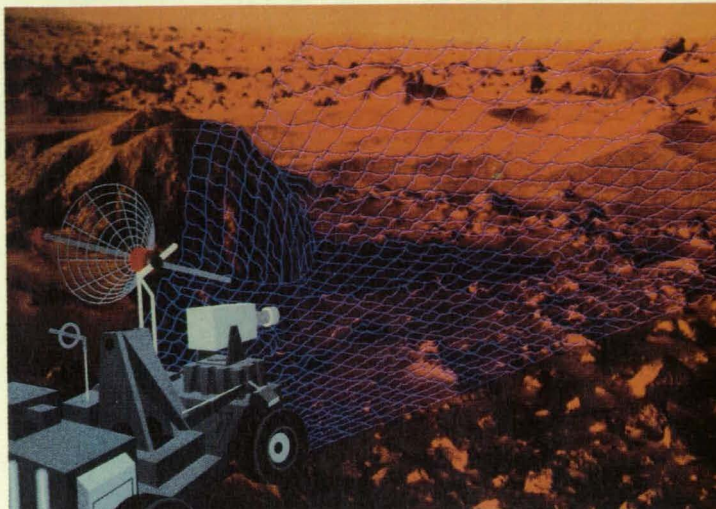
34 Research Drive, Hampton, Va. 23666
(804) 865-1243 Telex 901406 Fax 804-766-2644

SPECIAL FEATURES

NASA Tech Briefs Letter Writing Contest	14
NASA's Virtual Workstation: Using Computers To Alter Reality	20

TECHNICAL SECTION

 New Product Ideas	10
 NASA TU Services	12
 Electronic Components and Circuits	22
 Electronic Systems	32
 Physical Sciences	40
 Materials	48
 Computer Programs	54
 Mechanics	60
 Machinery	66
 Fabrication Technology	76
 Mathematics and Information Sciences	78
 Life Sciences	80
 Subject Index	83



Computers may one day use image data captured by a Mars Rover to recreate the Martian surface on Earth, allowing humans to virtually explore Mars from the comfort of their homes. Turn to page 20. (Photo courtesy NASA)

DEPARTMENTS

Win a free stay at the United States Space Camp for you or your child. See page 14 for details. (Photo courtesy U.S. Space Camp)

Editorial Notebook	14
New on the Market	81
Advertiser's Index	83



On The Cover: Computer graphics imagery surrounds the wearer of a NASA-developed helmet called the Virtual Visual Environment Display (VIVED). VIVED combines three-dimensional graphics and sound to immerse the wearer in an "artificial reality." The simple graphics depicted on the cover only hint at VIVED's simulation capabilities; the device could potentially recreate entire cities or planets inside the helmet. See page 20. (Photo courtesy NASA)



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

Permissions: Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Associated Business Publications, provided that the flat fee of \$3.00 per copy is paid directly to the Copyright Clearance Center (21 Congress St., Salem, MA 01970). For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Service is: ISSN 0145-319X/88 \$3.00 + .00

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright © 1988 in U.S., is published monthly except July/August and November/December (10x per year) 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 \$15.00. 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.



*Precision optics are shipped
directly to you from stock.*

Our new expanded line of optics now offers you . . .

...low scatter optical glass lenses

Scatter and unwanted diffraction effects are minimized thanks to surface quality that exceeds industry standards.

...zero fluorescence fused silica lenses

Our ultra-pure silica lenses provide accurate performance in ultraviolet experiments. And transmission is guaranteed to 185 nm.

...diffraction limited achromats

Crisp imaging and low wavefront distortion are assured with Newport's new achromat designs.

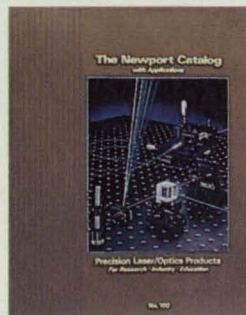
...laser damage resistant mirrors

Also windows, beamsplitters and filters. Survivability to multi-joule levels is certified by our unique in-house test facility.

...broadband polarizing beamsplitter cubes

Precise, convenient polarization control for multiple wavelength applications is available without interchanging optics.

*These are only a few of the over 2500
optics products in the Newport Catalog.
Call or write for your copy today.*



714/965-5406

Newport Corporation
18235 Mt. Baldy Circle
Fountain Valley, CA 92708
Europe: Newport GmbH, Ph. 06151-26116
U.K.: Newport Ltd., Ph. 05827-69995



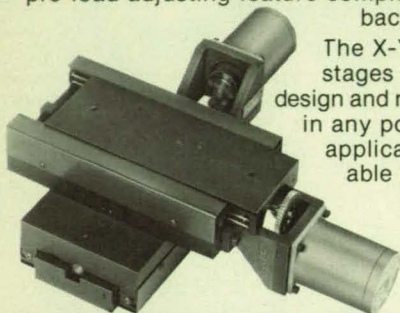
Newport

© 1988 NEWPORT CORPORATION

Circle Reader Action No. 540

AG Motorized Positioning Stages

AG's Hi-Precision X-Y Positioning Stages are available in 2", 4" and 6" standard travel models. They consist of two identical, specially designed AG Ball Slide assemblies mounted in tandem, driven by precision centrally located lead screws actuated by stepping motors. AG's exclusive tapered wedge pre-load adjusting feature completely eliminates backlash and play.



The X-Y or single axis stages are compact in design and may be mounted in any position. Custom applications are available to your specifications. Call or write for more information.

Smooth, accurate linear motion for instrumentation, product design, machine design and gaging devices.

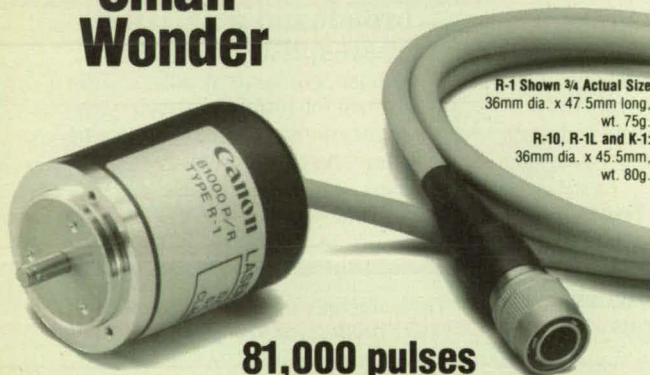
All standard AG Hi-Precision Slides are available with either ball or crossed roller bearing ways in eight cross-sectional sizes and a travel range from 1/2 to 15 inches for a total of 62 models from stock.



AG AUTOMATION GAGES, INC.
850 Hudson Ave., Rochester, NY 14621 Dept. 245
PHONE 716-544-0400 • 800-922-0329

Circle Reader Action No. 453

Small Wonder



R-1 Shown 3/4 Actual Size
36mm dia. x 47.5mm long,
wt. 75g.
R-10, R-1L and K-1:
36mm dia. x 45.5mm,
wt. 80g.

81,000 pulses per revolution!

- This low-cost incremental rotary optical encoder provides the highest resolution ever achieved in a package this small.
- For robotics, imaging systems, calibration equipment, surveying equipment, and machine tools, allows the use of direct drive motors controlled by directly measuring the motor's shaft rotation, reducing the error induced by reduction devices.
- Ideal for high resolution where smooth shaft rotation is required at low speeds.
- Light source, semiconductor laser, wavelength 780nm, maximum output 5mW.
- 81,000 pulses per revolution and angle/pulse of 16 arc seconds . . . without the use of electronic division.
- Output wave form is a 2-phase signal, A & B square or pure sinusoidal, each phase 90 degrees apart and an index signal.
- Low moment of inertia, 8g-cm².
- Power, DC ±5 volts, current 200 mA max.
- Maximum response frequency 500KHz (6 revolutions per second).

Ask for our free 16-page catalog and applications guide.

Canon New York Office/Headquarters One Canon Plaza
Lake Success, NY 11042 • 516/488-6700 • FAX 516/354-1114
CANON USA, INC. COMPONENTS DIVISION Santa Clara Office 4000 Burton Dr.
Santa Clara, CA 95054 • 408/986-8780 • FAX 408/986-0230

Circle Reader Action No. 623

NASA Tech Briefs

National
Aeronautics and
Space
Administration



NASA Tech Briefs:

Published by **Associated Business Publications**
Editor-in-Chief/Publisher **Bill Schnirring**
Associate Publisher **Frank Nothaft**
Associate Publisher **Robin J. DuCharme**
Managing Editor **R. J. Laer**
Associate Editor **Joseph T. Pramberger**
Technical Advisor **Dr. Robert E. Waterman**
Production Manager **Rita Nothaft**
Traffic Manager **James E. Cobb**
Circulation Director **Anita Weissman**
Marketing Research Manager **Leo D. Kluger**
Advertising Coordination Manager **Erving Dockery, Jr.**
Telecommunications Specialist **Evelyn Mars**
Reader Service Manager **Arlene Berrios**

Technical Staff:

Briefs prepared for National Aeronautics and Space Administration by **Logical Technical Services Corp., NY, NY**
Technical/Managing Editor **Ted Sellinsky**
Art Director **Ernest Gillespie**
Administrator **Elizabeth Texelra**
Chief Copy Editor **Lorne Bullen**
Staff Editors **Dr. James Boyd, Dr. Larry Grunberger, Jordan Randjelovich, George Watson, Oden Browne, Joseph Renzler, Dr. Theron Cole, Jr.**
Technical Advisers **Dr. Arthur Gilman, Dr. Jay Kirschenbaum**
Graphics **Luis Martinez, Vernald Gillman, Charles Sammartano**
Editorial & Production **Bill Little, Frank Ponce, Ivonne Valdes, Paul Marcus**

NASA:

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

Associated Business Publications

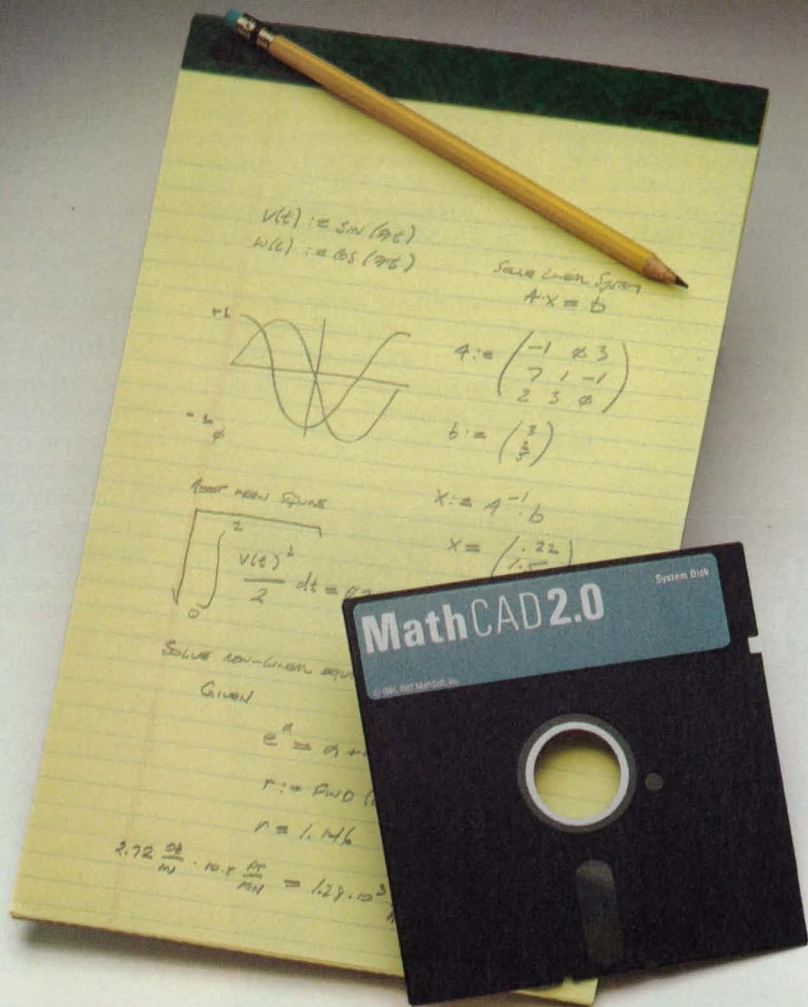
41 East 42nd Street, Suite 921, New York, NY 10017-5391
(212) 490-3999
President **Bill Schnirring**
Executive Vice President **Frank Nothaft**
Vice President Marketing **Mark J. Seitman**
Chief Financial Officer **Thomas Scherzer**

Advertising:

New York Office: (212) 490-3999 FAX (212) 986-7864
Sales Manager **Robin DuCharme**
Regional Sales Manager (Mid-Atlantic & Midwest) **Michelle Larsen**
Account Executive **Debby Crane** at (201) 967-9838
Account Executives (Midwest) **Jack Cartwright** or **Paul Leshar**
at (312) 501-4140
Account Executives (Eastern MA, NH, ME, RI) **Lee Arpin** or **Brian Clerkin**
at (617) 899-5613; **Bill Doucette** at (617) 278-7792
Account Executive (Western MA, CT, VT) **George Watts** or **David Haggett**
at (413) 253-9881
Account Executive (No. Calif., UT)
for Area Codes 415/408 — **Janice Richey King**
at (415) 656-3613
Account Executives (So. Calif., AZ, NV, NM)
for Area Codes 818/213/805 — **Thomas Stillman** or **Dana Gindoff**
and for Area Codes 619/714 — **Leslie Alley** at (213) 541-4699

NTBM-Research Center

Account Supervisor **Lourdes Del Valle**



Your pad or ours?

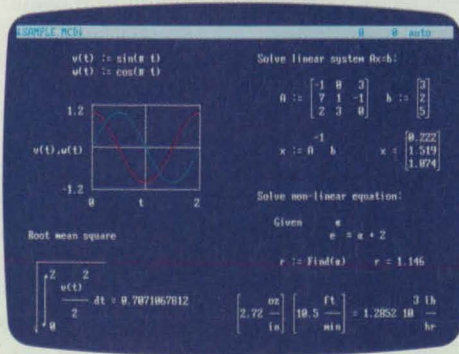
If you perform calculations, the answer is obvious.

MathCAD 2.0.

It's everything you appreciate about working on a scratchpad—simple, free-form math—and more. More speed. More accuracy. More flexibility.

Just define your variables and enter your formulas anywhere on the screen. MathCAD formats your equations as they're typed. Instantly calculates the results. And displays them exactly as you're used to seeing them—in real math notation, as numbers, tables or graphs.

MathCAD is more than an equation solver. Like a scratchpad, it allows you to add



text anywhere to support your work, and see and record every step. You can try an unlimited number of what-ifs. And print your entire calculation as an integrated document that anyone can understand.

Plus, MathCAD is loaded with powerful

built-in features. In addition to the usual trigonometric and exponential functions, it includes built-in statistical functions, cubic splines, Fourier transforms, and more. It also handles complex numbers and unit conversions in a completely transparent way.

Yet, MathCAD is so easy to learn, you'll be using its full power an hour after you begin.

What more could you ask for? How about the exciting new features we've just added to MathCAD 2.0...

- Built-in equation solver
- Full matrix operations
- Two to four times increase in calculating speed
- Easier full-page text processing
- Auto-scaled plots
- Memory enhancements
- Additional printer and plotter support
- And more.

If you're tired of doing calculations by hand or writing and debugging programs, come on over to our pad. MathCAD. The Electronic Scratchpad.

Call for a detailed spec sheet and the name of a MathCAD dealer near you. **1-800-MathCAD** (In MA: 617-577-1017).

Requires IBM PC® or compatible, 512KB RAM, graphics card.
IBM PC® International Business Machines Corporation.
MathCAD® MathSoft, Inc.

MathCAD®

MathSoft, Inc., One Kendall Sq., Cambridge, MA 02139



New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appro-

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 12). NASA's patent-licensing program to encourage commercial development is described on page 12.

Pressurized Sleeve

A fabric sleeve withstands a pressure difference of 8 lb/in.² (55 kPa) while allowing the wearer fairly easy movement. Developed as a replacement for a space-suit sleeve, the new sleeve gives greater

range of movement with lower restrictive torques. The sleeve offers the same advantages in such applications as protective clothing and sleeves for manipulation of objects in isolation chambers. (See page 80).

Schottky Diode With Surface Channel

An improved configuration for a Schottky-barrier diode reduces the parasitic shunt capacitance that degrades diode performance at frequencies above 30 GHz. The parasitic shunt capacitance is reduced by removing a portion of the high-dielectric-permeability, conductive semiconductor material from a region adjacent to the anode contact finger. (See page 22).

Flexible Ceramic-Insulated Cable

A proposed ceramic-insulated cable withstands heat, radiation, and oxidation. Developed for use in outer space, the cable is also suitable for furnaces, nuclear reactors, and robots operating in hot radioactive environments. (See page 30).

Graphite/Epoxy Deicing Heater

A graphite/epoxy composite heater prevents and reverses the formation of ice on advanced composite surfaces of aircraft. The heater includes a graphite-fiber/epoxy composite as the heating element. This heater can be thin and highly electrically and thermally conductive and can conform to irregular surfaces. (See page 48).

From Outer Space To Inner Space

Whether it's testing spacecraft to make sure they can operate in the exotic environment of Venus... or probing the molecular world of materials, major corporations and the Government rely upon National Technical Systems for answers.

Dynamic test facilities with data acquisition, reduction and analysis; mathematical models for finite-element analysis; test chambers for nearly every environment conceivable. Also, testing of hazardous products, high-pressure/high-temperature gases and liquids, cryogenics, EMI/EMC, PCB/PWBs. NTS — testing and analysis to simulate the space around you. And beyond.

We Test Out.

National Technical Systems

Call National Technical Systems In the west (714) 879-6110, In the east (617) 263-2933 Or write NTS, 1536 East Valencia Dr., Fullerton, CA 92631, or 533 Main St., Acton, MA 01720

This symbol appears next to technical briefs which describe inventions having potential commercial applications as new products. The process for developing a product from a NASA invention is described at the top of this page.

Still Crazy After All These Years.

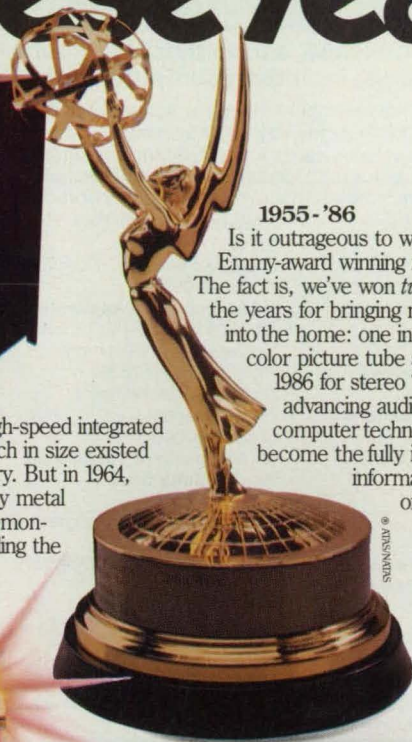
1946

When the David Sarnoff Research Center was working on color TV in the early 1940's, people may have thought, "That's crazy!" Yet, in '46 we publicly demonstrated a practical, all-electronic compatible color TV system. It was accepted as the industry standard in 1953, and is still used today.



1955-'86

Is it outrageous to work with an Emmy-award winning research center? The fact is, we've won *two* Emmys over the years for bringing new technology into the home: one in 1955 for the tri-color picture tube and another in 1986 for stereo TV. Today, we're advancing audio, video and computer technologies that may become the fully integrated home information center of the future.



1964

In the 1950's, the concept of low-power, high-speed integrated circuits a few thousandths of a square inch in size existed only in science fiction, and the laboratory. But in 1964, we introduced the first complementary metal oxide semiconducting chip. Then demonstrated its marketplace value by building the first CMOS 8-bit microprocessor.



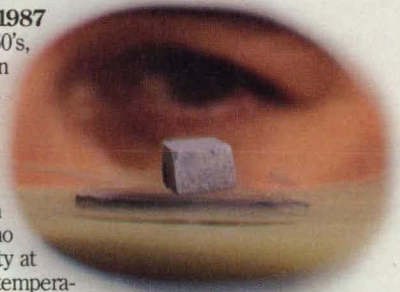
1986

Was it preposterous of us to try to reproduce the power of a room-sized laser in a smaller unit? No, we actually made our latest surface-emitting diode lasers smaller than the head of a pin. But what's really incredible are the opportunities they've opened for miniaturizing equipment in medicine, computing and satellite communications.



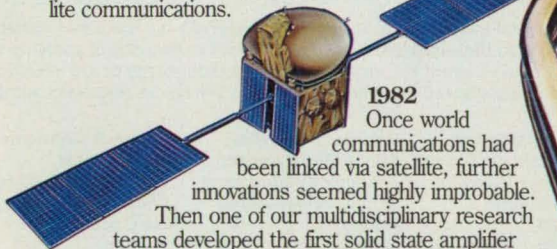
1987

During the early 60's, we were a pioneer in superconductivity research, and the leader in developing commercial applications for superconducting wire which operated at extremely low temperatures. Modern superconductors have no resistance to electricity at twice the previous temperature and can levitate a magnet like the one shown here, but we're working on superconductive circuits that will operate at room temperature.



1982

Once world communications had been linked via satellite, further innovations seemed highly improbable. Then one of our multidisciplinary research teams developed the first solid state amplifier for use in orbit, which doubled the capacity of our early "birds," and extended their operating life.



For over 40 years, the David Sarnoff Research Center has been turning man's wildest flights of fancy into marketplace realities.

Now, after all those years as a proprietary R&D facility for RCA and General Electric, Sarnoff is an independent contract research center.

And business is growing like crazy.

Our continuing success in contracts and joint ventures ranges from computerized automobile controls and radar measurements for steel blast furnaces to plasma physics.

Work in progress spans everything from high-definition television systems to transmitting data by laser to erasable optic disks. For our current capabilities report, contact Joseph C. Volpe, Vice President, Marketing, at the David Sarnoff Research Center, CN 5300, Princeton, NJ 08543-5300, or call (609) 734-2178.

Then bring us *your* troublesome projects, allegedly impossible technological hurdles and seemingly unreachable goals.

We're crazy enough to turn them into serious successes.

DAVID
Sarnoff
RESEARCH CENTER

A subsidiary of SRI International

Heads in the clouds, feet on the ground.



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 nine 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)

Southeastern Oklahoma State U.
Station A, Box 2584
Durant, OK 74701
Dr. Dickie Deel, Director
(405) 924-6822

North Carolina Science and Technology Research Center (NC/STRC)

Post Office Box 12235

Research Triangle Park, NC 27709

J. Graves Vann, Jr., Director
(919) 549-0671

NASA Industrial Applications Ctr.

823 William Pitt Union
University of Pittsburgh
Pittsburgh, PA 15260
Dr. Paul A. McWilliams, Exec. Director
(412) 648-7000

NASA/Southern Technology Applications Center

P. O. Box 24
Progress Ctr., One Progress Blvd.
Alachua, FL 32615
Dr. 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 (WESRAC)

University of Southern California
Research Annex
3716 South Hope Street, Room 200
Los Angeles, CA 90007
Radford G. King, Exec. Director
(213) 743-8988
(800) 642-2872 (CA only)
(800) 872-7477 (toll-free US)

NASA/SU Industrial Applications Center

Southern University Department of Computer Science
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) 694-5761
Patent Counsel:
Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 694-5104

Lewis Research Center

Technology Utilization
Officer: Daniel G. Soltis
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5567
Patent Counsel:
Gene E. Shook
Mail Code 301-6
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5753

John C. Stennis Space Center

Technology Utilization
Officer: Robert M. Barlow
Code GA-00
Stennis Space Center,
MS 39529
(601) 688-1929

John F. Kennedy Space Center

Technology Utilization
Officer: Thomas M. Hammond
Mail Stop PT-TPO-A
Kennedy Space Center, FL 32899
(305) 867-3017
Patent Counsel:
James O. Harrell
Mail Code PT-PAT
Kennedy Space Center, FL 32899
(305) 867-2544

Langley Research Ctr.

Technology Utilization
Officer: John Samos
Mail Stop 139A
Hampton, VA 23665
(804) 865-3281
Patent Counsel:
George F. Helfrich
Mail Code 279
Hampton, VA 23665
(804) 865-3725

Goddard Space Flight Center

Technology Utilization
Officer: Donald S. Friedman
Mail Code 702
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: 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
Patent Counsel:
Leon D. Wofford, Jr.
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0024

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) 453-2119
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

PRE-REGISTER TODAY AT SPECIAL RATES FOR 1988's MOST IMPORTANT CONFERENCE AND EXPOSITION

2ND ANNUAL

SPACE

TECHNOLOGY
COMMERCE &
COMMUNICATIONS

November 1-4, 1988

George R. Brown Convention Center
Houston, Texas USA

CO-SPONSORED BY:



THE SPACE FOUNDATION AND **SPACE** MAGAZINE

THE EXHIBITS

In order to make space ventures a reality, the industrial, scientific, and government communities worldwide will need exposure to new technologies, the potential of space, and information and demonstrations on the wide range of products and services to be exhibited:

- Launch Vehicle Industry
- Satellite Communications
- Remote Sensing/Imaging
- Materials Processing/Microgravity Research
- Financing of Space Ventures
- Project Management
- Information Systems
- Robotics
- Legal and Insurance Services

The debut of **SPACE: Technology, Commerce & Communications** in 1987 featured 75 international exhibitors and was the largest space event ever held in the U.S. Just a few 1988 exhibitors include: McDonnell Douglas, Ferranti International, Lockheed, Rockwell, Rocketdyne, General Dynamics, Space Industries, IBM, Honeywell and others. Nearly 100 companies are expected to exhibit this year.

THE CONFERENCE

SPACE: Technology, Commerce & Communications will address the opportunities, risks and potential for business in space, and will feature world renowned experts discussing technology advancements, new business opportunities, and more. Sessions will offer attendees a realistic assessment of today's industry and an insight into factors that influence the direction of future programs.

The conference program has been developed with the assistance of the following distinguished international experts who make up the Advisory Board for **SPACE: Technology, Commerce & Communications**:

- Dr. Joseph Allen**, Executive Vice President, Space Industries
- Mr. L.J. "Bud" Evans**, President, Center for Space and Advanced Technology, Arlington, VA
- Mr. Gregg Fawkes**, Director, Office of Commercial Space Programs, U.S. Dept of Commerce
- Mr. Alain Gaubert**, Executive Manager, PROSPACE, Paris, France
- Mr. John Hannon**, Vice President & General Manager, COMSAT World Systems Division
- Dr. Fred Henderson**, President, The GEOSAT Committee
- Dr. Alex Ignatiev**, Associate Director for Development, Space Vacuum Epitaxy Center, University of Houston
- Dr. Peter Kleber**, Project Manager — Industrialization of Space, DFVLR Germany
- Mr. Louis Laidet**, Scientific Attache, CNES
- The Honorable Manual Lujan, Jr.**, Member of U.S. Congress, House Committee on Science & Technology

- Mr. Gary Miglicco**, Partner, Peat, Marwick & Main
- Mr. Ian Parker**, Editor-in-Chief, SPACE Magazine, England
- Mr. Udo Pollvogt**, President, MBB-USA
- Mr. Ian Pryke**, Head, Washington Office, European Space Agency
- Mr. James Rose**, Assistant Administrator for Commercial Programs, NASA-HQ
- Mr. Peter Tambosi**, Vice President — Aerospace, Banque Nationale de Paris
- Mr. Robert Thompson**, Vice President & General Manager, McDonnell Douglas Astronautics Company
- The Honorable Robert S. Walker**, Member of U.S. Congress, Space Science & Applications Committee
- Mr. David O. Wicks, Jr.**, President, Criterion Investments
- Mr. Peter Wood**, Consultant and Past Sr. V.P., Booz-Allen & Hamilton

The preliminary outline for 1988's exciting program includes the following major session themes:

- Roles of Industry & Government in Commercialization of Space
- Establishing a Constituency for Space
- The International Space Station
- Current Space Transportation Services
- Research in Space: Opportunities for Industrial End User Companies
- Research in Space: Government Activities
- Financing Space Ventures (full day program)
- Corporate Joint Ventures
- Satellite Communications
- Future Space Transportation Concepts
- Information Systems
- Technical Papers
- How to Market Services
- Legal & Insurance Issues
- Remote Sensing Information Services
- Robotics
- Johnson Space Center Tour

Sign up today at special pre-registration rates!

Return to: Registration Dept. NTB788
SPACE: Technology, Commerce & Communications
c/o T.F. Associates, Inc.
79 Milk Street, Suite 1108
Boston, MA 02109 USA
Telephone: 617-292-6480 Telex: 951417 Ref: TFAS

- Yes, preregister me at the discount rate of \$445.00, including 3 luncheons, coffee breaks, reception and exhibits pass. (Government/institutional/Space Foundation member rate \$395.00). I understand you will send me written confirmation and detailed hotel information.
- My company may wish to exhibit. Please send exhibit information.

Name _____
Title _____
Address _____
City _____ State/Country _____ Zip _____
Tel _____ Telex _____

A Contest We're All Guaranteed To Win

A few months ago I read that several Congressmen suggested NASA contractors hire advertising agencies to help generate support for NASA because they weren't hearing much from their constituents and felt they didn't care. It's no secret that NASA's budget in constant dollars is about half what it was during the Apollo era. Nor is it a secret to anyone who is remotely familiar with *NASA Tech Briefs* that the benefits spun off through NASA's Technology Utilization Program have improved the quality of American life in myriad ways.

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 maintaining a strong national space program.

Our politicians certainly reflect the general inertia of their constituents. The response rate was only eight percent, which means the odds are better than ten to one that neither of your Senators nor your Representative responded to the survey. None of mine did. (If you'd like a list of those who did respond, write to us and we'll send you the list.)

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.

Here's how it works: Write a letter to the politician(s) of your choice, outlining your reasons for asking him or her to support NASA and the exploration of The Last Frontier. Then send us a copy of your letter(s). All letters received by August 31, 1988 will be judged by NTB's editorial board, and the winning letters will be published in the October issue. All letter writers will be listed on our *NASA Tech Briefs* Honor Roll, published in the same issue. We plan to send copies of each letter submitted to every Congressman on the Hill.

The grand prize winner will receive a tuition-free stay at the United States Space Camp. Second prize is a complete set of the NTB:BASE software library. Five runners-up will receive one free NTB:BASE category. Every reader who makes the honorable effort of writing a letter will get a certificate of honorable mention.



Gentlepeople, we are all responsible for what will or will not happen to our space program. We cannot afford to wait for the other guy to do it for us. So please, start those cards and letters flowing to the politicians. Send the original to the politician, and a copy to my attention at *NASA Tech Briefs*. Not only is this a contest wherein everyone who enters will get a prize, this is a contest in which every American will prove ultimately to be a winner. Thanks for your support. □

On the following page we've published excerpts from a recent speech by NASA Administrator Dr. James C. Fletcher and from an editorial by National Space Society President Ben Bova. Dr. Fletcher's warning on the consequences of cutting NASA's budget should sound the alarm for anyone interested in the preservation of our civil space program. And we hope Mr. Bova's words spur you to write your letter... today.

About The Contest



Deadline: August 31, 1988

Rules:

Write a letter to the politician of your choice, outlining your reasons for asking him or her to support NASA and the civil space program. Then send a copy of the letter, with your phone number, to the attention of Bill Schnirring at the following address:

NASA Tech Briefs
Letter Writing Contest
41 East 42nd Street, Suite 921
New York, N.Y. 10017

Prizes:

First prize is a tuition-free stay at the U.S. Space Camp, an educational camp that simulates an astronaut's training program. The winner will have the choice of attending the three day adult camp in Huntsville, AL or sending a child to a week-long camp in either Huntsville or in the Space Coast area of Florida. Second

U.S. Space Program At The Crossroads

Dr. James C. Fletcher
Administrator
National Aeronautics and
Space Administration



This may come as a surprise to you, but the nation's civil space program is facing extinction this year.

While I remain optimistic about the launch of the Space Shuttle this summer, I believe Americans must know that the long-term future of the space program hangs in the balance this year. The program's future rides on the outcome of current budget deliberations in Congress. And the outlook is grim.

The budget resolution approved by the House gives NASA a budget for fiscal year 1989 that falls way short of what the Administration has proposed. Should final Congressional action set the NASA budget at that level, the civil space program will be stopped in its tracks.

The budget levels being discussed on Capitol Hill would spell death to the Space Station, the key to our future in space. The Space Station will give the country a permanent presence in space and be the focus of our activities there through the 1990's and beyond. If we stop development, and we will have to if the budget is cut, the United States' civil space program will fall into disarray, and with it the prestige and leadership we worked so hard to gain. Major commitments to our Space Station international partners will have to be abrogated. Advanced astronomy observatories designed to be serviced from the station will never get off the ground. And scientific research that could lead to new products and processes here on Earth will never take place.

In addition, the Space Shuttle will be able to operate at only a reduced flight rate in the years ahead. This would mean that the scientific and critical national security payloads waiting to be launched will fall even further behind at a time when the Soviet Union, Japan and our European allies are moving steadily ahead.

In his new National Space Policy, the President cited leadership in space as the country's basic goal. He backed that policy with a budget request for NASA that would ensure the space program recovers and begins to move out on the road to leadership in the decades ahead. That budget is not extravagant; it contains no whistles and bells. It merely allows NASA to do its job for now.

The NASA budget—less than one percent of the entire federal budget—is probably the best investment we can make as a nation. If we fail to make that investment, the fire and spirit will be gone from NASA and the space program will come to a grinding halt. If the United States, the richest nation on Earth, cannot afford a fraction of one percent of its budget for its future, then clearly it cannot afford to be a world competitor in space or on Earth.

I don't believe the American people want our country to fall into that position. But unless the people speak out, I'm afraid we stand to lose by default what we've so carefully and effectively built. □

Space Gets Lost In Presidential Shuffle

So far in the 1988 Presidential campaign, space has been a non-issue. There is little evidence that any of the candidates believes space is vital to the nation's present and future economic strength in the global marketplace, little evidence that they understand how we must strive to allow private enterprise to move unfettered into this new frontier, little evidence that they see the human race expanding into the solar system.

This is because politicians perceive that space is not an important issue to the voters. They perceive correctly. While most Americans are in favor of a strong space

program, their support is at best lukewarm. They would gladly swap the space program for better law enforcement or garbage collection.

To the politicians and voters space is an expense, a drain on the treasury, a program that must be trimmed back in the largely delusional effort to control the national debt. None of them understands that space is the biggest, richest resource this nation has, more important economically than all of the coal, iron and other natural resources we possess. The technologies derived from space are already the backbone of our economy. Millions of jobs have been

created by space-derived technologies and trillions of dollars have poured into the economy as a result.

We must seek out the key people in each candidate's organization and convince them of the importance of space. For we are not only electing a President this November. We are electing a third of the Senate and the entire House of Representatives. At the local and state level you can—you must—establish contact with the key people. Do that, and you will have accomplished the first step on the road to human settlement of the solar system. □

Ben Bova, President
The National Space Society

prize is a complete set of NTB:BASE, NASA Tech Briefs' PC-compatible database covering 25 years of NASA technology. Five runners-up will each receive one NTB:BASE category. All entrants will receive a certificate of recognition and will have their names published in the October issue. Winners will be announced in the same issue.

Where To Write:

To United States Senators:
United States Senate
Washington, D.C. 20510

To members of the House of Representatives:
United States House of Representatives
Washington, D.C. 20510

Presidential candidates can be reached at the following addresses:

Vice President George Bush
212 Capitol Bldg.
Washington, D.C. 20510

Governor Michael Dukakis
105 Chauncey Street
Boston, MA 02111

Reverend Jesse Jackson
30 West Washington Street
Suite 300
Chicago, IL 60602

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 Bill Schnirring at NASA Tech Briefs.

WHO'D SPEND TWO CENTS ON GUM WHEN

Not these kids.

They've learned a manned Space Station will cost each one of us just two cents a day. And they know the payback in human benefits will be enormous.

With the special power of the young to imagine

what could be, children are among the first to see the value of the Space Station. So when we ran a message in the newspaper supporting it, they wrote us with their two cents' worth—not only in words, but in cash.

We're sharing some of their thoughts here as a

I think that the whole world should give space station 2¢ because it could only buy two pieces of bubble gum and two ¢ is hardly anything. I think I would feel better after because I would be helping the Space Station. I think it would be like a contribution.

But how long do we give two ¢?

By
Allison
Matthews

Nasa

Dear Sirs,
I think the United States should build a space station because some day I think we should find out. I think we should promote it because it would enable us to explore space. Enclosed is my 2¢ donation.

"My 2¢ Worth"

Game

I would like my two cents worth on spending money for the new space station. I feel that we should go out there and compete with Russia. It would be a great experiment to send up to space. After we send it up, it would be very helpful to us. It would help us learn about space and what space is really like. I think everyone should feel this way. That they would be supporting their country which they love!!

INASA

Dear Sirs,
Hello from [unclear]
I'm glad to hear that
that's a great
enough
the [unclear]

YOU CAN BUY A SPACE STATION INSTEAD?

reminder: The Space Station isn't just being built for scientists or astronauts or corporations or jobs. It is being built for America's children.

It is a legacy of American leadership, one we can leave them at a cost of only two cents a day. A better

buy than bubble gum any day.

Your letter will help support the Space Station, too. Write: "Get U.S. Into Space," c/o McDonnell Douglas, P.O. Box 14526, St. Louis, MO 63178.

MCDONNELL DOUGLAS

should have a space
live in space, and
about the unknown.
space station because
one of our dreams about
the space station.

Sincerely,
Scott Henry

Dear Sirs,

I think we should have a Space
Station because someday we could live
there. We will know more about space.
We might find new galaxies or planets.

Sincerely,
William
Lillespie

Dear Sirs,

I will be glad to give 2¢ because
it will benefit everyone who gives 2¢. The
people who give 2¢ will later in life have
more technology about space. So when we
kids have children or grandchildren for
that matter, we can tell them all
about it. I hope that everyone chips
in and you can make the space
station.

Sincerely,
All Everett

me is Devon and I'm
Blanc, Michigan. I would be
to 2¢ for the Space Station
to make. I think it's
and I hope that you get
from tapes to make
it.

Thank you and good luck!!

Sincerely,
Devon Woodruff

If I had two pennies

If I had two pennies I would give them
to you to build a space station. Even though
it seems like two pennies were not enough.
If the whole world gave two pennies we would probably
have about 4,000,000,000 dollars for it. And
it would be nice for when the people are up
in space.

Marin Orris

Letters from the fifth grade at Indian Hill School, Grand Blanc, Michigan.

Atlas

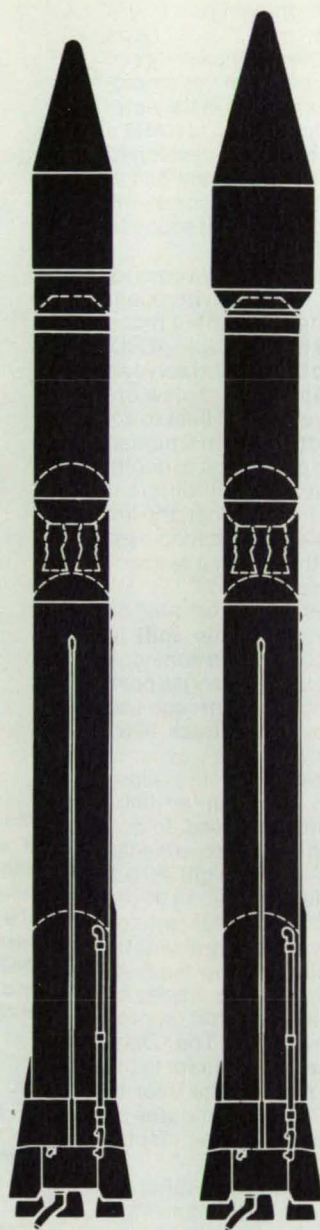
Atlas IIA, General Dynamics' new 6,000-pound class launch vehicle, has just opened up a new option for doing business in space.

This commercial derivative of the Atlas II, recently selected as the U.S. Air Force's new medium launch

vehicle, is now available in a cost-effective package that includes complete launch services. Scheduling is flexible to meet your needs, and we will start flying as early as 1991.

Reliable Atlas launch vehicles have been putting government and

rs



commercial satellites into orbit for nearly 30 years. Today, with our proven Atlas I and new Atlas IIA, we are prepared to deliver your 5,000- and 6,000-pound class payloads to geosynchronous transfer orbit with high reliability

and a schedule you can count on. Given the importance of your investment, Atlas IIA is the right way to do business in space.

GENERAL DYNAMICS
Commercial Launch Services

Circle Reader Action No. 531

Imagine having the power to instantly change your environment; to be transported at will to the surface of the moon or a distant star, and yet never physically leave the comfort of your living room. Though it sounds like science fiction, environment-hopping is not only possible but may one day be as commonplace as a drive in the family car.

NASA is at the forefront of this emerging technology. Researchers in the Aerospace Human Factors Division at NASA's Ames Research Center have developed an experimental display system called the Virtual Workstation that combines three-dimensional graphics and sound to create an "artificial reality."

The invention's key hardware component is the Virtual Visual Environment Display (VIVED), a head-mounted monitor containing liquid crystal display (LCD) panels that cover both eyes and serve as viewing screens. Wide field-of-view optics expand each eye's visual field to approximate the breadth of normal human vision. To create the perception of depth, each screen receives slightly different imagery. When viewed together, the images fuse to generate a stereoscopic experience that gives the wearer a sense of being inside the display.

Other depth clues come from motion parallax, which describes the shift in background that occurs when someone looking at a point in space changes position. This effect is achieved through use of electronic sensors that track head position and orientation. The sensors match imagery to head movement, allowing the wearer to scan an artificial panorama as he turns his head. In one current program, the wearer experiences a walk in space. Looking straight ahead, he sees a Space Station floating in the distance, while over his shoulder a satellite drifts into view. Looking down, he views the Earth "miles" below his feet.

The user interacts with the display by wearing a fiber optic glove that records hand and finger movements. The "DataGlove" provides a hand-like cursor in the virtual space that permits the user to issue instructions to the computer by pointing at menu items on the display screen.

In cooperation with Ames, NASA's Jet Propulsion Laboratory (JPL) is building a robotic arm that will be controlled using a DataGlove. NASA hopes that one day a robot will be able to repair orbiting satellites by mimicking the hand movements of an astronaut inside the Space Station.

Thrifty Technology

Manned systems engineer Dr. Michael McGreevy developed the Virtual Workstation concept in 1984 while exploring ways to use simulation to improve the spatial relationship between humans and computers. "In the past," said Dr. McGreevy, "people had thought of simulators solely in terms of aircraft simulation for pilot training. Our research team wanted to create a personal simulator for such applications as high fidelity telepresence, the projection of human capability to remote locations like Mars or a moon base."

Working with a shoestring budget, the Ames group crafted a helmet-mounted

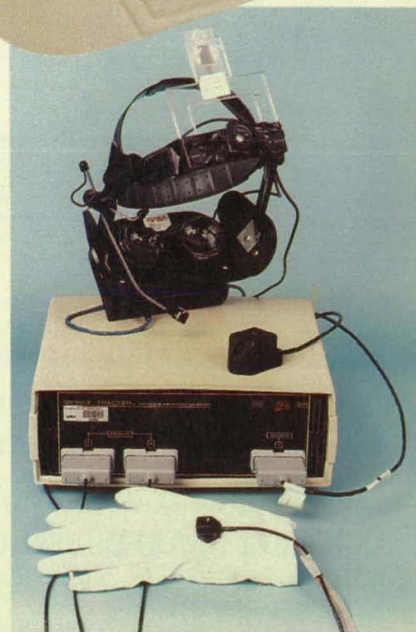
NASA's Virtual Workstation: Using Computers To Alter Reality

The astronaut on the right is wearing a first generation VIVED helmet. A computer-generated image of the physical workstation in the photo could be recreated inside the helmet, allowing the astronaut to see and operate it, but it would only exist in the virtual environment.

prototype within a year. "We used mostly off-the-shelf components," explained Informatics support contractor James Humphries, who designed VIVED's video processors and helmet packaging. "For instance, the LCDs were pulled from commercial pocket televisions and modified to present video imagery to the optics. This enabled us to produce a low-cost device while at the same time advancing the state of wide field-of-view displays."

The workstation's first customers are likely to be design engineers. By merging VIVED displays with computer aided design software such as NASA's PLAID, which models Space Station modules, an engineer could walk through a computer design prior to building mock-ups, thereby saving both time and money in the refinement of designs.

Scientists in Ames' Numerical Aerodynamic Simulation (NAS) Program plan to use the NASA workstation to create virtual wind tunnels for computational fluid dynamics (CFD) research. "The problem with present wind tunnel simulations is that you're stuck looking at a two-dimensional screen," said McGreevy.



Above: The second generation viewer eliminates the helmet and features higher resolution LCDs. Also shown are the commercial head tracker and the first generation DataGlove, which allows the wearer to interact with the VIVED display.



"But by combining CFD graphics with the virtual environment, a scientist could walk out onto the wing of a hypersonic aircraft without getting blown away and study the effects of airflow on a design configuration. Wearing a DataGlove, he could reach out and touch the simulated wing, or give a command to change its scale."

A Nation Of Space Explorers

McGreedy is working with JPL scientists to develop the concept of virtual planetary exploration. "Planetary environments could be recreated on Earth by integrating photography from space missions into a computer graphics database," explained the Ames engineer. "This would democratize space exploration. Large groups of people on Earth could virtually explore Mars through image data captured by a rover traveling the Martian surface."

Live television images transmitted from space to personal simulators on Earth would allow entire nations to participate in manned space missions. "They could stand next to an astronaut on the Space Station's observation deck and see exactly what he's seeing," stated McGreedy. At the same time, the astronaut could strap on VIVED and enjoy a virtual visit with earthbound family and friends.

McGreedy said his invention could revolutionize education by creating a "global classroom." "Instead of lecturing to students about a foreign land, you would give them a virtual database and let them fly over and discover it for themselves. My guess is that their natural curiosity will cause them to always wonder what's over the next hill or in the next town. They'd no longer be just students but explorers."

Space Age Television

One potential spinoff of VIVED technology is three-dimensional television that would surround the viewer with imagery. "TV has gotten very jaded," commented McGreedy. "Who wants to watch a half-hour of other people's families acting strange? But if you could be transported to another country or period in history for those thirty minutes, well, it could really excite the television market. You're looking at a multi-billion dollar market for programming alone."

Television programs and stereo videotapes can already be shown on the VIVED screen, but without the head tracking feature. "To add tracking to wide field-of-view TV, you'd probably have to be off-line," said McGreedy. "It would be difficult to have the image change independently for each viewer."

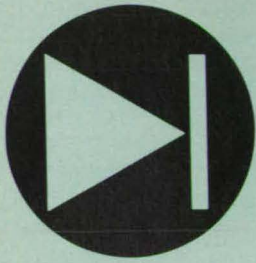
The Next Step

McGreedy describes the Virtual Workstation as a "constantly evolving technology." The current monochromatic screens of 320 x 240 picture element dots, or pixels, will be replaced by 512 x 512 color screens by year's end. Ames researchers are also developing voice interaction and enhanced 3D sound capabilities, and plan to create a wireless display system to be tested aboard the Space Shuttle.

The next step, according to McGreedy, is to put the workstation into the hands of graduate students. "I want to turn this device loose and give it to students in the best engineering schools and research labs across the country," he said. "That will incite an explosion of the technology."

McGreedy predicts that within a decade personal simulators will be manufactured on a production line, in a form resembling ordinary eyeglasses. "They'll be made from a sandwich of transparent plastic lenses and LCD panels a fraction of an inch thick, yet will feature much higher resolution than possible today," he said. "And everyone will have one."

"In the next century," he added, "this invention could turn today's televisions and computer terminals into museum pieces." □



Electronic Components & Circuits

Hardware Techniques, and Processes

22 Schottky Diode With Surface Channel

23 RF Testing of Microwave Integrated Circuits

24 Image-Method Gain Measurement With Mismatch

26 Hot-Film Anemometer for Boundary-Flow Transitions

28 Formula Gives Better Contact-Resistance Values

30 Flexible Ceramic-Insulated Cable

31 Acoustical Convective Cooling or Heating

Schottky Diode With Surface Channel

Straightforward design changes improve performance and simplify fabrication.

Goddard Space Flight Center, Greenbelt, Maryland

An improved configuration for a Schottky-barrier diode reduces the parasitic shunt capacitance. Schottky-barrier devices are used as microwave mixer and varactor diodes, and shunt capacitance degrades performance at the typical operating frequencies above 30 GHz.

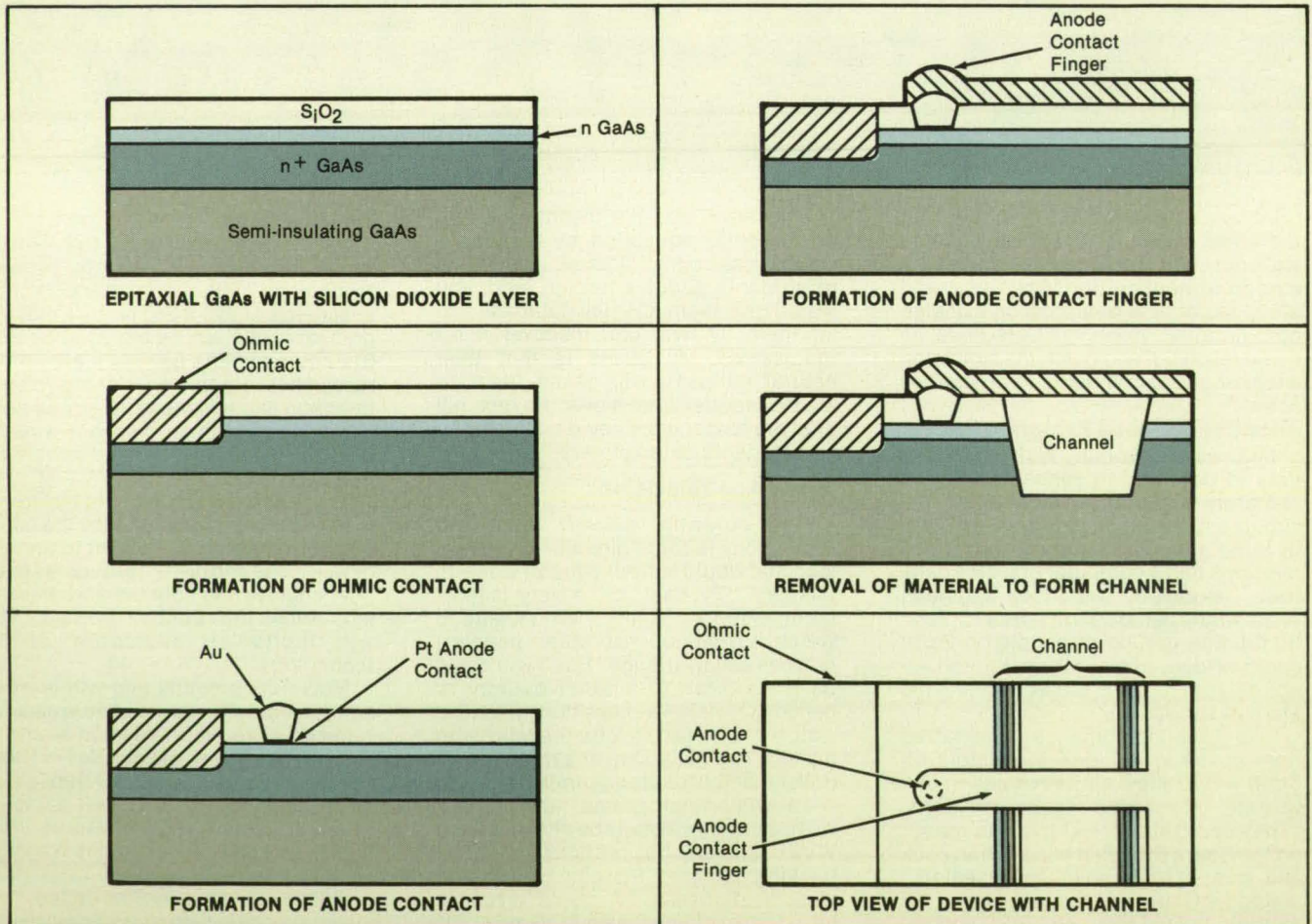
The new configuration avoids the need for the special skill and equipment required to make contact-whisker Schottky-barrier diodes, which have low shunt capacitance.

As in previous whiskerless designs, the contact whisker is replaced by an integrally-fabricated anode contact finger. However, the new configuration eliminates some of the difficulties encountered in the fabrication of prior, more-complicated whiskerless Schottky diodes of low shunt capacitance.

The parasitic shunt capacitance is reduced by removing a portion of the high-dielectric-permeability and conductive

semiconductor material from a region adjacent to the anode contact finger. If not removed, this material would support conduction and displacement currents between the anode contact finger and the metal/semiconductor junction, thereby giving rise to a relatively high shunt capacitance.

The fabrication process and the configuration of the diode are shown in the figure. The first step is the prefabrication of an



The **Anode Contact Finger** forms a bridge over the channel from which material has been removed to reduce the parasitic shunt capacitance. The device is made by standard processing techniques that readily accommodate changes of design.

epitaxial wafer that consists of a semi-insulating GaAs substrate layer, an intermediate buffer layer of n^+ GaAs, and an upper layer of n GaAs. An insulating layer, preferably of SiO_2 , is deposited on the upper n GaAs layer.

Space for an ohmic contact pad is formed by the use of a photoresist pattern and etching through the SiO_2 and, in some cases, the GaAs layers. The ohmic-contact metal is deposited by electroplating a sequence of tin, tin/nickel, and gold over the contact-pad area. The contact is alloyed, then overlaid with gold.

The anode region is defined by a photoresist pattern, and the anode window is etched through the SiO_2 layer. The photoresist is then removed, and a thin layer of platinum followed by a thicker layer of gold are plated into the anode window and onto the n GaAs to form the anode. A thin layer of chromium and another of gold are then sputtered onto the entire upper surface.

A photoresist is applied and patterned to define the anode contact pad and anode contact finger. A thick layer of gold for the pad and finger is then deposited. The photoresist is removed, and the thinner layers of gold and chromium are etched away, thus forming the anode contact pad and finger.

A photoresist is then applied and patterned to define the region from which the material will be removed to reduce the shunt capacitance. After the etching of the SiO_2 in this region, the photoresist is removed and the region is etched further, forming a channel that extends under the anode contact finger and into the semi-insulating GaAs layer.

This process allows for easy variation of the length, width, and thickness of the anode contact finger, thus enabling the design of the finger for optimum inductance. The size of the anode contact pad can also be varied easily for optimum coupling of power into the device. The depth and width of the channel can be adjusted to minimize shunt capacitance. Thus, design changes can be executed through routine processing variations to make devices that have parasitic series resistances and shunt capacitances approaching theoretical limits.

This work was done by William Bishop, Robert J. Mattauch, Kathleen McKinney, and Diane Garfield of the University of Virginia for Goddard Space Flight Center. For further information, Circle 11 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 12]. Refer to GSC-13063.

RF Testing of Microwave Integrated Circuits

Fixtures and techniques are undergoing development.

Lewis Research Center, Cleveland, Ohio

Four test fixtures and two advanced techniques have been developed in a continuing effort to improve the radio-frequency (RF) characterization of monolithic microwave integrated circuits (MMIC's) in the K and K_a bands (18 to 26.5 and 26.5 to 40 GHz, respectively). RF characterization requires small-signal input/output scattering-parameter measurements by automatic

vector network analyzers; these measurements are difficult at and above the K band because the increased effects of parasitics at these frequencies introduce inaccuracy and nonrepeatability, the mounting of MMIC's in conventional fixtures is time consuming, and it is difficult or impossible to couple test equipment to MMIC's in a nondestructive manner.



GET INTO THE FASTEST GAME IN TOWN.

High-speed chips, high-speed QuickChip™ turnaround—it's our 8.5 GHz process... that's our game. For semicustom ICs, there's no better, faster source. Bet on it.

For a sure win, call Tektronix:
1 800-835-9433. Ask for Ext. 100.

Tektronix
COMMITTED TO EXCELLENCE

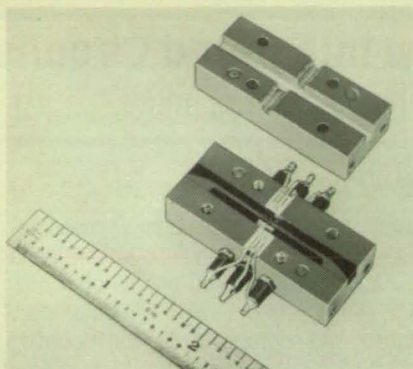


Figure 1. This **K-Band Fixture** is used to test MMIC submodules of a 30-GHz receiver. A 3-bit switched-line phase shifter is bonded to the fixture.

The finline/waveguide test fixture shown in Figure 1 was developed to test submodules of a 30-GHz monolithic receiver. The fixture provides accurate and repeatable data. However, ribbon and wire bonds are needed to secure each MMIC, and skill is required to solder the MMIC to a carrier block in the fixture; consequently, testing is difficult, and it is almost impossible to re-use the MMIC after testing.

A "universal" commercially-manufactured coaxial test fixture was modified to enable the characterization of various microwave solid-state devices in the frequency range of 26.5 to 40 GHz. The coaxial-to-microstrip transition and its housing were replaced by a waveguide-to-microstrip transition and a suitable housing, which is compatible with the existing fixture while minimizing transition losses and eliminating resonant modes. Preliminary tests indicate problems with waveguide modes and nonreproducibility of characteristics.

The probe/waveguide fixture of Figure 2 is compact, simple, and designed for the nondestructive testing of a large number of MMIC's. All four scattering parameters have been measured on this fixture. Although the measurements were less repeatable than they were on other fixtures, they are expected to improve considerably with the addition of a precise probe-alignment cover.

Another nondestructive-testing fixture includes a cosine-tapered ridge, to match the impedance of the waveguide to that of the microstrip. Although contact is achieved through a critical pressure fit between the ridge and the chip carrier, this fixture promises high repeatability due to the elimination of ribbon bonds and of the need for a spring mechanism.

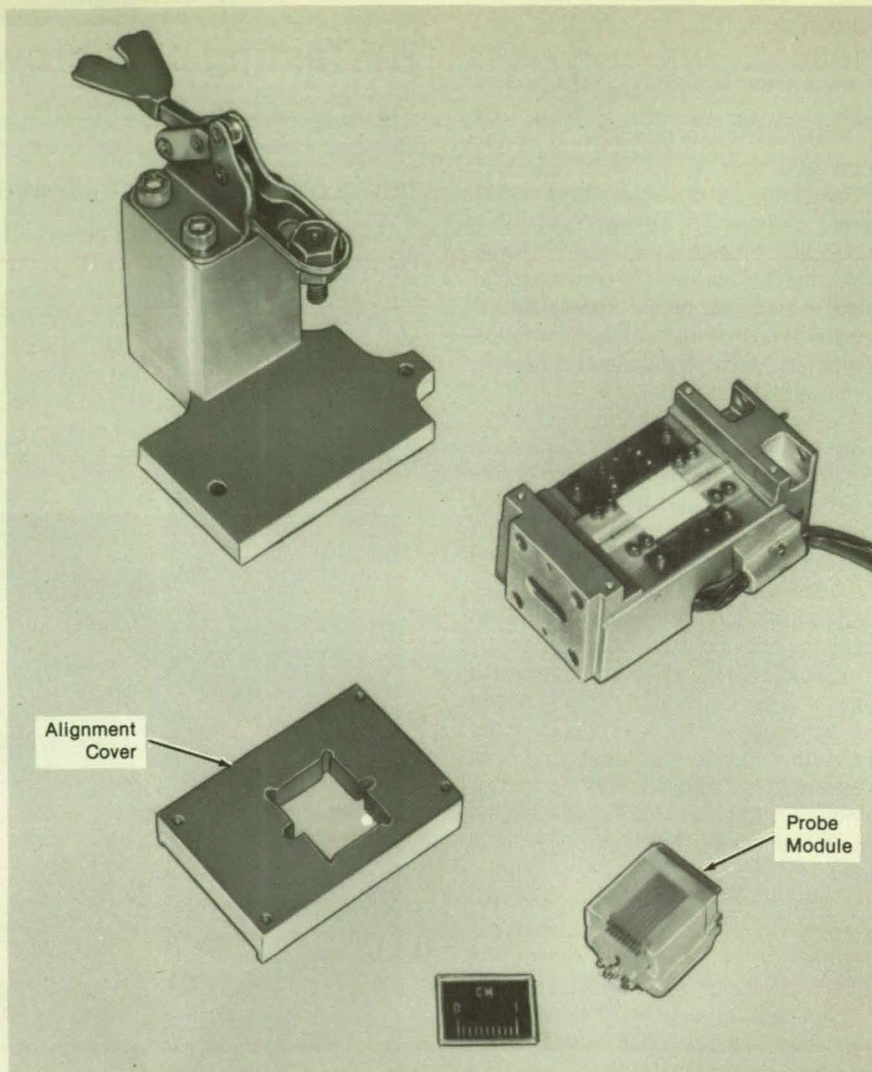


Figure 2. This **K-Band Fixture** is used to test packaged components of a 20-GHz MMIC transmitter. The alignment cover guides the probe module onto the MMIC.

One of the emerging techniques for characterization is microwave-wafer probing. A wafer probe is essentially an adapter from coaxial cable to bonding pads and performs about as well as a normal SMA connector. However, accuracy can be enhanced significantly through the use of chip-level impedance standards. A "de-embedding" procedure requires the use of short, open, and load standards for one-port characterization and an additional through connection and isolation standards for two-port characterization.

The second emerging technique is electro-optical sampling. Short-pulse lasers and ultra-high-speed photoconductors are used to generate wideband electronic pulses to provide direct electronic sam-

pling on GaAs devices or integrated circuits. The technique provides characterization without bonding of the device or circuit under test and can yield measurements at frequencies from 2 to 100 GHz.

This work was done by R. R. Romanofsky, G. E. Ponchak, K. A. Shalkhauser, and K. B. Bhasin of Lewis Research Center. Further information may be found in NASA TM-88948 [N87-22065/NSP], "RF Characterization of Monolithic Microwave and mm-Wave IC's."

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-14639

Image-Method Gain Measurement With Mismatch

A new formula accounts for multiple reflections.

Lewis Research Center, Cleveland, Ohio

An equation has been derived for measurement of the absolute gain of a

microwave antenna by the image method where the antenna is mismatched with its

waveguide. While the image method (see figure) is simple to use, up to now its ac-

An open letter on America's Space Program

Today, the United States' space program stands at a crossroads. Funding of the 1989 NASA budget request is being weighed by the U.S. Congress. The nation's position as a world leader in space exploration—with its long-range implications for America's economic well-being and competitive strength—is at issue.

After thoughtful consideration, the President has endorsed a space policy that is aggressive, multifaceted and balanced. Importantly, the policy promotes our nation's economic well-being by encouraging the commercial use and exploitation of space technologies.

Public opinion surveys consistently indicate strong support for a national commitment to space exploration.

The budget requested for NASA seeks to invigorate space technology to move America forward, with both manned and unmanned missions, and to gain ready access to space through a fleet of Space Shuttle orbiters and expendable launch vehicles.

At its core, the U.S. plan is centered on the Space Station, a platform in space which will unlock new opportunities for economic development here on earth. The station will aid in finding global solutions for forecasting weather, monitoring and protecting the environment, and in continuing America's exploration of the universe.

International cooperation in space is already on the drawing boards, with Japanese, Canadian and European participation in the Space Station. Meanwhile, these and other nations are funding extensive competitive space programs, including the Soviet Union which launches nearly 80% of all space payloads.

Thus the critical issues are: Is America willing to compete in space? And is America willing to make this investment in our nation's future and that of our children?

The nation that leads in space will lead on earth, with the technologies and innovations that will create and master high technology markets, and assure competitiveness in the years ahead.

So an investment in space offers a means through which we can solve budgetary problems by increasing our ability to compete—in every industry, in every market.

The issue at hand is a strong, vital space program for America.

We respectfully urge Congress to support the proposed NASA budget. And we urge all Americans to let their Congressional representatives know they strongly support America's leadership role in space.



Rockwell International

... where science gets down to business

Aerospace / Electronics / Automotive
General Industries / A-B Industrial Automation

curacy has depended on the assumption of a perfect match.

The perfect-match formula for absolute-gain measurements is

$$|\Gamma|^{-1} = 8\pi R/G\lambda$$

where Γ^2 is the ratio of received power to transmitted power, R is the distance from the antenna to the reflecting plane as shown in the figure, λ is the wavelength, and G is the gain. To obtain G , it is first necessary to measure the received and transmitted powers at various distances R to obtain a plot of $1/|\Gamma|$ versus R . The slope of the mean straight line interpolated through this plot is $8\pi/G\lambda$, from which G is then easily calculated.

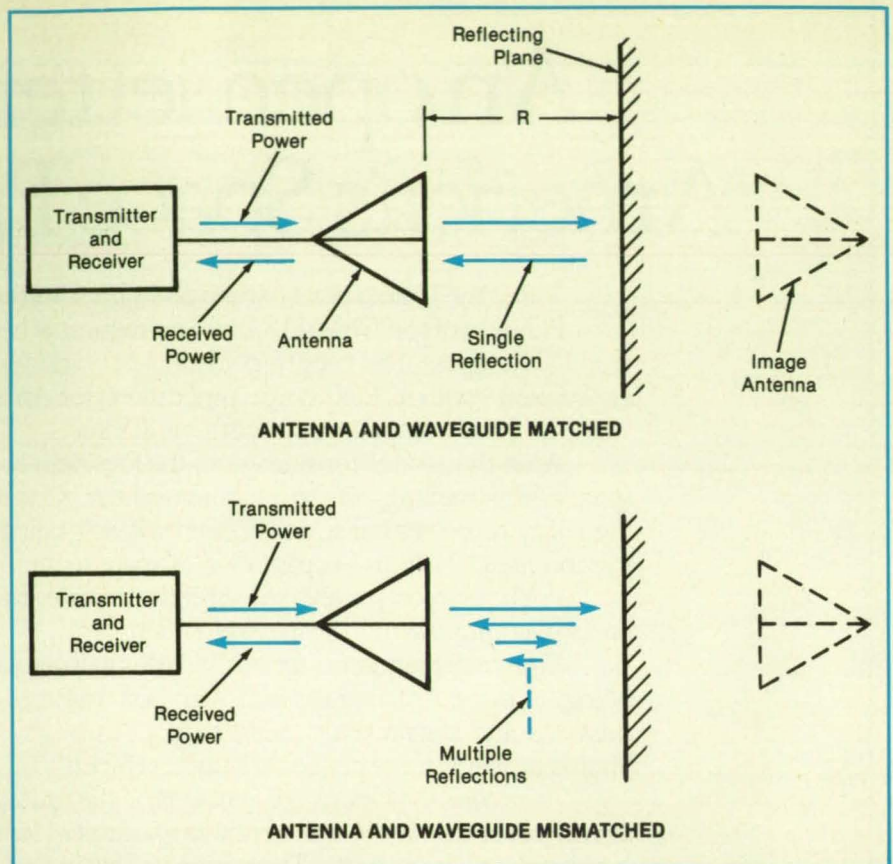
If the antenna and waveguide are mismatched, then some of the received power is reflected from the waveguide/antenna junction and sent out again along with the transmitted power. A portion of this reflected power is returned to the antenna in a series of reflections of ever-decreasing power. When the effects of the multiple reflections are included, the gain-measurement formula becomes

$$|\Gamma - \Gamma_0|^{-1} = 8\pi R/G\lambda(1 - |\Gamma_0|^2)$$

where Γ_0 is the reflection coefficient of the waveguide/antenna junction and it is assumed that the imaging plane is a perfect reflector.

The formula was tested by applying the image method to two antennas having previously known gains of 15.0 dB at 22 GHz and 23.9 dB at 20 GHz, respectively. Using the formula, the image-method gains were 14.65 dB and 23.98 dB, respectively.

This work was done by Richard Q. Lee and Maurice F. Baddour of **Lewis Research Center**. Further information may



In the **Image Method** an antenna is placed facing its image in a reflecting plane. The power transmitted by the antenna and the portion of the transmitted power received by the antenna after reflection from the plane are measured at various distances R .

be found in NASA TM-88924 [87-16968/NSP], "Absolute Gain Measurement by the Image Method Under Mismatched Condition."

Copies may be purchased [prepayment required] from the National Technical In-

formation Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-14555

Hot-Film Anemometer for Boundary-Flow Transitions

A temperature-compensated instrument yields data at subsonic and supersonic speeds.

Ames Research Center, Moffett Field, California

An improved temperature-compensated hot-film anemometer detects aircraft boundary-layer transitions at transonic speeds over a range of altitudes and speeds. In previous experiments, the sensitivity of a hot-film anemometer varied with changes in the speed and altitude of the aircraft. During extremes of high speed at low altitude or low speed at high altitude, the anemometer output saturated, resulting in the loss of data on the flow transition. The new anemometer corrects for this effect by measuring the local total temperature (the ambient temperature at a stagnation point) and heating the hot-film gauge to a fixed differential of 90 °C above the total temperature. The configuration of the circuit and electrical shielding of the new instrument also improve the quality of the measured data by increasing the ability of the anemometer amplifier to reject noise.

The basic instrument employed a hot-film gauge with a bridge circuit to maintain a constant film temperature. The new instrument (see figure) adds an external temperature-compensating resistor to maintain the film at the constant temperature differential rather than at constant temperature. As the airflow varies, so does the amount of heat carried away from the film. Thus, the amplifier output gives an indication of the flow past the hot film. When a transition of the boundary layer is encountered, the amplitude and frequency of the dynamic voltage output rise sharply. The steady-state voltage changes correspondingly.

The hot-film gauge and the temperature-control resistor are mounted on the surface of the aircraft. Both components are wired through the same cable to the electronic circuitry inside an instrumenta-

tion fin on the aircraft. The common side of each is connected to the cable shield, which is grounded inside the electronic housing to increase the rejection of noise by the amplifier.

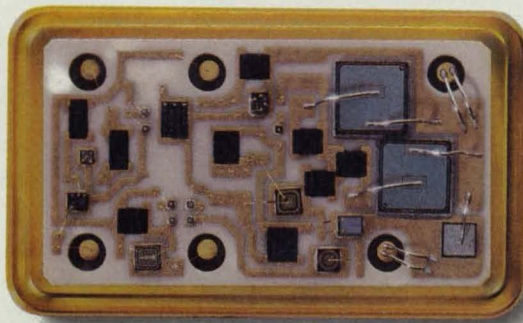
Several maneuvers were flown to demonstrate the characteristics of the temperature-compensated anemometer. Constant-mach-number and constant-dynamic-pressure ascents and descents were flown. Altitudes ranged from 5,000 to 40,000 ft (1.5 to 12 km), mach numbers from 0.7 to 1.8, and dynamic pressures from 300 to 600 lb/ft² (2 to 4 MPa). The sensors survived rapidly passing shock waves as well as high dynamic pressures.

This work was done by Harry R. Chiles and J. Blair Johnson of **Ames Research Center**. Further information may be found in NASA TM-86732 [N85-33121/NSP], "Development of a Temperature-Compensat-

SOLID STATE RELAY

Short Circuit Protection and True Output Status

- Current Overload Protection
- Optical Isolation
- TTL & CMOS Compatible Control
- DESC Drawing Number Pending

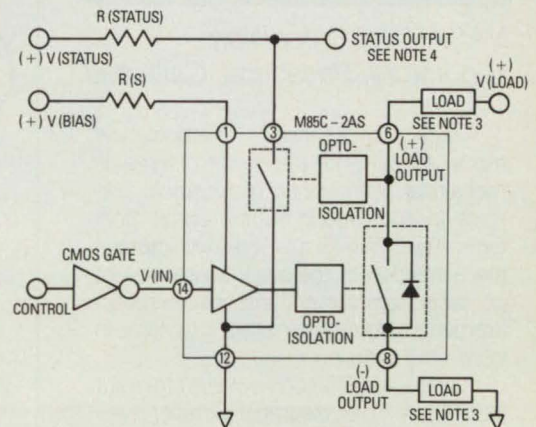


PART #M85C-2AS

ELECTRICAL CHARACTERISTICS (-55°C to +105°C unless otherwise noted)

	Min	Max	Units	
Bias Voltage (V_{BIAS})	3.8	32	V_{DC}	See Note 1
Bias Current (I_{BIAS})		15	mA	$V_{BIAS} = 5V_{DC}$
Control Voltage (V_{IN})	0	18	V_{DC}	
Control Current (I_{IN})		250	μA	$V_{IN} = 5V_{DC}$
Turn-Off Voltage	3.2		V_{DC}	-55°C to +25°C
$V_{IN(OFF)}$	2.8		V_{DC}	+25°C to +105°C
Turn-On Voltage		0.5	V_{DC}	-55°C to +25°C
$V_{IN(ON)}$		0.3	V_{DC}	+25°C to +105°C
Continuous Load Current		2.0	A	-55°C to +25°C
I_{LOAD}		400	mA	+105°C
Output Trip Current (I_{TRIP})	8 (TYP.)		A	+25°C, 100 ms
Continuous Load Voltage (V_{LOAD})		60	V_{DC}	
Output Leakage Current (I_{LEAK})		2	mA	
On-Resistance (R_{ON})		0.28	Ohms	
Turn-On Time (T_{ON})		3.0	ms	
Turn-Off Time (T_{OFF})		1.0	ms	
Status Voltage (V_{STATUS})	1	18	V_{DC}	
Status Current (I_{STATUS})		0.6	mA	See Note 2

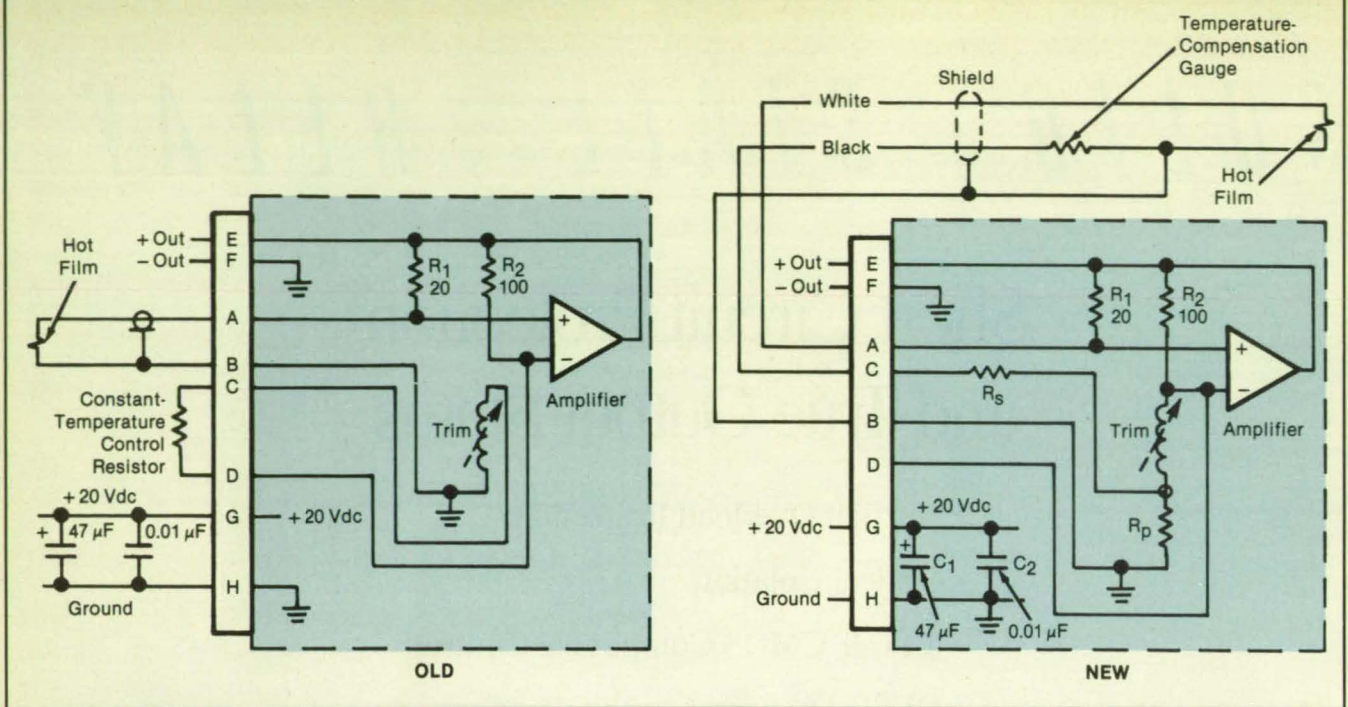
- Notes:
1. Series resistor is required for bias voltages above $6V_{DC}$. $R_S = (V_{BIAS} - 5V_{DC})/15 \text{ mA}$
 2. A pull up resistor is required for the status output. $R_{STATUS} = V_{STATUS}/600 \mu A$
 3. Output will drive loads connected to either terminal (sink or source).
 4. Status output is low when the load output is off.



TELEDYNE SOLID STATE
A Division of Teledyne Relays

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

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



Old and New Anemometers are compared. Modifications in the new version include the addition of the temperature-compensation resistor and resistors R_s and R_p in series and parallel with the compensation device.

ed Hot-Film Anemometer System for Boundary-Layer Transition Detection on High-Performance Aircraft." Copies may be purchased [prepayment required] from the National Technical In-

formation Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. Inquiries concerning rights for the

commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 12]. Refer to ARC-11811.

Formula Gives Better Contact-Resistance Values

Lateral currents in the contact strips are taken into account.

NASA's Jet Propulsion Laboratory, Pasadena, California

A quasi-two-dimensional, mathematical model accounts for the effects of three-dimensional distributions of electrical currents in and around square ohmic contacts. The "Thin-Film" model will improve the extraction of the areal resistivities of contacts from current and voltage measurements of four-terminal test structures in integrated circuits.

In a four-terminal contact-test structure (see Figure 1), an electrical current I is applied through taps on the upper and lower conducting strips, while the voltage V_K across the contact is measured via side taps connected to the conducting strips. Because some of the current flows laterally in the strips around the narrower square contact, the measured contact resistance $R_K = V_K/I$ is larger than the true contact resistance $R_t = \rho/L^2$ (where ρ is the areal contact resistivity and L is the width of the square).

In the Thin-Film model, the upper con-

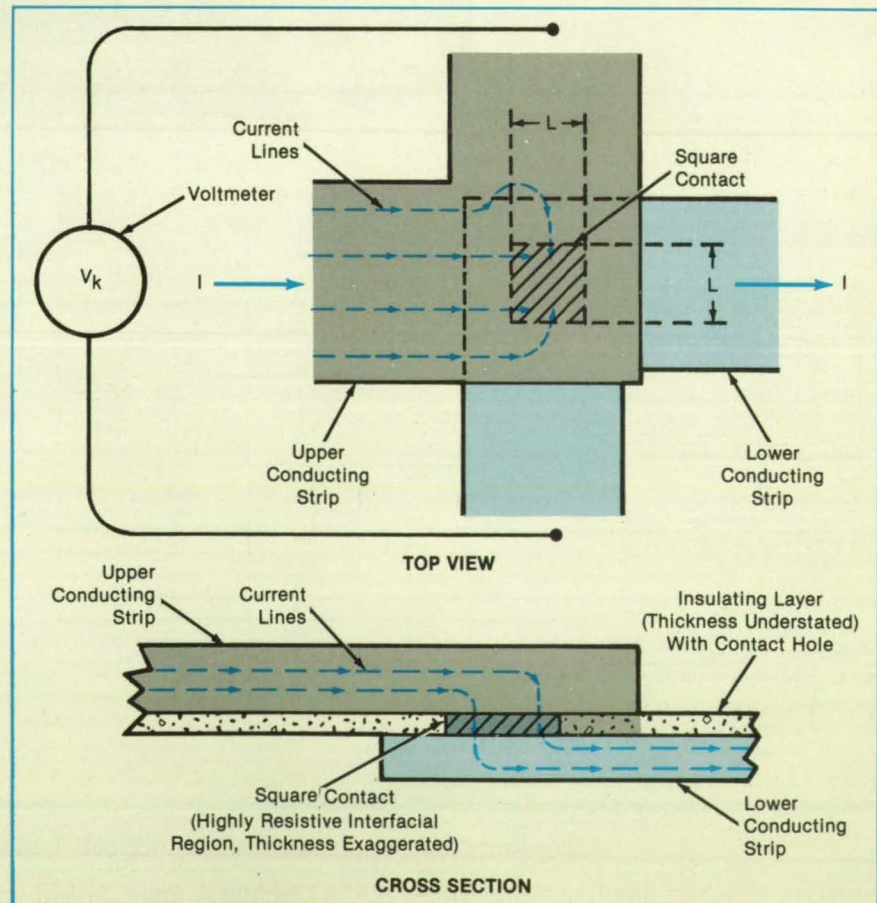


Figure 1. **Four-Terminal Test Structures** like this one are added to integrated circuits to enable the measurement of interfacial resistivities of contacts between thin conducting layers.

The complex world of microprocessor development just got simpler.

As the challenges of developing and debugging embedded microprocessor designs becomes more and more complex, you need the best development tools possible.

And nobody offers you higher reliability, better performance or a quicker way to develop and debug your 8, 16 or 32-bit systems than Applied Microsystems.

Our emulators, for example, can be controlled from the host computer you work with (VAX, Sun, Apollo, IBM PC or compatible). Your target system will run exactly as if its microprocessor were in place. And you'll get a clear picture of your design and how it interfaces with interrupts, clocks and the flow of software.

Our emulators are designed to work with easy-to-use VALIDATE software to give you powerful source level or symbolic debugging capabilities. You also get our powerful Event Monitor System, a hierarchical, real-time breakpoint and triggering system.

The list of benefits goes on and on; but the end result is a faster, easier and more accurate approach to developing, debugging and integrating your design.

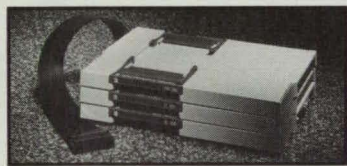
To find out more, write Applied Microsystems Corporation, P.O. Box 97002, Redmond, Washington, USA 98073-9702. Or call (800) 426-3925, in WA call (206) 882-2000.

In Europe contact Applied Microsystems Corporation Ltd., Chiltem Court, High Street, Wendover, Aylesbury, Bucks, HP22 6EP, United Kingdom. Telephone 44(0)-296-625462. AMC-230

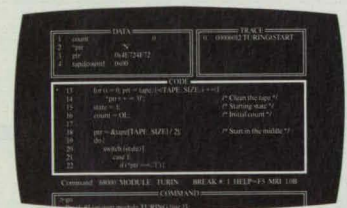


Applied
Microsystems
Corporation

Circle Reader Action No. 612



High-performance 8, 16 and 32-bit emulation.



Software development tools, including source and symbolic level debuggers.



Motorola, Intel, Zilog and Hitachi microprocessor support.

ducting strip (e.g., metal) is treated as an equipotential surface. The lower conducting strip (e.g., doped semiconductor) is treated as two-dimensional. An equipotential core smaller than the contact is considered to be embedded in the lower conducting strip, connected to the upper strip through a lumped resistance of R_i (see Figure 2). The last two features model horizontal current flow under and vertical current flow in the actual contact; i.e., a thin but highly resistive layer between the conducting strips (Figure 1).*

The current is introduced to the lower conductor at the left, far from the contact (Figure 2). While the current through the back edge of the contact is neglected, the currents through the front and side edges are analyzed by dividing the structure into three regions. No current is allowed to flow between regions. Current is considered to be injected into those regions through long feeding strips and, therefore, to be distributed according to the width of each strip.

The resulting potential distribution in the side region with the voltage tap is found by conformal mapping. The potential at the end of this tap, referred to the core zone, is $V_S = R_S I$, where R_S is given as a function of contact size L , width and sheet resistance of the lower strip, and the areal resistivity ρ itself.* From Figure 2 follows

$$R_K = R_S + R_i$$

and, hence,

$$\rho = L^2 (R_K - R_S)$$

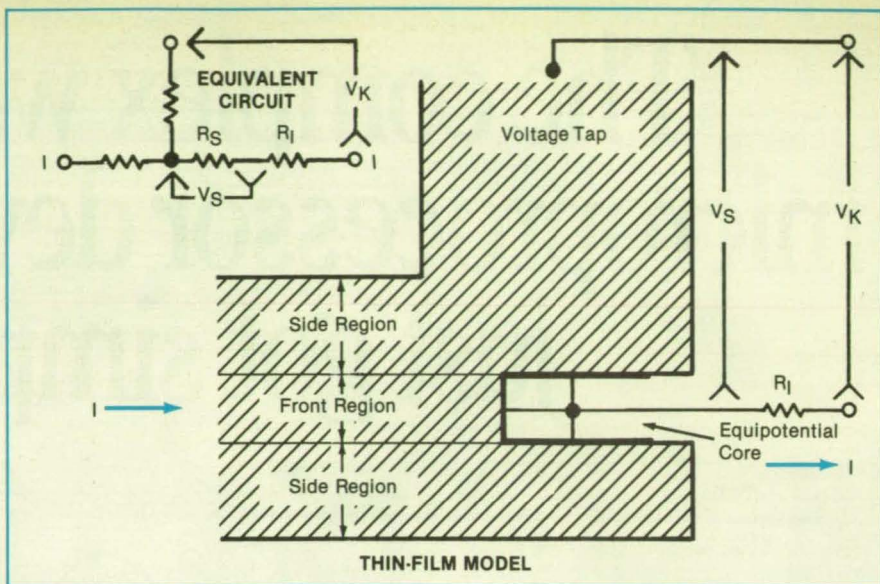


Figure 2. The **Thin-Film Model** is a simplified quasi-two-dimensional potential model that accounts adequately for the complicated three-dimensional, nonuniform current densities in the test structure of Figure 1. The effects of nonuniformity caused by lateral current flow in the strips are summarized in the equivalent resistance R_S and voltage V_S .

This equation must be solved iteratively. However, the solution converges rapidly; a FORTRAN program on a VAX (or equivalent) computer requires only about 0.3 s of central-processor time.

The model has been used to analyze square contacts of AuGeNi/GaAs. The areal resistivities of the contacts were found to be 2 to 8 times lower than extracted previously (without subtraction of R_S) and independent of contact size in the

range of 1.5 to 10 μm .

*U. Lieneweg and D. J. Hannaman, "New Flange Correction Formula Applied to Interfacial Resistance Measurements of Ohmic Contacts to GaAs," IEEE Electron Device Letters, in print.

This work was done by Udo Lieneweg and David J. Hannaman of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 135 on the TSP Request Card. NPO-17096

Flexible Ceramic-Insulated Cable

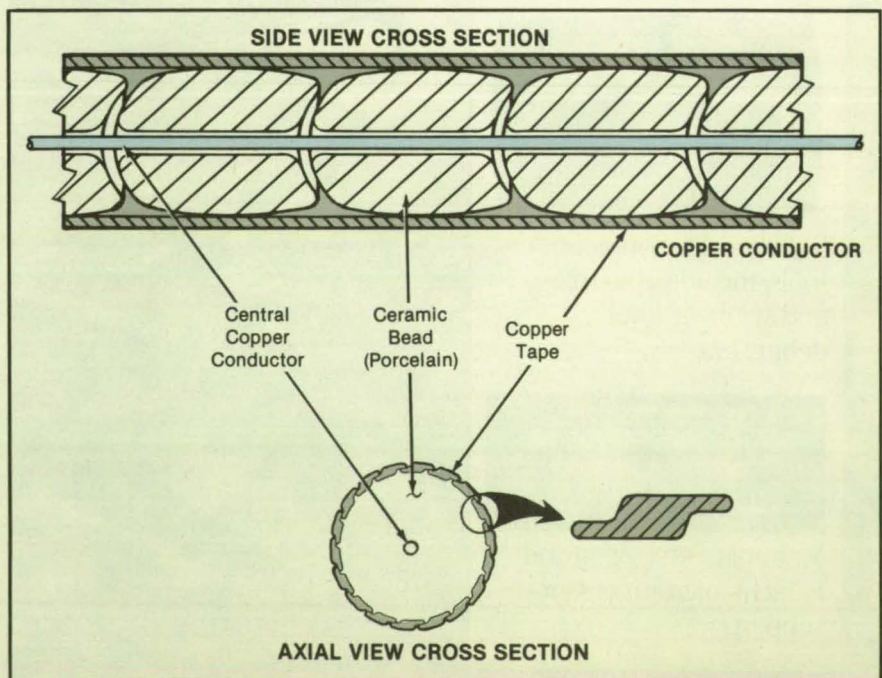
The cable withstands heat, radiation, and oxidation.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed ceramic-insulated cable would be flexible, would protect its metal conductor from ionizing radiation, and would resist high temperatures. Developed for use in outer space, the cable is also suitable for furnaces, nuclear reactors, and robots operating in hot, radioactive environments — in dismantling aging nuclear power plants, for example.

The cable would include a central conductor of copper surrounded by ceramic beads shaped so that their ends slide on each other, thus allowing the cable to flex (see figure). Two layers of copper tapes would be wrapped diagonally around the beads to absorb or deflect ions, electrons, protons, and electromagnetic radiation. An indium tin oxide coating on the surface of the outer tape would protect against oxidants.

To ensure reliable service at temperatures up to 800 °C, copper was selected as the conductor rather than aluminum because the former has a higher melting point. The insulating beads would be made of a porcelain that offers high dielectric



Ceramic Beads would electrically insulate a copper conductor from a sheath of copper tape.

strength, high electrical volume resistivity, and low dielectric loss factor.

The beads would be fabricated by casting. The central hole for the copper conductor could be drilled by a laser beam. The ends of the beads would be finished by grinding and polishing to provide smooth sliding surfaces for adjacent beads. The ends of the central holes would be rounded so that the conductor could flex easily in the beads. Lubricants, which would deteriorate in a hot, radiation-filled environment, would not be used. All the beads along a cable would be identical except for those at the ends of the cable, which would be slotted to hold the ends of the tapes.

Each tape would be wrapped at an

angle of 30° to 45° with a small amount of slack to prevent binding. To prevent the formation of gaps during flexing, each tape would overlap each adjacent tape by about one-eighth inch (3 mm).

For service at higher temperatures, the tapes could be made of tantalum instead of copper. In addition, for added tensile strength, a wire of metal that does not soften as much as copper does in the range of operating temperatures could be twined around the copper core or around the ceramic beads.

This work was done by Frank L. Bouquet of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 113 on the TSP Request Card. NPO-16917

Acoustical Convective Cooling or Heating

A small, efficient ultrasonic device circulates a fluid.

NASA's Jet Propulsion Laboratory, Pasadena, California

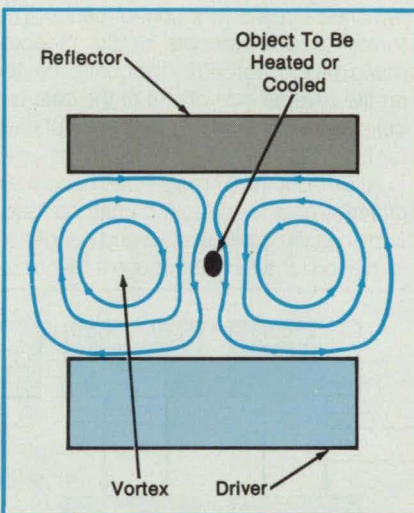
A device provides convective cooling or heating by acoustical streaming. It produces vortices in a small volume in which a liquid or gas flows at speeds up to about 50 meters per second. It employs no fans or rotors. Conceived to generate convection for heating or cooling electronic equipment in zero gravity, where there is no natural convection, the device can also be used on Earth to apply localized or concentrated cooling to individual electronic components or other small parts.

With suitable design, the device can direct convection in a small, localized volume and can control the rate of cooling or heating. It therefore can be used to cool particularly hot components on a circuit board, for example. A fan, in contrast, circulates air uniformly over the board rather than where the most heat is generated. Also, unlike a fan, the acoustical cooling device consumes only a fraction of a watt of power.

In containerless processing of materials by acoustic levitation, the convector can augment cooling or heating of freely suspended samples when natural convection is insufficient. Fans or pumps cannot be used in such processes because they would interfere with levitation.

The device consists of a piezoelectric driver and a reflector. Vibrating at ultrasonic frequencies, the driver creates a pair of counterrotating vortices in the space between it and the reflector (see figure). An object in this space is cooled by the flow if heat is removed from either the driver or reflector (or heated if heat is supplied to the driver or reflector).

The frequency of the driver can be chosen at a value between 10 and 500 kHz to adjust the diameter of the vortices to a value between 10 cm and 0.5 mm. At 40 kHz, for example, the distance between the driver and the reflector is 1.2 cm, about



Vibrating at an Ultrasonic Frequency, a piezoelectric driver sets up vortices that transfer heat to or from an object in the space, depending on whether the reflector is heated or cooled.

three-fourths the wavelength of the sound in air at room temperature.

In a demonstration, the temperature of a thermistor measured at various voltages was substantially lower when acoustical cooling was applied. At 10 V, for example, the thermistor operated at about 260 °C when the sound was off and 150 °C with the sound on. At higher voltages, the effect was even more pronounced.

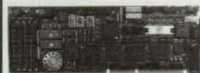
This work was done by Eugene H. Trinh and Judith L. Robey of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 90 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 12]. Refer to NPO-17278.

SINGLE SLOT /AT COMPUTERS

ONE BOARD CAN DO IT ALL!

SCSI or ST-506
& FLOPPY INTERFACES
EGA-CGA VIDEO



CAT901

A true 12 MHz, 0 wait state single board computer with ST-506 hard drive interface, dual floppy controller. Dynamic clock speed change, up to 4 meg RAM, 64K PROM, 1 parallel and 2 serial ports, keyboard port, and a speaker. Optional 80287 and EGA.



CAT902

A 10 MHz, 1 wait state single board computer with SCSI hard disk interface, dual floppy controller, 640K RAM, 2 serial, 1 parallel, keyboard, speaker and reset ports. CGA. Optional EGA and 80287.



CAT903

A true 12 MHz, 0 wait state single board computer with ST506 hard drive interface, on-board EGA, downward compatible video, dual floppy, dynamic clock speed change, up to 4 meg RAM, 64K PROM, 1 parallel, 2 serial, keyboard and speaker ports.



CAT904

A true 12 MHz, 0 wait state single board computer with SCSI hard drive interface, on-board EGA, downward compatible video, dual floppy, dynamic clock speed change, up to 4 meg RAM, 64K PROM, 1 parallel, 2 serial, keyboard and speaker ports.

NEW SYSTEMS

CRM-710

A hardened 19" NEMA rack mount enclosure, 7" of vertical space with 150w p.s. and the space to add a second 150w supply, 3.5" or 5.25" drive capacity. Any CAT900 series slot board computers can power the system.



PACKAGING SUPPORT

4, 6, 10, and 14 Position Card Cages, Backplanes • Industrial & Rack Mount Chassis • Fans • Plug-In Power Supplies • Low Profile Enclosures • Small Footprint Enclosures

Diversified Technology

1-800-443-2667

RIDGELAND, MS 39158

601-856-4121

Circle Reader Action No. 629



Electronic Systems

Hardware Techniques, and Processes

- 32 Programmable Data Formatter
- 33 Fast Synchronization With Burst-Mode Digital Signals
- 34 Adaptive Receiver for Coded Communications

Books and Reports

- 36 Simulating Instrument Helicopter Takeoffs and Landings
- 36 Synchronous Versus Asynchronous Flight Control

- 37 Fault-Tolerant Software for Flight Control
- 38 GPS Satellite Multipath Range Errors

Programmable Data Formatter

A system adapts data in diverse formats for transmission.

Goddard Space Flight Center, Greenbelt, Maryland

A programmable formatting system assembles digital data signals in various formats into standard blocks for transmission over switched telecommunications circuits. With the system, diverse data systems can be connected over long distances by space- or land-based relay stations.

The formatter can be programmed to handle any data block or package format in lengths up to 65,000 bits. Any type of information can be transferred, either on separate lines or on multiplexed lines. The formatter can be tailored to the requirements imposed by users upon both equipment and computer programs. The formatter

can be used to simulate, test, and control data networks.

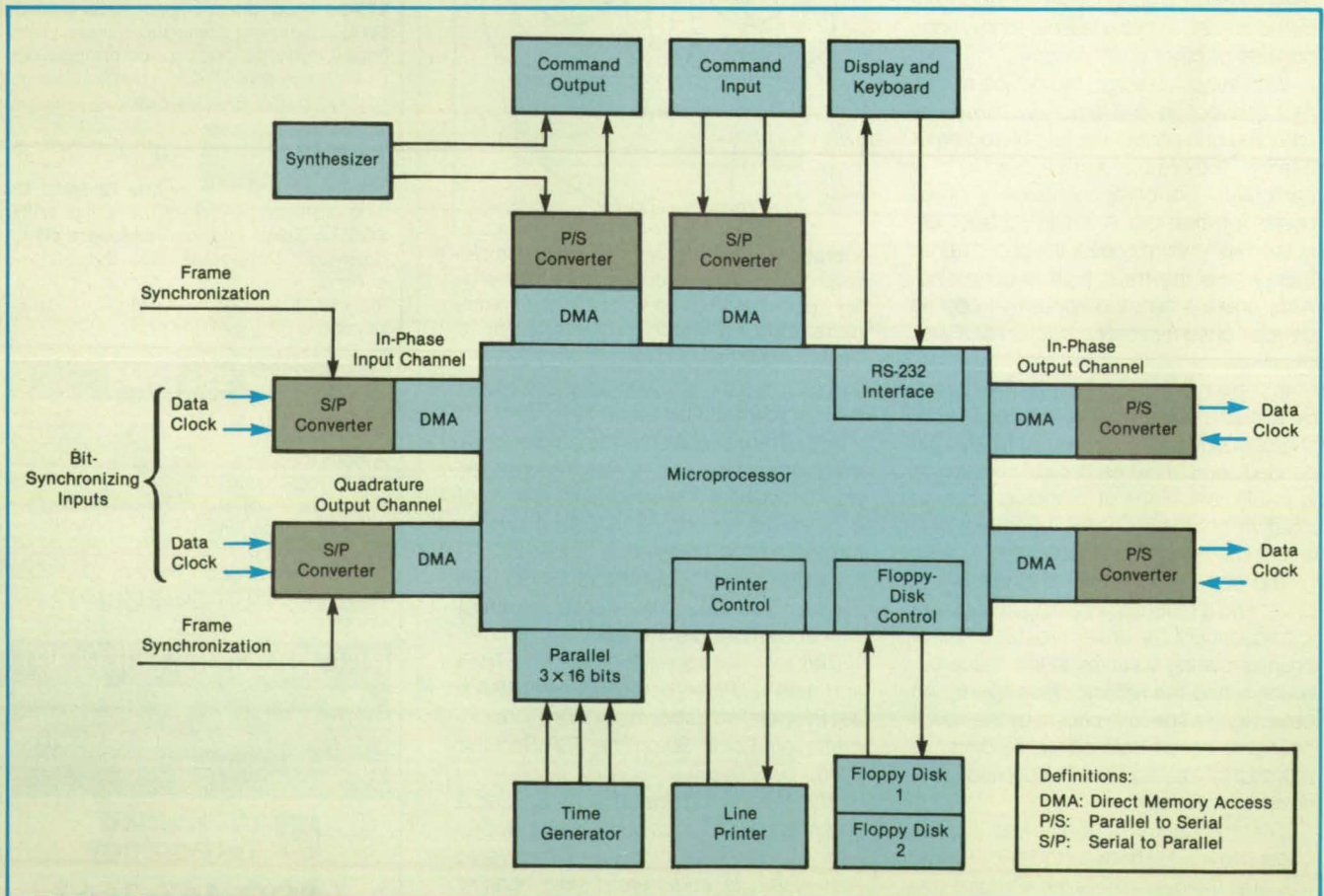
In its present form, the formatter assembles data streams from two sources into blocks and forwards them over two switched circuits to a control center. The formatter also accepts blocks of command data forwarded by the control center on the reverse side of one of the data circuits for transmission to the data sources.

At present the formatter can handle six different data formats. A human operator furnishes the configuration and header information for a format through a menu dis-

play. For each of a total of five formats, this information can be stored in an overlay file on a disk and recalled when desired, and the formatter automatically loads the correct program overlay.

The formatter has been tested in dual-channel operation at data rates from 9.6 through 224 kb/s. Preliminary testing has been done at a data rate of more than 1 Mb/s on one channel. Eventually, the formatter may be able to handle at least two 1.5-Mb/s channels simultaneously.

The formatter was developed as a replacement for a multiplicity of small data-blocking systems. These microprocessor-



A Microprocessor Controls the Complex Activities of data formatting, error checking, and transmission-priority arbitration. The shaded blocks are specially designed interfaces; other blocks represent standard commercial products. The system was developed for formatting signals from and to telemetry units on spacecraft for a widespread telecommunication network.

based systems stored their formatting programs in read-only memories. Program changes were therefore time consuming and difficult; it was impossible to handle many different data formats and data rates. Moreover, each system could format data at a maximum rate of only 250 kb/s.

The controller of the new formatting system is a microprocessor with a video display, memory, and interface circuitry (see figure). The operator loads the system software on 8-inch (20.3-centimeter) floppy disks. A line printer logs and prints out the command data, which can also be recorded on a floppy disk. A timing generator provides time tags for the data blocks and the commands.

Direct-memory-access units control the input and output channels, arbitrating priorities for data transfer. The data-input

channels are driven by serial-bit synchronizers or parallel-bit (frame) synchronizers — the choice is made by software through custom-made interface circuits equipped with internal buffers (first-in/first-out memories). The input data are placed in reserved buffers in memory with header information. When a data buffer is full, its contents are presented to the output channels.

The command-input channel accepts formatted blocks, storing a complete block in a reserved command buffer. After a command block has been checked, it is forwarded to the data source.

This work was done by Robert E. Martin of Goddard Space Flight Center. For further information, Circle 28 on the TSP Request Card. GSC-13104

Fast Synchronization With Burst-Mode Digital Signals

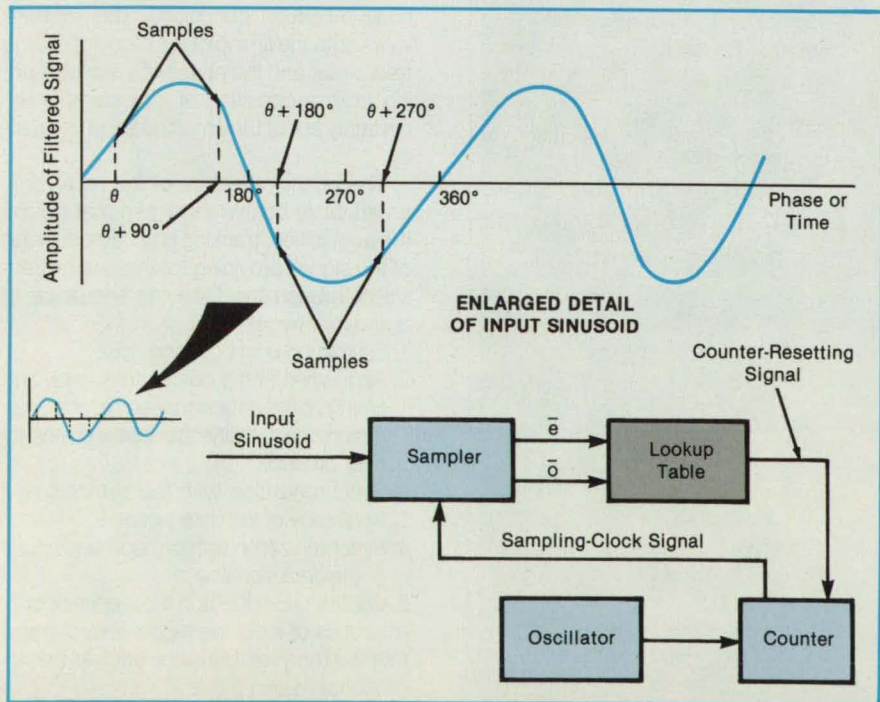
An oscillator is quickly synchronized with the data clock.

NASA's Jet Propulsion Laboratory, Pasadena, California

A clock-signal-extracting system reduces the time required by a receiver in a burst-mode digital communication system to synchronize its data-sampling oscillator with the digital signal to be sampled. By reducing the number of bit periods required for synchronization, the system reduces the required length of the preamble at the beginning of each burst of transmission, thereby increasing the amount of time available for the transmission of information during the burst. The system is

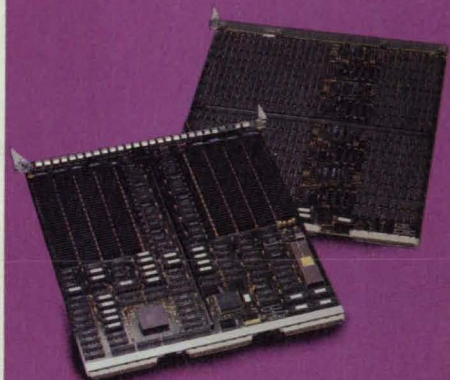
compatible with most modulation techniques used for digital transmissions, and because it consists mostly of digital components, it reduces the complexity of the receiver.

The receiver includes circuits that sample the modulation of the received signal. For correct sampling and to minimize the bit-error rate, the sampling clock must be brought quickly into synchronism with the beginnings of the symbol periods; in effect, the system must extract the data-clock



The **Sampling Clock Is Synchronized** with a sinusoid by a feedback technique. The feedback signal is a measure of the phase-error angle θ and is generated digitally by a technique related to the calculation of θ from periodic samples of the sinusoid.

Only One Vendor
Delivers All Your
SUN
Workstation
Memory Needs



Clearpoint!

Sun 3/2XX and 4/2XX-Compatible

The SNX2RAM/32 MB, delivering the Sun 3/2XX system maximum on a single board, also offers the enhanced functionality of a microprocessor-managed "on-board hotline" for local and remote diagnostics.

Sun 3/1XX-Compatible

The SNXRAM* fits up to 28 MB in just one slot, freeing four slots for peripherals. Using the latest one megabit DRAMs, you get the highest density plus increased reliability.

Sun 3/60-Compatible

The SNX60 comes in 4 MB SIMM sets that upgrade your Sun 3/60 to an expansive 24 MB maximum. Each SIMM is one MB of memory with a megabit DRAM to support parity checking.

Registered Trademarks—Clearpoint: Clearpoint Research Corp.; Sun: Sun Microsystems, Inc.

Call for our Product Catalog and Designer's Guide to Add-in Memory.



CLEARPOINT

99 South Street
Hopkinton, MA 01748-2204
1-800-CLEARPT (617) 435-2000
Clearpoint Europe b.v. Tel: 31-23-273744
Clearpoint Canada 416-620-7242
Clearpoint Asia 03-221-9726

signal from the data signal.

The digital sequence "0101..." is contained in the preamble of each burst. The input signal is passed through a channel filter to remove noise; this filter has such a narrow passband that it strongly attenuates the harmonics of the 0101... square-wave modulation, so that its output is almost a pure sinusoid with a frequency equal to half the symbol rate.

The sampling clock causes the sinusoid to be sampled at intervals of approximately one-fourth the sinusoidal period (see figure). If the time of the sampling signal differs from the zero crossing of the sinusoid by a phase angle θ with respect to the sinusoid, then the samples have the values $\sin \theta$, $\cos \theta$, $-\sin \theta$, and $-\cos \theta$, respec-

tively. In principle, θ can be calculated by taking the arc tangent of the sine and cosine samples and the result used to generate a control signal to adjust the oscillator to the correct timing.

The system functions according to a variation of this principle. To make the phase of the sampling clock digitally controllable, the clock includes an analog voltage-controlled oscillator that runs at a higher frequency, and the sampling signal is obtained by dividing the frequency in a resettable digital counter. Initially, the clock runs freely at its nominal frequency. The even-numbered samples e_j are collected in one group, and the odd-numbered samples o_j are collected in another group.

When n samples in each group have

been accumulated, the system computes the averages

$$\bar{e} = \frac{1}{n} \sum_{j=1}^n |e_j| \text{ and } \bar{o} = \frac{1}{n} \sum_{j=1}^n |o_j|$$

The values of \bar{e} and \bar{o} are quantized, then fed as address inputs to a read-only memory "lookup" table that contains digital oscillator-phase-correction values for every possible combination of \bar{e} and \bar{o} . The correction value is sent to the frequency-dividing counter, causing it to reset to the proper phase. Once synchronization is acquired, the digital decision feedback loop of the receiver takes over the responsibility of maintaining the correct sample timing.

This work was done by Lin-nan Lee, Ajit Shenoy, and Michael Kitming Eng of Comsat Laboratories for NASA's Jet Propulsion Laboratory. For further information, Circle 48 on the TSP Request Card. NPO-16925

We Don't Ruggedize Our Optical Disk Drives.

We don't have to. Our drives are *designed and built rugged from the start.*



A ruggedized product is just not the same as a product that is designed and manufactured as a rugged product. Ruggedized optical disk drives are ordinary drives that have been repackaged for use in harsh environments. Cherokee doesn't buy somebody else's commercial optical drive and then put it in a rugged package. Instead, Cherokee manufactures complete, rugged optical disk drives from the ground up.

The Tracker Series drives are specifically designed, manufactured and tested for applications in rugged environments, so you know that each and every component is up to the task. Tracker Drives are the only truly rugged optical disk drives available. Call today for detailed specifications and information.

Tracker Features

- Rugged Base Plate Construction
- Low EMI Emissions
- High Performance Optical Head
- Shock and Vibration Levels Suitable for Avionics
- No Altitude Restrictions
- Lowest Power Consumption
- Positive Air Flow System
- High Reliability Components
- Internal Temperature Compensation



Cherokee Data Systems, Inc.
1880 S. Flatiron Ct.
Complex H
Boulder, Colorado 80301
(303) 449-8850
FAX: (303) 449-8859

Adaptive Receiver for Coded Communications

Acquisition and tracking of the signal are controlled automatically.

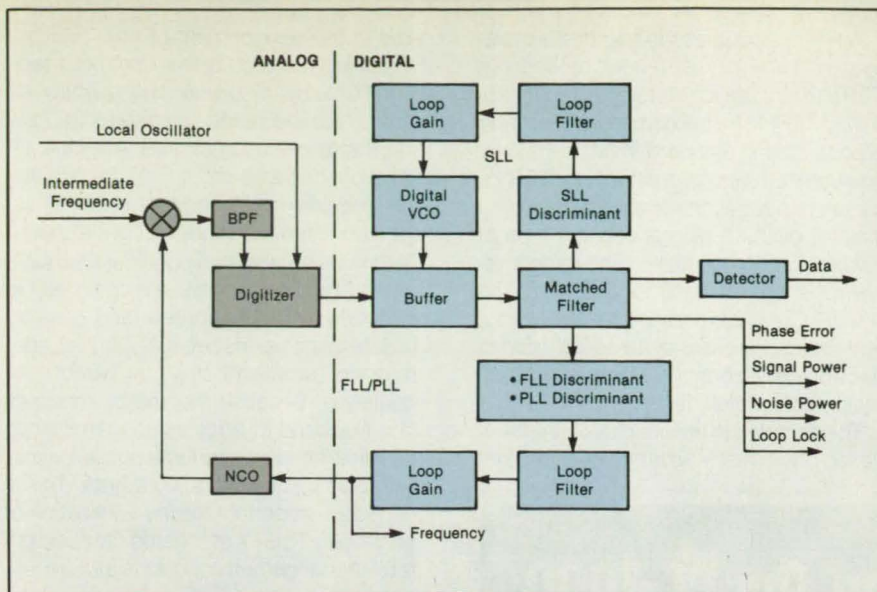
*Ames Research Center,
Moffett Field, California*

A radio receiver operating under automatic control processes Manchester-coded binary-phase-shift-keying signals under difficult reception conditions. The receiver locks onto the timing of the modulation, the frequency, and the phase of a signal, starting from a condition of considerable uncertainty about the amplitude and frequency.

The principal feature of the receiver is an adaptive control algorithm that guides the acquisition, tracking and demodulation of the signal, providing for the orderly transition through the following sequence of operating modes:

1. Estimation of out-of-band noise;
 2. Acquisition of the coarse frequency and timing of the data signal employing a sequential probability-ratio test and a hand-over process;
 3. Synchronization with the symbols and frequency of the data signal;
 4. Synchronization with symbols and phase of the data signal; and
 5. Confirmation of lock in the feedback loop.
- After loss of lock, the mode control transfers the receiver operation back to the appropriate restart mode.

The acquisition of the signal begins with a sequential probability-ratio-test (SPRT) search of the frequency-uncertainty band.



The Receiver is Constructed in Analog and Digital Portions so that signal-processing functions that would otherwise be unwieldy can be performed economically by digital micro-processors.

This is done by sweeping the band with a 4-point discrete-Fourier-transform (DFT) filter bank. Each filter is matched to the 512-Hz Manchester symbol rate, which is twice the coded-symbol rate $1/T = 256$ Hz, so that the bandwidth covered by the filter bank is 1,536 Hz.

Two filter sets separated in time by an offset of $T/2$ are formed at the Manchester symbol rate. At each dwell, the DFT filter outputs are accumulated and compared with SPRT thresholds until it is decided that the signal is or is not present. After the signal is detected, the residual 1536-Hz frequency uncertainty is too large to permit the frequency-lock loop (FLL) to start. Consequently, a handover procedure is initiated to narrow the uncertainty band to 512 Hz.

In handover, multiple DFT filters are formed to cover the uncertainty regions of frequency and time. Outputs are accumulated, and the filter with the largest sum is chosen. The chosen filter center frequency and time offset are accepted as estimates of the signal frequency and timing if, in addition, the sum passes a Neyman-Pearson false-alarm-threshold test.

Following handover, the FLL and symbol-lock loop (SLL) are initiated. The FLL tracks the frequency and enables the performance of a least-squares estimate of the frequency and the rate of change of frequency. These estimates are calculated at the end of the FLL operation and are used to start the phase-lock loop (PLL).

The SLL tracks the symbol timing. When the PLL is turned on, its bandwidth is opened wide to improve acquisition and gradually narrowed to its operating value under the control of the PLL lock-detector statistic. After lock is confirmed by the other lock detectors, the demodulator output data are considered to be valid, and

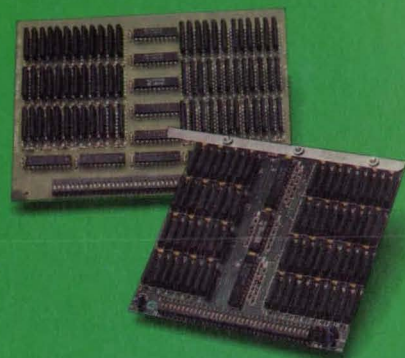
telemetry data are measured.

Preferably, the receiver is constructed as a hybrid analog/digital system (see figure). This partitioning enables the computation-intensive operations to be performed by programmable digital micro-processors. After being heterodyned to the intermediate frequency, the input signal is mixed with the output of the numerically controlled oscillator (NCO), limited in bandwidth by a bandpass filter (BPF), and synchronously translated to baseband where it is digitized with 8-bit resolution. The resulting in-phase and quadrature digital data streams are processed to form the set of 4-point (DFT) filters at the Manchester symbol rate. DFT outputs are used to form the tracking-loop discriminants, the lock detectors, and the symbol-detection filter that provides the soft-decision demodulator output.

The FLL, PLL, and SLL operate at the symbol rate. FLL and PLL outputs drive the NCO, and the SLL output drives the digital voltage-controlled oscillator (VCO). This VCO is a digital integrator, the output of which is a pointer that selects the starting time for the DFT matched filters. Since the SLL resides in the processor, the digitizer operates at 4 times the Nyquist rate of 2 kHz for the DFT filters. This enables the SLL to select the DFT timing at time increments of $T/32$. Every $T/2$ seconds, the DFT filters are formed, and at T -second intervals, the receiver state is updated. To improve the performance, the loop bandwidths for the FLL, SLL, and PLL are opened wider at turn-on and then reduced with time.

This work was done by U. A. von der Embse of Hughes Aircraft Co. for Ames Research Center. For further information, Circle 27 on the TSP Request Card. ARC-11815

Only One Vendor Delivers All Your APOLLO Workstation Memory Needs



Clearpoint!

APOLLO

DN 4000-Compatible

Bring your DN 4000 up to its 32 MB capacity with the DNX4RAM. Available in 4 and 8 MB boards, Clearpoint's cost-effective memory provides Apollo-equivalent performance, and adds Clearpoint's unconditional lifetime warranty and 24-hour-a-day product support.

DN 3000-Compatible

The economical 1 or 2 MB DNXRAM memory offers Clearpoint's quality engineering and manufacturing with performance identical to Apollo. With an access time of 120 ns, the DNXRAM supports the the DN 3000's 32-bit data bus with byte, longword and unaligned transfers.

Registered Trademarks—Clearpoint: Clearpoint Research Corp.; Apollo: Apollo Computer.

Call for our Product
Catalog and
Designer's Guide to
Add-in Memory.



CLEARPOINT

99 South Street
Hopkinton, MA 01748-2204
1-800-CLEARPT (617) 435-2000
Clearpoint Europe b.v. Tel: 31-23-273744
Clearpoint Canada 416-620-7242
Clearpoint Asia 03-221-9726

Circle Reader Action No. 620 35

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.

Simulating Instrument Helicopter Takeoffs and Landings

Advantages and disadvantages of computer-based simulations are reviewed.

A report evaluates the merits of simulations of terminal instrument procedures (TERP's) for helicopters. Currently approved TERP's for helicopters apply only to airports having standard instrument landing system (ILS) equipment. New TERP's are needed for such nonstandard landing sites as offshore oil rigs and the tops of buildings and mountains. The report reviews current methods for the evaluation of TERP's. It discusses the feasibility, benefits, and liabilities of the substitution of electronically controlled flight-simulation equipment for flight tests.

The study led to the conclusion that simulation offers many advantages over flight

tests in the development of new TERP's. Simulation provides better control of test conditions, better quality and quantity of data, increased safety, and greater flexibility in the modification of tests. After the initial expenditure for equipment, the simulation also offers reduced test costs — as low as one-tenth the cost of flight testing.

Simulation also has potential disadvantages. The use of a simulator could lead to erroneous or unwarranted (and possibly unsafe) conclusions because the simulator may not represent the real world adequately or because it could be misused. The likelihood of error can be diminished by following extensive tests on a simulator with a limited series of flight tests. This is especially important for the verification of enhanced TERP's standards for such potentially dangerous conditions as zero visibility.

The report recommends that flight simulators be used to duplicate previous helicopter flight tests to verify that simulation produces accurate data. Such simulations would also provide a comparison between simple fixed-base and elaborate moving-base simulators. The report also recommends that mathematical models be developed for low-speed helicopter dynamics, nonconventional navigation sources and guidance avionics, data bases for computer-generated imagery, and wind.

This work was done by Anil V. Phatak and John A. Sorensen of Ames Research Center. Further information may be found in NASA CR-177408 [N86-28931/NSP], "Evaluation of the Usefulness of Various Simulation Technology Options for TERP's Enhancement."

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

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 12]. Refer to ARC-11813.

Synchronous Versus Asynchronous Flight Control

Both types of digital systems have been evaluated in flight and on the ground.

A report compares synchronous and asynchronous digital flight-control systems. It evaluates four different systems by such criteria as software reliability, cost increases, and schedule delays.

Flight-control systems have undergone a revolution since the days of simple mechanical linkages. Today, the most ad-

Pick your application. Our PC-1000 will supply the control



Investigate passive damping and active control of sophisticated applications with our PC-1000 real-time data acquisition and control processor.

Ideal for Vibration Control Experiments

The PC-1000 is ideal for vibration control of large space structures, aircraft flight control simulation and dynamic testing. You'll cut vibration control test and evaluation time from weeks to hours - enabling

your vibration control research to move to practice more rapidly.

Real-time Measurement and Control

Providing 32 analog measurements, 32 control channels, a 64 state model and a 9.2 MFLOP 32-bit brain, the PC-1000 offers outstanding closed-loop performance on all channels simultaneously.

For an active approach to your vibration control applications, call or write today.



SYSTOLIC SYSTEMS
INCORPORATED

2240 N. First St., San Jose, CA 95131
(408) 435-1760

Outside California Call:
1-800-621-0854 Ext. 123

vanced systems are full-authority, full-time digital systems controlling unstable aircraft. With such systems, an aircraft can incorporate aerodynamic features that boost performance and save fuel. The digital control provides the stability and handling characteristics that ensure safe flight.

A key question, however, is whether a multichannel digital control system should be synchronous or asynchronous. Each channel in a synchronous system operates at the same point in the software cycle at any given time. Each channel in an asynchronous system may be operating at any point in its software cycle; data are passed when available, and the other channels receive the data when they are ready. Synchronous systems are said to be more reliable and to yield lower design and testing costs. Asynchronous systems are reported to provide greater protection against lightning, electromagnetic interference, and battle damage.

The report covers the following systems, which range from simple to highly complex:

- A digital fly-by-wire (DFBW) system for the F-8 aircraft;
- An asynchronous resident backup software (REBUS) system;
- A combined synchronous/asynchronous system for highly-maneuverable-aircraft-technology (HiMAT) vehicles; and
- An asynchronous advanced-fighter-technology-integration (AFTI) system for the F-16 aircraft.

The AFTI/F-16 system is complex in its control laws and management of redundancy. Its asynchronous operation and multimode control structure resulted in a series of anomalies in both flight and ground testing. The HiMAT system, also complex, was tested in an integrated environment that closely simulated the flight environment, thus allowing the early detection of potential problems so that anomalies could be minimized. The REBUS system has a simple control structure and limits the data cross-link to avoid problems ordinarily associated with asynchronous operation. The F-8 DFBW system, while not extremely complex, nevertheless was complicated enough to show that for some situations, a synchronous system may be better for complex systems. The F-8 DFBW system avoided problems that could have occurred and yielded a highly-successful, relatively trouble-free test.

Asynchronous or synchronous operation was not in itself a determining factor in the number of anomalies and difficulties in testing. However, the complexity of a system can cause major effects in terms of anomalies. A simple asynchronous system without a complicated data-cross-link structure may be easier to develop than is a synchronous system of the same size. A system designed as an integrated system, including all interactions and interfaces, is likely to encounter fewer difficulties in test-

ing and operation.

This work was done by Victoria A. Regenie, Claude V. Chacon, and Wilton P. Lock of Ames Research Center. Further information may be found in NASA TM-88271 [N86-29866/NSP], "Experience With Synchronous and Asynchronous Digital Control Systems."

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

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 12]. Refer to ARC-11799.

Fault-Tolerant Software for Flight Control

A redundant system performed well in flight tests.

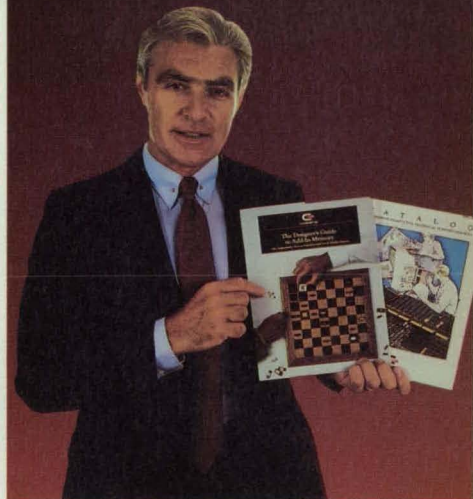
A report discusses the design and testing of a redundant control system for the F-8 digital fly-by-wire airplane. The outstanding feature of the system is the fault-tolerant software [resident backup software (REBUS)] that resides in the primary digital computers. The transition to operation on backup software is smooth.

The basic F-8 airplane control system that was modified for operation with REBUS is a fail-operate, fail-safe digital fly-by-wire system with a frame-synchronized triplex digital primary system and a triplex analog-computer bypass system as backup. Commands for the control surfaces are passed through analog midvalue voting circuits, which can declare any one of the digital outputs to have failed. The analog backup is a direct electrical link between the pilot's stick and the servo-drive electronics, and its outputs are passed through the same midvalue voting circuits as those used by the primary system.

The REBUS software provides an augmented control law with three-axis, fixed-gain rate damping. Many of the self-check functions of the primary software are eliminated to reduce complexity. Overall, the REBUS software requires less than one-tenth the memory required by the primary software.

The system automatically transfers to the backup mode when there are failure declarations in two of the three primary channels. On the assumption that a generic software error may degrade the record of the state of the aircraft in the memories of the primary computers, the REBUS software is initialized to the control-surface commands at the moment of transfer: this generates no transients other than the small ones that result from the reinitialization of any active filters and changes in loop gains from state-dependent to fixed

FREE, the Expanded Designer's Guide from



Clearpoint!

Write or call for the 1988 Upgraded Version of the authoritative text on memory. An invaluable reference for buyers with a need to know, the Designer's Guide includes in-depth reviews of buses, systems and management-level concerns of price, performance and reliability. The expanded 1988 edition includes a survey of major systems: IBM - from the 9370 to the PS/2, the HP 9000 line, the Sun 4/2XX and the Apollo DN4000 Series workstations.

Get the New Catalog of Products & Services, too.

A comprehensive technical brochure, the catalog presents the full spectrum of Clearpoint products, Quality Assurance procedures, customer support and product specifications.

Registered Trademarks—Clearpoint: Clearpoint Research Corp. IBM, PS/2: International Business Machine Corp.; HP9000: Hewlett-Packard Corp.; Sun: Sun Microsystems, Inc.; Apollo DN4000: Apollo Computer.

Call Now for Your Free Copies!
1-800-CLEARPT

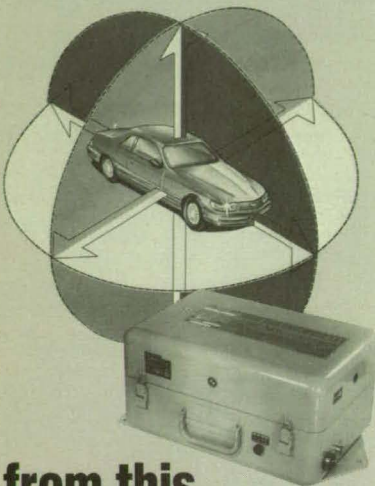


CLEARPOINT

99 South Street
Hopkinton, MA 01748-2204
1-800-CLEARPT (617) 435-2000

Clearpoint Europe b.v. Tel: 31-23-273744
Clearpoint Canada 416-620-7242
Clearpoint Asia 03-221-9726

NOW! All Dynamic Measurements



from this ONE Box

A complete, gyro-stabilized dynamic test system in one environmentally-sealed box that can be bolted to any vehicle frame or installed in almost any remote location. It gives you the most comprehensive dynamic measurements possible on all types of land, water, or airborne vehicles.

It provides acceleration and direction measurements referenced to vertical and horizontal planes. Has outputs for 3-axis position, 3-axis acceleration, and 3-axis angular rate measurements. Gyros are electronically caged and uncaged. 12V DC or 28V DC systems available.

Write for full details and costs:
Humphrey, Inc., 9212 Balboa Ave.,
San Diego, California 92123
Dept.NTB 880
Telephone (619) 565-6631

FREE BROCHURE



Humphrey Inc.
SAN DIEGO • WICHITA
WORLDWIDE REPRESENTATION

values.

To reduce complexity further, REBUS was established as an asynchronous system. Therefore, unlike the primary system, the backup system does not support the exchange of data among computers. Each computer operates on independent, dedicated sensors. Because of this inter-channel independence, one important issue in testing is the variations among channels.

The REBUS system was tested in an F-8 simulator on the ground and in an F-8 airplane in flight, using simulated software errors. The channels tracked each other closely. The transfer transients were negligible, even during high-transverse-acceleration (high-g) maneuvers. In most cases, the transfer to REBUS could not be detected in the control-surface measurements. There were no unwanted transfers. The success of the F-8 REBUS flight tests, coupled with the incorporation of similar backup-software approaches in other advanced aircraft, is evidence that the underlying control concept will find industry-wide acceptance as a viable solution to the generic software-error problem.

This work was done by Dwain A. Deets and Wilton P. Lock of Ames Research Center and Vincent A. Megna of Charles Stark Draper Laboratory. Further information may be found in NASA TM-86807 [N86-19325/NSP], "Flight Test of a Resident Backup Software System."

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

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 12]. Refer to ARC-11763.

GPS Satellite Multipath Range Errors Measurements are proposed to resolve uncertainties.

A report discusses errors in range measurements in the Global Positioning Satellite (GPS) system due to multipath transmissions originating at the satellites. At present, large uncertainties in the sizes of multipath errors limit the precision of GPS measurements. Experiments are proposed to determine the systematic multipath errors under various operating conditions, with a view toward applying corrections to increase the precision of future GPS measurements.

The use of properly-designed GPS receivers is expected to enable the accurate measurements of baselines up to thousands of kilometers in length. A key to these accurate measurements is the common-mode rejection of instrumental errors originating at the satellites through differ-

encing of the measured pseudorange to a pair of ground receivers from a single satellite.

This measurement technique fails in the presence of effects that originate at a satellite but that are not the same for different ground receivers observing the same satellite. Multipath caused by some of the signal power from a satellite antenna bouncing off other parts of the satellite is an example of this: The additional signal delay caused by multipath transmission is dependent on the angle between the centerline of the antenna and the line of sight to the receiver on the ground, also called the "angle off boresight" or "boresight angle."

It has been estimated that a multipath effect with a magnitude of a few centimeters may remain after differencing and cannot be calculated with confidence. It is, therefore, necessary to conduct experiments to quantify the effect, to determine whether it can be ignored, must be modeled, or presents a fundamental obstacle to the use of P-code (a pseudorandom-noise code used in the GPS system) measurements to resolve carrier-cycle ambiguities.

At an antenna-testing range, a GPS antenna was mounted on a ground plane and used to transmit P-code ranging signals toward a GPS receiver 800 ft (240 m) away. The P-code delay was measured as a function of the boresight angle from 0° to 14° and found to have variations of as much as 67 times the 0.03-ns accuracy required for the use of P-code pseudorange measurements to reliably resolve carrier-cycle ambiguities. However, the measurements may have been strongly affected by multipath effects of the test range itself, and experiments are being conducted with a satellite in orbit to determine whether the variations due to the satellite and its antenna are either less than, or can be calculated to, within 0.03 ns.

The experiments exploit the fact that the changes in delay due to multipath are expected to be much larger in the P-code than in the carrier signals in most instances. The differential change in range between the carrier and P-code is monitored as a function of the satellite elevation. The remaining sources of experimental error include system noise, multipath at the ground antenna, errors in ionospheric calibration, noncoherence of carrier and P-code circuits at the satellite or ground receiver, and errors in the orientations of satellites. Possible variations of effects among satellites, or dependence of delay on the azimuth angles of the satellite antennas will be investigated.

This work was done by Lawrence E. Young of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "An Experimental Technique To Monitor the In-Orbit Multipath Performance of Satellite Antennas," Circle 136 on the TSP Request Card. NPO-17020

INSIDE SYSTEMS INTEGRATION.

Systems integration. The science of mixing apples and oranges. Yet when you look inside, there's an art to creating simple solutions to complex problems. It's an art Grumman Data Systems has been perfecting for more than 25 years. We design, develop, integrate, operate and maintain information systems that are cost-effective. Reliable. User-friendly. Dependable. In short, value-added systems that do more than meet program requirements. For more information, contact

Grumman Data Systems,
1000 Woodbury Road, Woodbury,
NY 11797. (516) 682-8500.

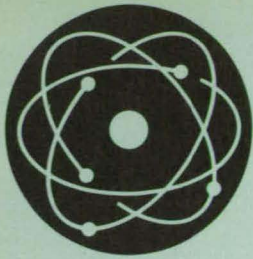
Only GRUMMAN



GRUMMAN[®]

Data Systems

® A registered trademark of Grumman Corporation



Physical Sciences

Hardware Techniques, and Processes

40 Quick-Change Optical-Filter Holder

42 Device Maintains Water at the Triple Point

44 Holocinematographic Velocimeter

44 Simultaneous Sampling of Two Spectral Sources

Computer Programs

54 Program Collects and Analyzes Thermoelectric Data

Quick-Change Optical-Filter Holder

A dark slide and interlock protect against ambient light.

Goddard Space Flight Center, Greenbelt, Maryland

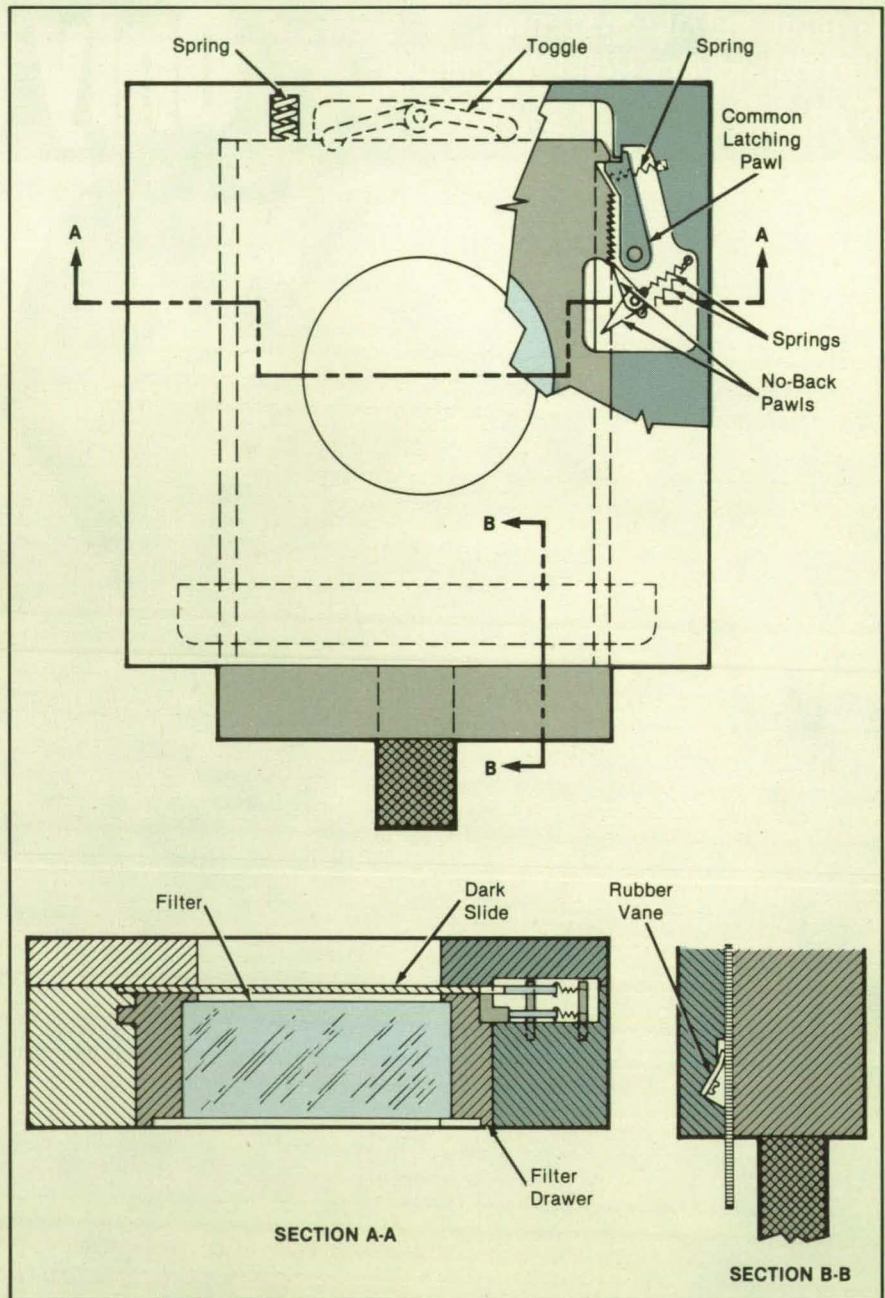
A mechanism enables a technician to remove and insert optical filters quickly and protects delicate parts of an optical system against ambient light. Designed for use with band-pass optical filters in 10 channels leading to photomultiplier tubes in a water-vapor lidar/ozon instrument, the mechanism can be modified to operate in other optical systems that require the rapid change of filters.

Previously, to change a filter without damaging a photomultiplier tube, it was necessary to turn the tube off and remove it from the instrument to gain access to the filter holder. Care had to be taken not to expose the face of the tube to ambient light. The operation was both tedious and time consuming.

With the new mechanism, it is not necessary to remove the photomultiplier. The mechanism (see figure) includes a filter drawer that operates in interlocking fashion with a dark slide. To remove the filter drawer, the technician first inserts the dark slide firmly into its slot; this releases the drawer. The technician then pulls the drawer out; this latches the dark slide in place, and the dark slide shields the photomultiplier from stray light during the entire time in which the drawer is removed. The technician places the new filter in the drawer, the drawer is reinserted firmly to release the dark slide, the drawer becomes latched, and the dark slide is removed.

Both the drawer and the dark slide have ratchet serrations that engage a common latching pawl. The sliding members also engage separate spring-loaded, no-back pawls that ensure that once either member is inserted, it must be inserted fully before it can be withdrawn. A newly inserted member must be fully latched by the common pawl before the no-back pawls release. Strong springs help to release the previously latched member when the newly inserted member disengages the common latching pawl.

To assure that both members are not latched simultaneously, a bilevel toggle pushes the other member out when the new one is inserted. A rubber vane blocks the entrance hole of the dark slide to



The **Quick-Change Filter Holder** contains an interlocking mechanism that prevents the simultaneous removal of both the dark slide and the filter drawer.

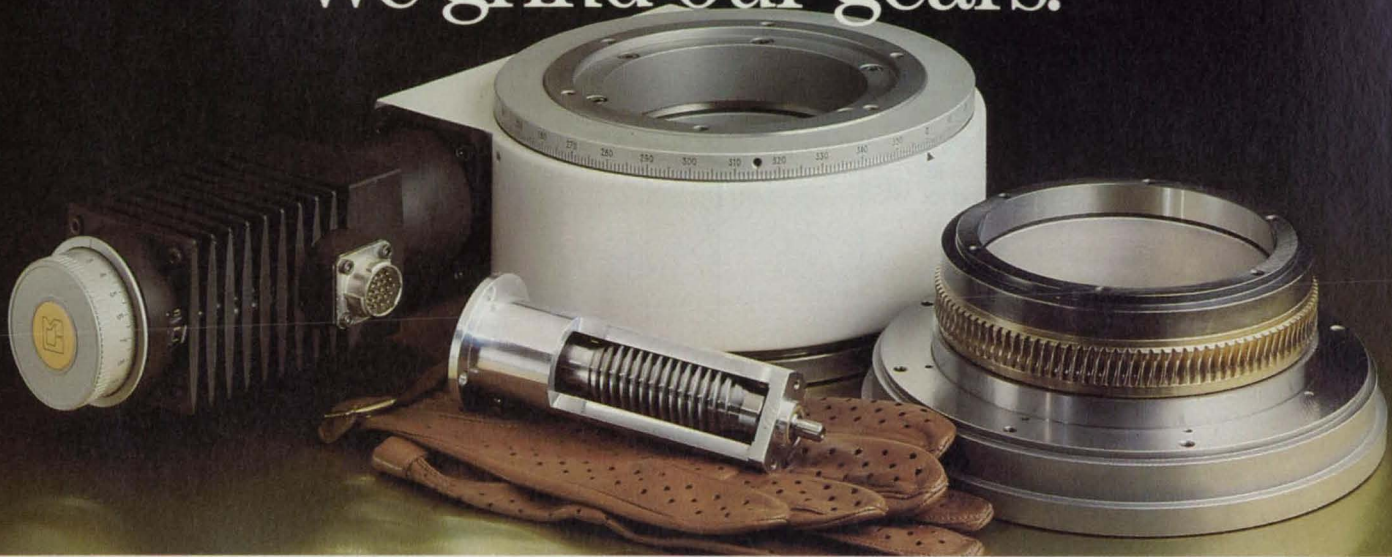
prevent the entry of stray ambient light when the dark slide is removed.

This work was done by Peter Leone of

Goddard Space Flight Center. No further documentation is available.

GSC-13148

How does Klinger drive its rotary stages with 5-microradian repeatability? We grind our gears.



When you're driving a performance car, the last thing you want to do is grind your gears. But when you're driven to build the world's finest rotary stages, grinding gears—to microscopic perfection—is what it's all about.

That's why Klinger technicians precision grind both the worm and gear in our rotary stages to jewel-like precision. It's the only way to have the worm and gear mesh perfectly and the best way to reduce backlash to imperceptibility.

The fine art of grinding gears at Klinger produces very scientific results. Resolution of our motorized rotary stages is 1/1000 degree. Repeatability is an astounding 5 microradians. And we precision grind our bearing surfaces to insure minimal trajectory errors.

We're proud of these specs at Klinger. So we ship page after page of test results with every stage that document its unequalled accuracy.

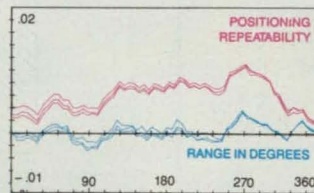
These tests prove that when you buy a rotary or linear stage from Klinger, you are, in fact, buying a work of art.

DESIGNED FOR LONGER LIFE. BUILT FOR LARGER LOADS.

The close tolerances, precision machining and assembly of our stages also mean they—like all Klinger products—will last longer. And will continue to deliver

their superior accuracy through thousands of hours of operation.

We select the materials and design the bearings of our rotary stages to handle



large loads: up to 400 Kgf. And we preload the play-free ball bearing race so the wobble is less than 20 microradians.

LARGEST SELECTION AT LOWER PRICES.

Combine any of our more than 30 rotary stages with thousands of other Klinger components to create an unlimited variety of systems. We provide adaptor plates for metric or English mounting hole patterns to further increase versatility. And the priceless precision of Klinger equipment has never been as affordable as it is right now. So there's no reason to settle for less.

To learn more about the thousands of Klinger micro-positioners and systems, send for our free micro-positioning handbook. Write or call Klinger Scientific Corporation, 999 Stewart Avenue, Garden City, NY 11530. (516) 745-6800.

KLINGER SCIENTIFIC

Building better positioning systems, piece by perfect piece.

U.S.A. Headquarters: 999 Stewart Avenue, Garden City, NY 11530 (516) 745-6800.

Regional Offices: Northern California (415) 969-0247; Southern California (714) 999-5088. Worldwide distribution network: Contact Micro-Controle, Z.I. de St. Guenault, B.P. 144, 91005 Evry Cedex, France. Tel. 33(1)64.97.98.98. FAX 33(1)60.79.45.61.

Circle Reader Action No. 368

Device Maintains Water at the Triple Point

A modified commercial freezer keeps water at 0.01 °C for over 10 weeks.

Langley Research Center, Hampton, Virginia

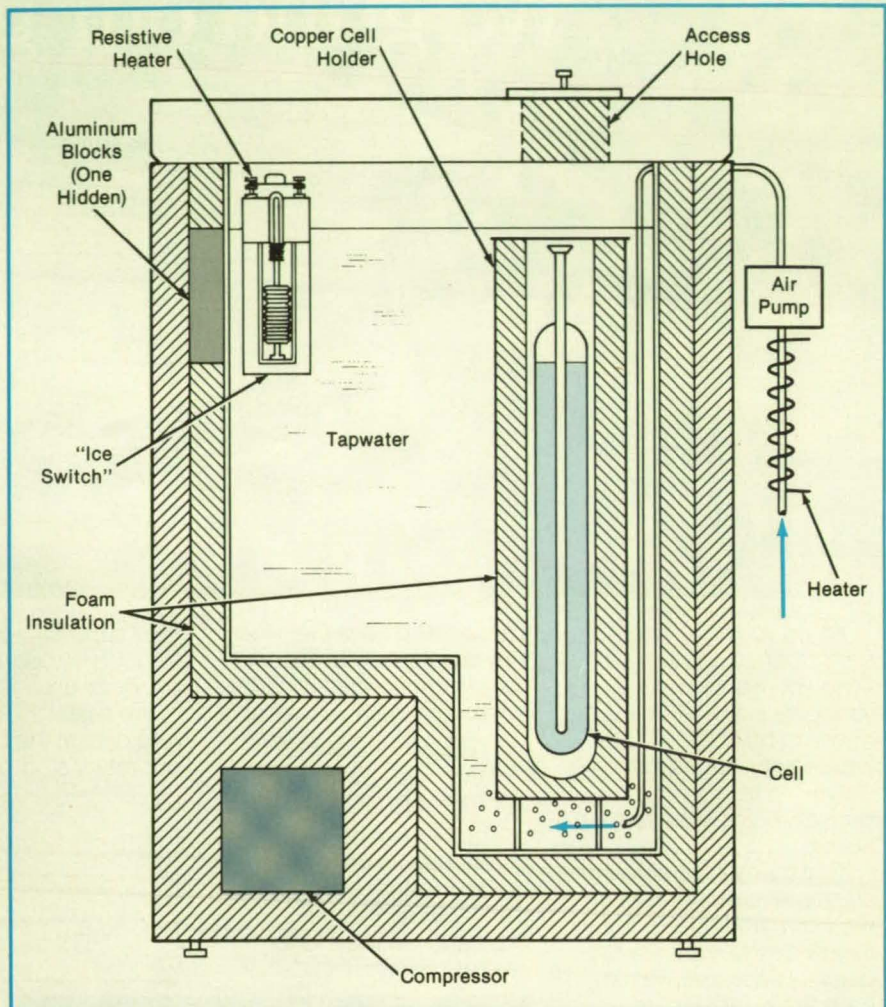
A relatively inexpensive device maintains the triple point (T_p) of water for 10 weeks or longer. The T_p of water, 0.01 °C, is the most useful and important of the defining temperature points for the calibration of standard platinum resistance thermometers (SPRT's). The freezing of a T_p cell is tedious and time consuming, and because a usable cell can rarely be maintained for more than a few hours, fewer T_p measurements can be made than desired. Attempts to extend the lives of T_p cells by the use of crushed-ice baths have not been successful.

The new device (see figure) consists of four basic assemblies: a small, commercial chest freezer containing an insulated water tank; an insulated copper cell holder; an "ice switch" for cycling the freezer compressor; and an externally-mounted air pump for circulation. The tank is made of stainless steel and lined with 2-in. (5-cm) R-10 foam insulation on all interior surfaces. An access hole cut in the freezer lid allows T_p measurements without opening the lid.

The copper cell holder, mounted on standoffs, is filled with foam insulation in which holes have been cut for two cells. Copper "hats" fit over the cell tops. A ring of insulation is added to the outside of the copper box, near the bottom, to displace a portion of the ice that tends to grow in the bottom of the freezer and up the side of the cell holder.

The quantity of ice in the freezer is controlled by the "ice switch," which is constructed from a small bellows, sealed with brass at both ends, in an aluminum housing. A hole drilled in the center of the housing is lined with 2-in. (5-cm) PVC (polyvinyl chloride), and the aluminum is coated with epoxy to prevent corrosion. The bellows is filled with distilled water and bolted to the bottom of the hole. The airspace between bellows and PVC is filled with silicone oil. A spring and nylon plunger are fitted above the bellows to activate a standard 20-A miniature switch.

The bellows assembly is immersed in one corner of the freezer, with the switch well above the surface of the water. Two aluminum bars, inserted between the freezer walls and the water tank, cause ice to form in the "ice-switch" corner first. The fluid in the bellows freezes and expands, causing the plunger to open the switch, shutting off the compressor. As the fluid in the bellows melts, the plunger falls, closing the switch and turning on the compressor. Two paral-



This Modified Freezer is used to calibrate standard platinum resistance thermometers.

lel 5-k Ω , 2-W resistors, mounted across the switch and thermally bonded to the bellows housing, add heat to reduce the cycle time while the compressor is off.

The bath water is circulated by air pumped to the bottom of the tank and bubbling to the surface. The air-intake line is wrapped with heater tape to prevent ice from blocking its outlet at the bottom of the tank. A flexible wire run down through the air line may be necessary to prevent the formation of ice during long periods of operation.

The triple-point-of-water maintenance device has been in operation over a year. Daily checks of working SPRT's were used in identifying errors before they were introduced into critical test data. Experience shows that, before cell storage is attempted, the freezer should be in operation and monitored closely for about a week to ensure a stable bath temperature that will not

overfreeze the T_p . In fact, turning the freezer control to maximum was found to give better results than did a lower setting.

Typical bath temperatures swing from -10 m °C to +27 m °C over a 24-h period. The cell should be visually inspected daily before measurements are made to ensure the ice mantle is "free." If excessive ice crystals (dendrites) begin to grow from the bottom of the mantle, a 5- to 10-s immersion in ambient water keeps them at bay while minor freezer adjustments are made. Finally, 1 to 2 tablespoons of household bleach, added as needed, help prevent the bath water from discoloring and acquiring an unpleasant odor after several months of operation.

This work was done by J. W. West and C. G. Burkett of Wyle Laboratories for Langley Research Center. No further documentation is available.
LAR-13708

TUFOIL® IS SLIPPERIER THAN TEFLON!

FREE
SAMPLES
SEE DETAILS
BELOW.

When I first saw the data from our government's most prestigious laboratory charting their tests of TUFOIL, I almost fell off my chair.

I know TUFOIL is a superior product. After all, I've been working on the problems of dispersing Teflon® or Fluon® in oil since the early 1970's and getting patents all over the world. **But here was confirmation from on high!** My reaction was, "Wow! TUFOIL's slipperier than Teflon!"

Their test data showed a steel on steel 4-ball surface friction of .029 with remarkably low wear. I rushed to my library, grabbed a lubricant handbook to see if my memory was correct. Sure enough! Teflon was listed at .04.

TUFOIL is not just a little slipperier than Teflon. It's a lot slipperier than Teflon. There was the handbook data right in front of me!

People ask, "Why don't the auto and oil companies recommend TUFOIL?" It's simple. The big oil companies' profit comes from gasoline, not lubricants. The auto companies' comes from car sales. Just think. Some of our test cars are pushing 200,000 miles. If Detroit recommended TUFOIL, they might cut their sales in half . . . not likely! **Some of our customers' cars are well over 200,000 miles, with their engines purring like kittens.**

So it's up to you to decide for yourself, just as tens of thousands of our customers already have!

People like you send us letters raving about **improved starting, smoother operation, spectacular acceleration, gas savings and much longer trouble-free engine life.**

TUFOIL has been written up in prestigious scientific journals, newspapers such as the Wall Street Journal, Boston Globe, New York Times and Christian Science Monitor and tested in Universities and laboratories all over the world. The results are overwhelming! As far as we can see, **TUFOIL has the lowest**

friction and wear of any known lubricant. TUFOIL is making history!

For the last few years, we've been running full page award-winning ads in **NASA Tech Briefs.** In them, we call TUFOIL, "The Transistor of Lubrication." Our competitors are way back in the vacuum tube era with products primitive by comparison. **No other lubricant even comes close.**

We're occasionally asked about lubricants that claim to be one-time engine treatments. The answer is simple! **There is no record in the scientific literature that we've seen so far, that a one-time treatment by any lubricant will last the life of an engine.** So don't believe it!

TUFOIL means big savings for you, your car and your machines! So rush your order now and get these marvelous benefits.

- **Increases acceleration**
- **Boosts gas mileage**
- **Easier starts—hot or cold**
- **Makes engines run better, last longer**

Here's what some of our customers say. This customer wrote a beautiful 4-page letter raving about gas savings, easy starts. He went on . . .

"My acceleration was also noticeably increased and where my normal engine running temperature had been with the needle halfway between HOT and COLD, it is now only one third of the way in between."

. . . R. W., Yarmouth Port, Ma.

This customer got fantastic fuel savings...

"The use of TUFOIL in my autos has been so successful that I purchased a gallon of TUFOIL and now use it in my 3 lawnmowers, garden tiller and shredder."

. . . D. W., Seattle, Wa.

MAKES YOUR CAR'S ENGINE WORK BETTER — LAST LONGER —



How To Use TUFOIL®

Just add one 8-oz. container of TUFOIL to your standard crankcase. (It'll treat 4 to 5 quarts of engine oil.) If you want to super treat your engine, add two bottles! **You will see the results in less than 1,000 miles.** Once your engine is broken in on TUFOIL, add 4 ounces (½ bottle) with each oil change to keep new performance levels. Use TUFOIL repeatedly over the life of your engine to help keep it purring like new!

TRY ONE 8 OZ. BOTTLE OF TUFOIL FOR 30 DAYS OR 1000 MILES

If you're not satisfied, simply send us proof of purchase with a note and we'll refund your money immediately—no questions asked.

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.)



FREE . . . Products based on TUFOIL technology. Check one with each order of 2 bottles or more. 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.

©1987 Fluoramics, Inc.
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**

After you've tested TUFOIL and like it, buy a gallon of TUFOIL to share with your friends & save **\$159*!!**

- ONE GALLON . . . treat 16 cars for \$125.00 (plus \$6.00 shipping and handling.)

We ship within days!

*over the single bottle price **BIG SAVINGS**

Fluoramics, Inc.

103 Pleasant Avenue
Upper Saddle River, N.J. 07458

My check or money order for \$ _____ is enclosed.
Charge my credit card:

- Am. Express
- MasterCard
- Visa

Card No. _____

Exp. Date _____

Signature _____

Name _____

Address _____

City _____

State _____ Zip _____

(N.J. residents please add 6% sales tax). Orders to Canada: Send check or money order in U.S. currency. Add \$10 extra shipping charges.

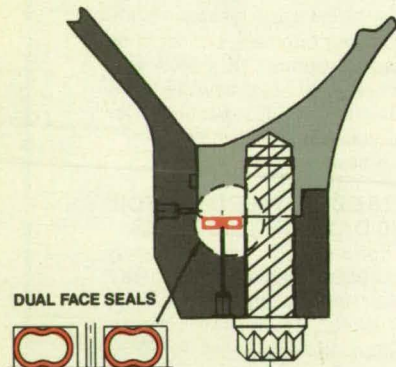
keep positive face-seal
contact even under
extreme pressure-cycling
and flange separation ...
at cryogenics or 2000°F.

METAL-O-RING Seals

Even under these difficult operating conditions, commonplace in aerospace, the resilience found only in EnerRing all-metal seals causes them to "spring-back" and maintain continuing 360°, no-leak, seal-face contact.

12 Ft. & Up. For 30 years, we have made big Metal-O-Ring seals in a wide range of X-sections, and from the most technologically advanced metals, in O.D.s up to our giant 25' nuclear pressure vessel seals.

No Seal Deterioration. Unlike polymers, all-metal EnerRings don't crack or shrink; are dimensionally and chemically stable; and suffer no shelf-life or in-use deterioration, assuring continuing resilience.



MIL-Q-9858A/MIL-I-45208A are among the many strict quality standards met. The properties of all materials used are closely documented.

In-House Production means that design, engineering, manufacturing, and silver, nickel and other plating are performed under the strict supervision of qualified, experienced personnel.

ASK FOR COMPLETE, FREE DESIGN DATA

33 Defco Park Road
North Haven, CT 06473
(203) 239-3341



**ADVANCED
PRODUCTS COMPANY**

NORTH HAVEN, CONNECTICUT, U.S.A.

□ BELGIUM □ FRANCE □ PUERTO RICO
□ UNITED KINGDOM

Holocinematographic Velocimeter

Holographic movies are used to study turbulent flows.

Langley Research Center, Hampton, Virginia

A dual-view, high-speed, holographic movie technique has been developed for studying the physics of the control of turbulent flows. This approach, which eliminates some of the limitations of previous holographic techniques, uses the holocinematographic velocimeter, or HCV. The data from this system can be used to verify the results of theoretical models and numerical simulations of turbulence, to visualize and measure coherent structures in "non-simple" turbulent flows, and to examine the mechanisms operative in various turbulence-control/drag-reduction concepts. This system shows promise for giving the most-complete experimental characterization of turbulent flows yet available.

In this technique, a high-speed movie is composed of single-exposure holograms of tracer particles in each of two simultaneous orthogonal views of a flow. The time resolution is set by the movie frame rate, and the total time is limited by the length of the movie.

These holographic movies are reduced to velocity data in three steps. First, the coordinates of the tracer particles are found by scanning the reconstructed images from the holograms. Next, the two views are combined to allow equal position accuracy to be obtained for all three coordinates. Finally, the particles are tracked in successive time steps for the entire holographic movie to determine the time-varying velocity field through the entire test volume. The size of the tracers is a compromise between the quality of the image

and the spacing of the tracers. Commercially-available, 40- μ m-diameter, hollow glass spheres called microballoons have been used.

Because of limitations on the movie frame rate, the HCV will be used to study turbulence physics in slow flows of water. A new type of vertical water tunnel was developed to satisfy the requirements of this study. This tunnel is like a vertical towing tank, but the tank, rather than the model, is moved. The tunnel has a very low disturbance flow and is far less expensive to construct than are continuous-flow or intermittent-flow tunnels.

Even though the tunnel velocity is low (≤ 1 m/s), the film-transport speed required to obtain 500 frames/s is 17.5 m/s. This motion plus vibration could cause smearing of the images in the holograms. Smearing is avoided by the use of a pulsed copper-vapor laser. An argon-ion laser has been used during the reduction of the holograms.

The HCV appears to be capable of obtaining data uniquely with resolutions in time and in three-dimensional space that approach those of full real-time realizations of complex flows. Although the system can be used only for low-speed flows, it could help in the solution of a large number of problems in the physics of fluids and, particularly, problems in the control of flows.

This work was done by Leonard M. Weinstein and George B. Beeler of Langley Research Center. For further information, Circle 19 on the TSP Request Card. LAR-13699

Simultaneous Sampling of Two Spectral Sources

A fiber-optic bundle is used to sample a dye laser and a spectral lamp.

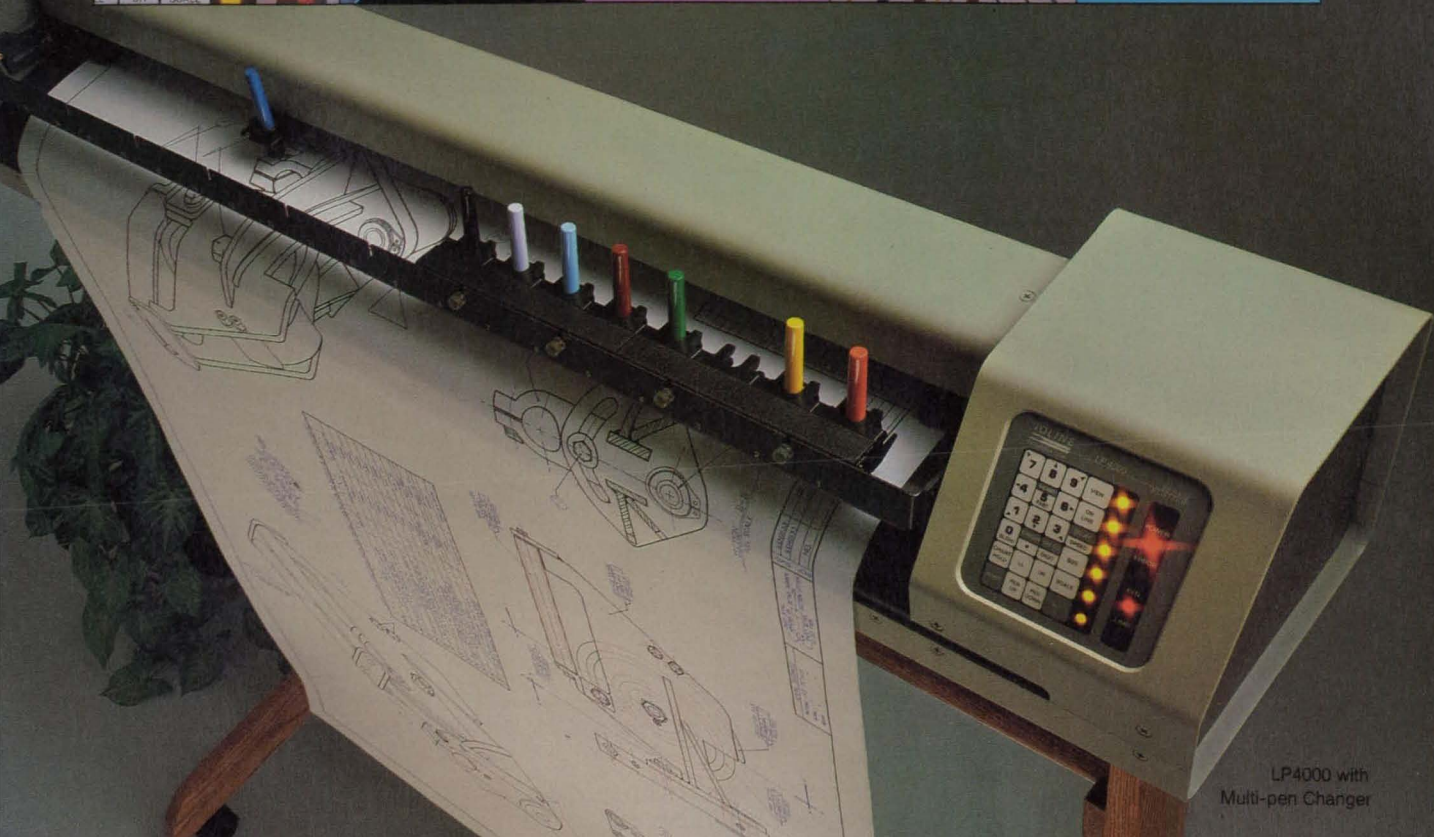
Langley Research Center, Hampton, Virginia

Many applications of broadband dye lasers require that the spectral outputs be accurately known. A new technique uses a bundle of fiber optics to sample a dye laser and a spectral lamp simultaneously. By use of a real-time display with this sampling technique, the two signals are superimposed, and the effect of any spectral adjustments can be determined immediately.

Figure 1 shows some of the major components of the system. The fiber-optic bundle is split into two bundles at the input end. A portion of the beam from the dye laser is

reflected to one of these bundles by an uncoated microscope slide. A spectral lamp is sampled with the other input bundle. The effect of the fiber-optic bundle is to mix the light from the two sampled sources at the output end before insertion into a detector.

For convenience, the input ends and the spectral lamp are mounted in a block. The dye-laser energy accepted by the fiber-optic bundle is attenuated by rotating the block to adjust the input angle. The output end of the fiber-optic block is fastened to the input slit of the sampling monochroma-



LP4000 with
Multi-pen Changer

Here's what to look for when you want great value

IOLINE plotters are designed to give you more flexibility and features for less cost than any other machine of their kind.

For example, our plotters draw not only on A through E sizes of media, but also plot on hundreds of in-between sizes from 1.5" x 1.5" up to 37" wide roll stock. This saves you time and money by allowing you to make "check plots" on small, low-cost paper before committing to full-size media for final work.

It's easy also to set paper size, pen speed, micro-calibration, plot rotation—everything exactly as you want—by just tapping a few keys on the plotter's intelligent keypad. Plus, up to 3 sets of personalized defaults can be saved in its non-volatile memory.

They're fast, too. Our high-

performance LP4000™ draws at speeds selectable up to 20 inches per second (ips) axially with .001" resolution. For less demanding applications, our economical LP3700™ plots up to 10 ips axially with .0025" resolution.

Another feature is compatibility. IOLINE plotters emulate both HP-GL and DM/PL plotter languages so they work with a host of software like AutoCAD, VersaCAD, and CADKEY, to name a few.

Furthermore, our Multi-pen Changer™ option holds up to 20

pens and, with our hyper-BUFFER™ option, you can dramatically increase plotting throughput with intelligent vector sorting and compression buffering of up to 1MB of plot data.

Now here's the clincher: Our top-gun LP4000 costs just \$5,495* less options. And there are other models priced even lower!

Why wait? Call us now at 1-206-775-7861. Or, circle our reader service number and we'll gladly send you our brochure.

Remember, getting your money's worth—that's what IOLINE plotters are all about.

IOLINE™

LARGE-FORMAT PEN PLOTTERS

Circle Reader Action No. 472

IOLINE CORPORATION 19417-36TH AVE. W LYNNWOOD, WASH. 98036 (206) 775-7861 TELEX 4949856 IC UI FAX (206) 775-2818
LP4000, LP3700, Multi-pen Changer, and hyperBUFFER are trademarks of Ioline Corporation. AutoCAD is a registered trademark of Auto Desk Inc.
VersaCAD is a registered trademark of T&W Systems. CADKEY is a registered trademark of MicroControl Systems, Inc. *Suggested U.S. List price.

AVAILABLE ON GSA CONTRACT

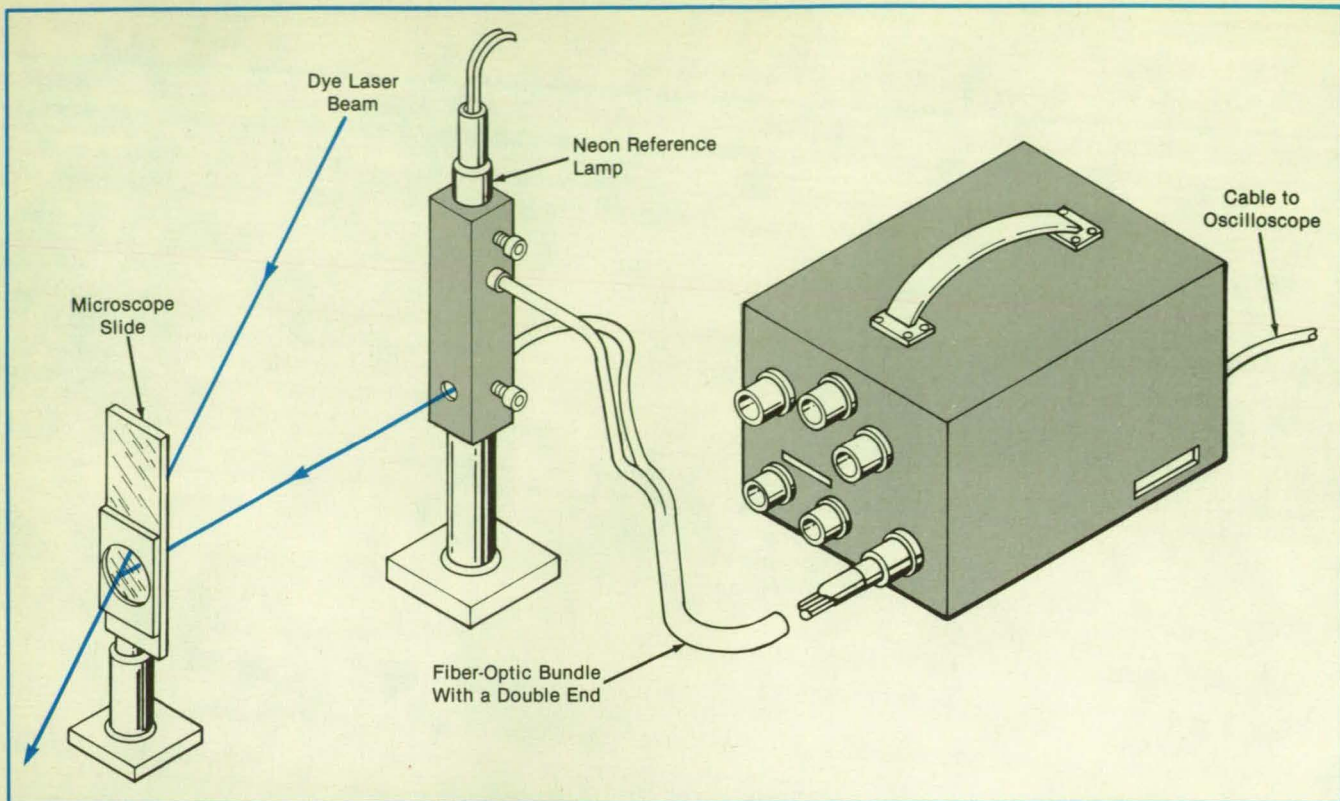


Figure 1. A Split Fiber Optic Bundle mixes the light from a broadband dye laser and a spectral lamp.

tor. A rapidly scanning spectrometer and oscilloscope are used to display the laser and spectral-lamp data as a function of

wavelength.

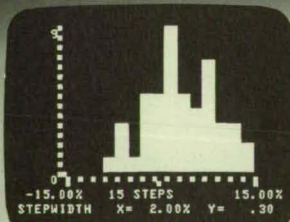
Figure 2 illustrates the display obtained during the sampling of a dye laser centered

at 606.5 nm. Neon reference lines at 603.00, 607.43, and 609.62 nm are also displayed, thus enabling the simultaneous determination of the dispersion and the wavelength. By the use of this system, adjustments can be made to the dye laser, and the effect can be determined immediately.

This technique is routinely used as part of the Coherent anti-Stokes Raman Scattering (CARS) system at NASA Langley Research Center. In the system, the dye laser mixes with a simultaneously-pulsed Nd: YAG laser at 532 nm to probe the vibrational levels of nitrogen. This system is used to diagnose combustion.

This work was done by Olin Jarrett, Jr., of Langley Research Center. No further documentation is available. LAR-13756

GET STATISTICS WHILE YOU TEST C, R, AND L.



No need to buy a computer. Or write your own software. Only ESI's Model 2160 LRC VideoBridge[®] with Statistics Software gives you automatic data collection and statistical analysis while you perform regular incoming tests of capacitors, resistors and inductors.

The VideoBridge CRT screen displays four pages of data—histogram, test setup, yield prediction, and data summary. Need permanent records? No problem. Just output all the data to an RS-232C compatible printer.

You'll be amazed by the Video-

Bridge's flexibility and ease of use. Choose from 16 impedance factors and over 3,000 test frequencies from 20Hz to 150kHz. All at a basic accuracy of 0.02%.

Call our test engineers today, toll-free for more information.



Electro Scientific Industries, Inc.
13900 NW Science Park Dr. • Portland, Oregon 97229
(800) 547-1863
In Oregon call (503) 641-4141

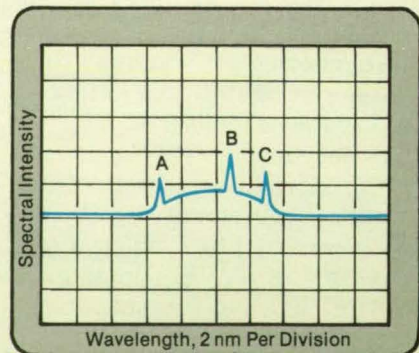


Figure 2. An Oscilloscope Display of the Spectrum of a broadband dye laser, centered at a wavelength of 606.5 nm, also shows neon reference lines at wavelengths A, B, and C.



YOU'RE LOOKING AT SOME OF THE MOST VALUED REFERENCE BOOKS IN YOUR INDUSTRY.

When it comes to the best known, high performance, heat and corrosion resisting high-nickel alloys, we wrote the books. If you want more information on MONEL^{*}; INCONEL^{*}; INCOLOY^{*}; INCO^{*}; NILO^{*}; BRIGHTRAY^{*}; or NIMONIC^{*} alloys, let us know. We're the only source for these products. And we have them available in the widest range of forms and sizes in the industry. All with the proven ability to save you money in repair, replacement and downtime.

Others may imitate our products, use our books for reference and guidance, and even use our

numbering system; but they cannot use our trademarks. And they can't match the range of alloys and forms Inco Alloys International offers.

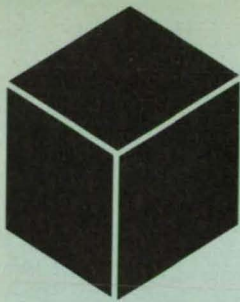
Start your own reference library. Get our "Quick Reference Guide" free just by writing or calling us. In the U.S., Inco Alloys International, Inc., Huntington, West Virginia 25720. Telephone (304) 526-5388. Telex 886413. Telefax (304) 526-5441. Or in Europe, Inco Alloys International Ltd., Wiggin Works, Hereford, England HR4 9SL. Telephone (0432) 272777. Telex 35101. Telefax (0432) 264030.

^{*}Trademark of the Inco family of companies.



INCO ALLOYS INTERNATIONAL

Circle Reader Action No. 569



Materials

Hardware Techniques, and Processes

48 Halogenation Enhances Carbon-Fiber/Epoxy Composites
48 Graphite/Epoxy Deicing Heater

51 Metal/Ceramic Bond Coatings for High Temperatures
51 Wear-Resistant, Thermally Conductive Coating

52 Automatic Replenishment of Dopant in Silicon Growth

Halogenation Enhances Carbon-Fiber/Epoxy Composites

Interlaminar shear strength is increased by an inexpensive treatment.

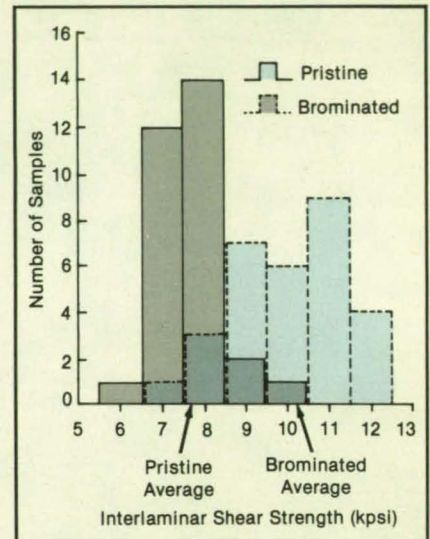
Lewis Research Center, Cleveland, Ohio

Recent work has identified a new, relatively-inexpensive surface treatment for carbon fibers that enhances the interlaminar shear strength (ILSS) without altering the tensile strength significantly. One of the factors that limits the usefulness of carbon-fiber/epoxy composites is the comparatively poor strength of the bond between the fibers and the matrix, often measured in terms of the ILSS. For example, conventional S-glass fiber composites typically have an ILSS on the order of 15 kpsi (100 MPa), while untreated carbon-fiber composites can have ILSS as low as 4 kpsi (28 MPa).

Many different surface treatments have been proposed to improve the interfacial bond between the fiber and the matrix by either modifying the functional groups on the surface of the fiber or by enhancing the surface area of the fiber. These include wet and dry oxidative etching, chemical-vapor deposition, whiskerizing, and a multitude of polymer coatings. Although threefold to fivefold improvements in ILSS can be achieved with some of these surface treatments, the treatment process often degrades the tensile strength or is prohibi-

tively expensive.

The exposure of polyacrylonitrile-based T-300 (or equivalent) fibers to bromine vapor at room temperature improves the ILSS of epoxy composites made from these fibers by 30 percent, from an average of 7.7 kpsi (53 MPa) to 10.0 kpsi (69 MPa), as shown in the figure. The mechanism responsible for the improvement is still under investigation. The improvement may be due to adsorbed or reacted bromine on the surface of the carbon fibers or to an increase in the surface area of the carbon fibers as a result of exposure to bromine. Amoco pitch-based P-100 (or equivalent) fibers show similar results but to a lesser degree. The ILSS of the P-100 increases from 3.8 kpsi (26 MPa) to 4.5 kpsi (31 MPa). The effect of bromination on the tensile strength of the composite samples is minimal: 122 ± 16 kpsi (840 ± 110 MPa) for the pristine P-100 composite compared to 122 ± 7 kpsi (840 ± 48 MPa) for the brominated P-100 composite. The enhanced ILSS obtained from the halogenation of carbon fibers may prove to be beneficial in many aerospace and terrestrial applications.



The Interlaminar Shear Strengths of pristine and brominated samples of composite material are compared.

This work was done by Donald A. Jaworske and Raymond D. Vannucci of Lewis Research Center and Reza Zinolabedini of Cleveland State University. No further documentation is available. LEW-14584

Graphite/Epoxy Deicing Heater

Heat is applied close to the surface to be protected.

Lewis Research Center, Cleveland, Ohio

Both military and civilian aircraft of the future will have an increasing number of components fabricated from composite materials. This trend stems from not only the desire to reduce the aircraft weight but also to make aircraft surfaces smoother for more laminar flow and hence less drag.

If leading edges of lifting surfaces (i.e., wings and tails) and engine inlets are to be made from composite materials, then one problem that must be addressed is that of protection from ice. Thermal anti-icing and deicing systems that have been used for years by the aircraft industry do not appear to be useful for composite designs, be-

cause composites characteristically have low thermal conductivities in their transverse directions; and hence, large amounts of heat would have to be provided to ensure that the outer surfaces reach the required anti-icing or deicing temperatures.

A surface heater developed to remedy this deficiency includes a graphite-fiber/epoxy composite as the heating element. This heater can be thin and highly electrically and thermally conductive and can conform to irregular surfaces. Therefore, it can be used in the thermal deicing system of an aircraft to heat the surface of

the aircraft quickly and uniformly.

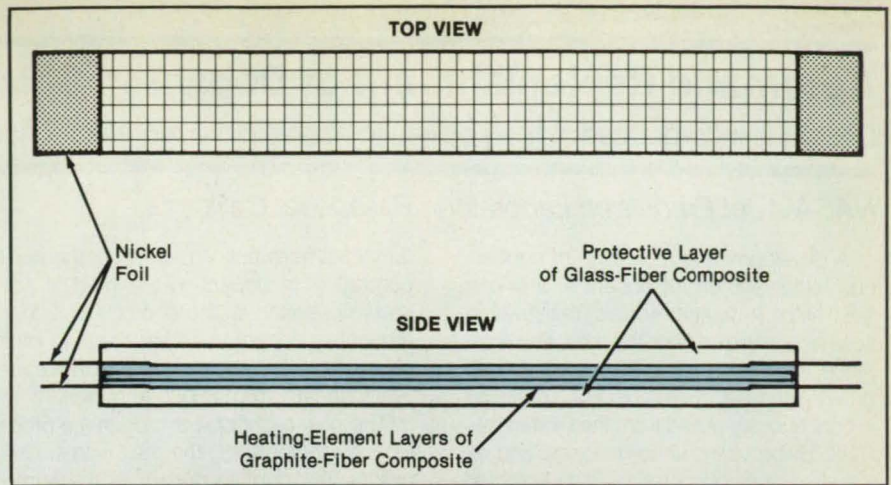
The basic design of the heater is illustrated in the figure. One ply of highly electrically- and thermally-conductive brominated-graphite-fiber composite was laminated between two plies of electrically-insulating composite material, with nickel foil making contact with the end portions of the graphite fibers. Part of the foil was exposed beyond the composite to serve as an electrical contact. Several model heaters were fabricated to demonstrate the concept and perform the preliminary experiments.

The electrical resistivity, thermal conductivity, and density of the fibers were $50 \mu\text{m}\cdot\text{cm}$, $270 \text{ W/m}\cdot\text{K}$, and $2.30 \text{ g}/(\text{cm})^3$, respectively. The electricity was found to penetrate through the composite in the transverse direction to make the resis-

tance of the contact between the foil and the composite acceptably low. When the electrical current was applied, the increase in the temperature of the heater reached 50 percent of the steady-state value within 20 s.

There was no overheating at the ends of the heater, provided there was no corrosion by water. Where the foil/composite bond failed during storage, exposure to liquid water was found to have oxidized the foil. Such failure of the bond can be avoided if perforated nickel foil is used, so that the plies of the composite can bond to each other through the perforated holes and therefore lock the foil in place. However, further study is needed to address the corrosion of the foil/composite bonding by liquid water.

This work was done by Ching-cheh Hung of Lewis Research Center and Michael E. Dillehay and Mark Stahl of Cleveland State University. Further information may be found in NASA TM-88888 [N87-12559/NSP], "A Heater Made From Graphite Composite Material for Potential Deicing Application."



This **Graphite/Epoxy Composite Heater** was developed to prevent and reverse the formation of ice on advanced composite surfaces of aircraft.

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.

This invention is owned by NASA, and a

patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 12]. Refer to LEW-14551.

Metal/Ceramic Bond Coatings for High Temperatures

Features include low thermal-expansion mismatch and resistance to oxidation.

Lewis Research Center, Cleveland, Ohio

A new class of reduced-thermal-expansion bond coatings has been developed for use at high temperatures in thermal-barrier-coating systems. These bond coatings are composed of low-pressure-plasma-sprayed metallic matrices dispersed with low-thermal-expansion, high-bulk-modulus ceramic particles. The new coatings and the method of application represent improvements over the prior practice of applying a ceramic coat directly over a metallic bond coat in that they lower the thermal-expansion-mismatch strain while maintaining integrity at high temperatures.

The dispersoids are initially processed so as to possess high cohesive strength, low porosity, and roughly spherical shapes. The anticipated optimum microstructure would be obtained by adjusting plasma-spraying conditions so that the metallic particles melt completely while the dispersoids exhibit only surface melting and remain roughly spherical.

The resulting bond coat ideally consists of a dense matrix of metal with well-bonded, roughly-spherical ceramic dispersoids. However, in practice, many dispersoids may melt completely and flatten upon im-

pact. The volume fraction of the ceramic is kept sufficiently low so that the dispersoids tend not to be in contact with each other, thereby enabling the dispersoids to constrain the thermal expansion of the metal matrix while maintaining inherent resistance to oxidation.

This work was done by Robert A. Miller of Lewis Research Center and George W. Leissler of Sverdrup Technology, Inc. No further documentation is available. LEW-14541

Wear-Resistant, Thermally Conductive Coating

A new process makes a coating with unusual properties.

Lewis Research Center, Cleveland, Ohio

Coatings resistant to wear are used in a variety of applications ranging from earth-moving equipment to space vehicles. One of the most severe environments for such coatings involves both high temperatures and abrasion.

If it becomes necessary to remove large quantities of heat from a wear surface, high thermal conductivity is also necessary and further complicates the selection of a coating material. Copper and copper alloys have high thermal conductivity but only limited resistance to abrasion. Attempts to

overcome this poor resistance to wear generally lead to plating or coating of copper substrates with materials that have greater resistance to wear but less thermal conductivity.

A process developed at the Lewis Research Center applies a wear-resistant, highly thermally conductive coating to a copper substrate. The coating is copper or copper alloy with a controlled dispersion of oxide or carbide particles. The process results in a coating that has thermal expansion similar to that of the base material, in-

creased resistance to abrasion when hot, and high thermal conductivity.

This work was done by Brian J. Edmonds of Lewis Research Center, George W. Leissler of Sverdrup Corp., and William J. Waters of Waters and Associates. No further documentation is available.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 12]. Refer to LEW-14562.

Automatic Replenishment of Dopant in Silicon Growth

Dopant is incorporated in feed pellets to maintain the required concentration.

NASA's Jet Propulsion Laboratory, Pasadena, California

A developmental technique of continuous replenishment of dopant in a silicon melt helps to ensure correct resistivity in solid silicon grown from the melt. The technique is to be used in the dendritic-web growth process, in which a ribbon of silicon is continuously pulled from the molten material. By providing uniform doping and resistivity in the ribbon, the technique should enable the production of high-quality silicon ribbon at high yields for use in semiconductor devices.

Although it is common practice to replenish the silicon in a melt by automatic continuous addition, dopant has been added to the melt in the form of pellets when a pull has ended and a new one is about to start. Because silicon rejects dopant to the surrounding melt when it solidifies, the concentration of dopant in the melt increases during a pull, and the concentration at the growing end of the ribbon increases as a consequence.

Moreover, the amount of ribbon extract-

ed varies from pull to pull. Thus, the concentration of dopant in the melt is not known precisely at the end of a pull. The amount of dopant to add at the start of a new pull has to be estimated, and the resistivity can vary from ribbon to ribbon.

The new technique avoids these problems by replenishing the melt with silicon pellets that contain dopant in the same concentration as that desired in the grown crystal. For example, an n-type silicon crystal of $2 \Omega \cdot \text{cm}$ resistivity contains 1.05×10^{15} atoms of phosphorus per gram of silicon. The ratio of phosphorus concentration in the crystal to that in the liquid silicon is 0.35, which means that initially the melt must contain 3×10^{15} atoms of phosphorus per gram of silicon to produce the requisite concentration in the crystal. Once the withdrawal of the crystal from the melt has begun, the inclusion of 1.05×10^{15} atoms of phosphorus with every gram of silicon added to the melt will ensure that the required concentration in the liquid is

maintained but not exceeded.

The phosphorus is included by diffusion into the silicon pellets. In a demonstration, silicon pellets were heated in a quartz crucible in a heated diffusion tube while a carrier gas containing POCl_3 vapor flowed over them. The extent of diffusion of phosphorus from the vapor depended on the time, temperature, pellet size, vapor concentration, and cooling rate. Under the proper conditions, the desired concentration of phosphorus can be attained.

Eventually, dopants might be added as part of a fluidized-bed process used to make the silicon pellets. Dopant gases would be added to the process gas stream and would condense in the silicon particles as they form by chemical vapor deposition.

This work was done by E. L. Kochka of Westinghouse Electric Corp. for NASA's Jet Propulsion Laboratory. For further information, Circle 22 on the TSP Request Card.

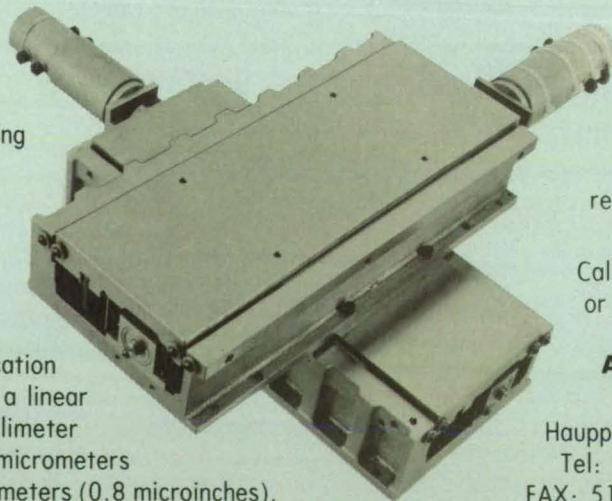
NPO-17138

EXCELLENCE IN MOTION

Linear Stages With Unsurpassed Resolution

With resolution available better than 1 microinch, Anorad's linear stages provide performance that is virtually unsurpassed. Precision is assured by measuring the phase within a cycle to determine the position, rather than the more commonly used method of counting within a cycle.

With controller logic multiplication factors of 256X and 1024X, a linear encoder of 50 cycles per millimeter provides resolution of 0.08 micrometers (3 microinches) to 0.02 micrometers (0.8 microinches). These system resolutions are now available with Anorad's



high-accuracy cross roller Anoride™ stages, or the air bearing Anoglide™ models. Anorad's highest resolution encoder has line spacing of 250 cycles per millimeter, which provides resolution of 0.015 micrometers (0.6 microinches) at 256X.

Call or write for a free brochure, or call our Application Engineers.

ANORAD CORPORATION


110 Oser Avenue
Hauppauge, NY 11788

Tel: 516-231-1995

FAX: 516-435-1612

TWX: 510-227-9894





Power. Harnessed for you.

ICADEM: Integrated Computer-Aided Design, Engineering, Manufacturing.

Phenomenal depth of software for productivity and performance.

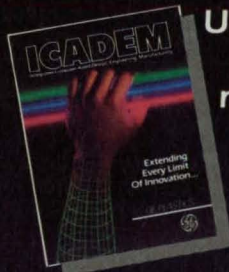
Humanizing technology.

Earth-shaking opportunities accelerating product innovations.

Dynamic. Interactive. Beyond incomparable materials performance and advanced process development.

A powerful matrix of resources.

Only from GE.



Unleash the power to extend your innovations past every limit. Call now for exciting ICADEM details: (800) 845-0600.



GE Plastics

Circle Reader Action No. 615



**FIRST
INTERNATIONAL
CONFERENCE
ON
HYPERSONIC
FLIGHT
IN THE
21ST CENTURY**

The Center for Aerospace Sciences at the University of North Dakota, in cooperation with NASA, ESA, NAL/STRG, IEEE/AESS, AIAA, AAS, will host the First International Conference on Hypersonic Flight at the University of North Dakota on September 20-23, 1988.

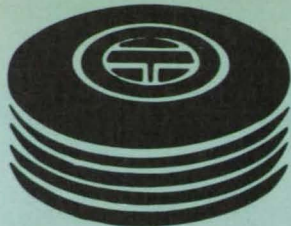
Special sessions will include status reports on hypersonic research and development from the U.S., Europe, Japan and U.S.S.R. Presentations will be made by Robert Barthelemy (U.S. Air Force), Robert Williams (DARPA), Duncan McIver (NASA), Peter Conchie and B.R.A. Burns (British Aerospace), H. Kuczera (MBB), Tatsuio Yamanaka (NAL/STRG), Hiroyuki Hirakoso (Mitsubishi), T. Ito (NASDA), and to be announced (U.S.S.R.).

Sessions addressing specific hypersonic flight issues include propulsion, computational fluid dynamics, operational infrastructure, public policy, environmental issues, airframe & vehicle designs, avionics & AI, legal issues, military uses, and economics.

Registration fee is \$495 (U.S.) prior to August 1, \$595 from August 1 through the conference.

For registration information contact: Dawn Botsford, Continuing Education, University of North Dakota, Box 8277, University Station, Grand Forks, ND U.S.A. 58202; phone (701) 777-3633.

Circle Reader Action No. 590



Computer Programs

- 54 Program Collects and Analyzes Thermoelectric Data
- 58 Archival-System Computer Program

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 1988 *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.



Physical Sciences

Program Collects and Analyzes Thermoelectric Data

The program is also adaptable to other types of experimental data.

The Large Gradient Seebeck Coefficient Measurement computer program gathers many channels of data, performs analysis, and plots each set of data simultaneously.

HIGH ACCURACY AND LIGHT WEIGHT

...crucial!

Testing systems in flight is crucial and requires equipment that is highly accurate, lightweight and compact in size. Teledyne Taber meets these requirements with a line of flight test transducers, the result of 35 years' experience in the development and production of quality pressure transducers.

The Taber line of flight test transducers includes units from 0-15 to 0-50,000 PSI.

Flight test transducer models feature:

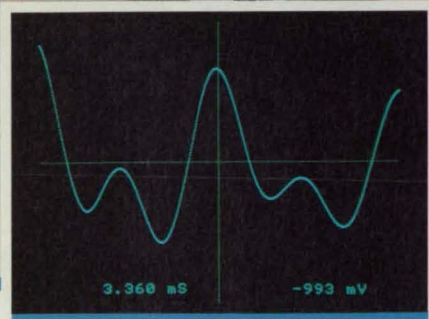
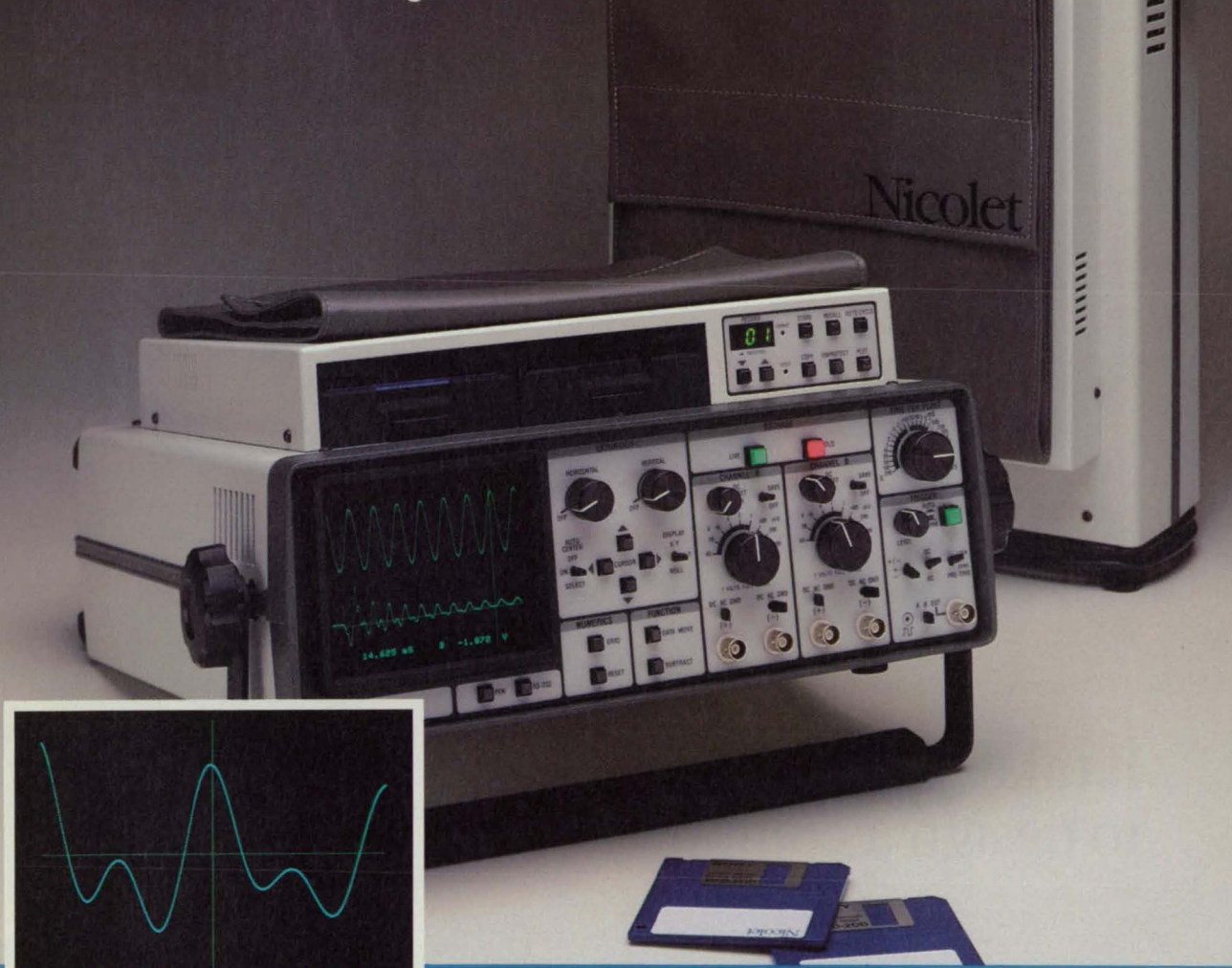
- Lightweight units, as small as 2.7 oz.
- Miniature units, 7/8" in diameter
- Leak test integrity better than 2×10^{-9} cc. std. helium per second
- Austenitic stainless steel pressure cavity
- Positive mechanical stops for high overload pressures
- Excellent thermal stability

TELEDYNE TABER

455 BRYANT STREET, NORTH TONAWANDA, NY 14120
(716) 694-4000 Telecopier: (716) 694-1450
Call toll free 1-800-333-5300

Write or call today for more information on the full line of Taber transducers.

Reliability, Precision, Portability



Meet the NIC-310!

- 2 Differential Input Channels
- 4000 Points Per Channel
- Y/T or X/Y Display
- Display Expansion Up To x60
- IBM-PC Formatted Disks
- 12-Bit Resolution
- Autocycle Mode
- IEEE-488/RS-232 Interfaces

Laboratory Precision in a Portable Package!

Nicolet introduces the NIC-310, the world's only portable 12-bit Digital Oscilloscope featuring either 3.5 or 5.25 inch IBM-PC formatted floppy disk storage. The NIC-310 is ideally suited for multiple single shot transient capture using its "Autocycle" mode to monitor transients and store up to 88 waveforms on one disk. The "Autocycle" mode automatically rearms the NIC-310 for each new trigger. Zoom expansion lets you see details you've never seen before. Easy to use cursor display permits you to visually set the trigger position for pre-trigger data. With the proven reliability of Nicolet digital oscilloscopes, the NIC-310 offers you a range of options that make it one of the most versatile portable instruments available.

For more information call or write:

Nicolet Test Instruments Division

5225-2 Verona Road, Madison, WI 53711 608/273-5008 or 800/356-3090

Nicolet

INSTRUMENTS OF DISCOVERY

Circle Reader Action No. 350

It takes quite a computer to design a computer.

When IBM design engineers need a workstation to design the future, they turn to the IBM RT™ system for developing everything from circuits to software.

More and more commercial users are also recognizing that the RT's power, enhanced connectivity, extensive application library, outstanding graphics and low price make it the system-of-choice to build on. Medical practices, bridge builders and retail chains are among those that have already put the RT to work.

IBM RT™ Specifications

Users

1-32

System Memory

2MB-16MB

Operating System

AIX (native mode)

Languages

C, Advanced C, VS Pascal, Pascal,
Basic, VS Fortran, Fortran 77, RM
Cobol, Common LISP, Assembler

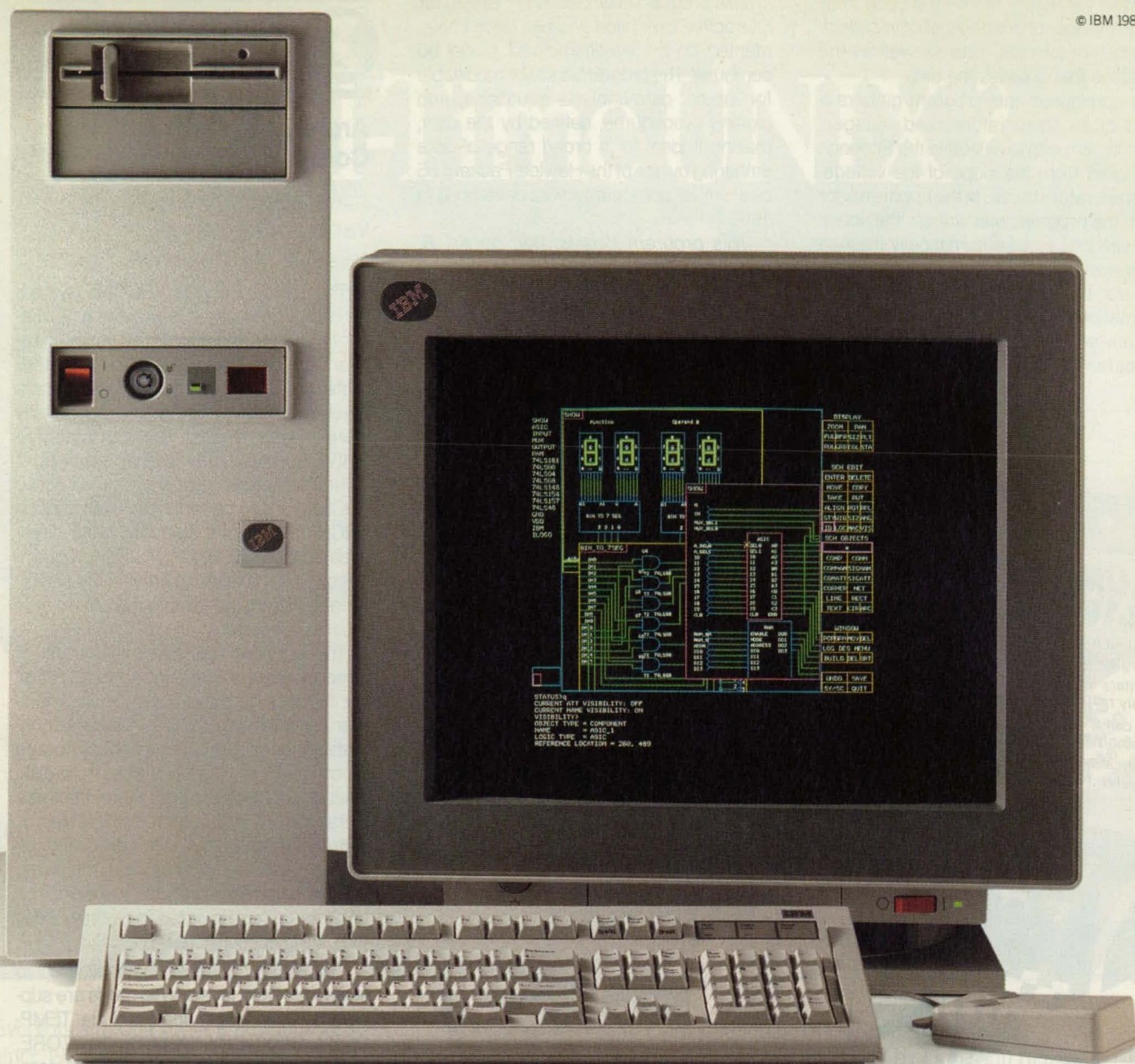
Data Base

Oracle™ Ingres

Microprocessor

RISC processor, 170 or 100
nanoseconds, 20MHz Motorola
68881 Floating Point unit

The IBM RT is a high-performance system based on Reduced Instruction Set Computer (RISC) technology, an innovation pioneered by IBM to execute most instructions in a single cycle. Designed with the UNIX™ environment in mind, the RT can run hundreds of existing programs and



take full advantage of future AIX™ and UNIX innovations.

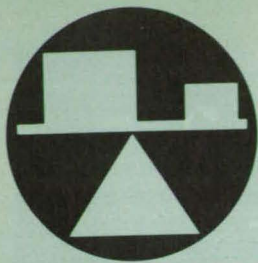
To meet your complex communications requirements, the RT supports TCP/IP, ASCII, SNA, Ethernet®, Token-Ring and NFS™ networking configurations for homogeneous/heterogeneous distributed networks for up to 32 users per RT. And you can easily customize your RT system to your particular needs using languages and programming tools for commercial, scientific and expert system applications.

Add to this winning formula the RT's advanced memory management, data base management systems, floating point capabilities and IBM's unparalleled service and support. And you've got quite a computer, indeed.

To arrange for a call from an IBM marketing representative or an IBM industry remarketer, or for literature, call 1-800-IBM-2468, Ext. 41.



The Bigger Picture



Mechanics

Hardware Techniques, and Processes

60 Measuring Flow by Holographic Interferometry
62 Linear-Alignment Testing Grips

Books and Reports
64 Stiffening Rings for Rocket-Case Joints

65 Acoustical Tests of a Scale-Model Helicopter Rotor

Measuring Flow by Holographic Interferometry

The flow field is reconstructed by computer-aided tomography.

Ames Research Center, Moffett Field, California

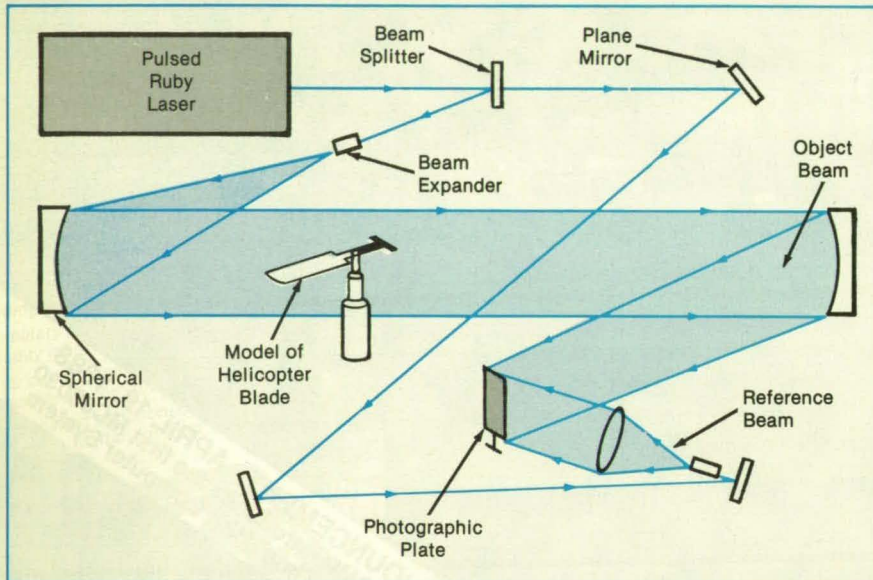


Figure 1. A **Holographic Interferogram** is formed on the photographic plate by the interference between the object and reference beams. Double-exposure interferograms taken with the blade rotating and stationary at various positions are processed to reconstruct mathematically the airflow about the blade.

A method for determining the flow of air about a model helicopter-rotor blade combines the techniques of holographic interferometry and computer-aided tomography. The transonic flow field obtained by applying the method to a 1/7-scale blade operating at a tip speed of mach 0.90 agreed well with a nonviscous theoretical flow field, except in a small region near the tip where the computer code did not predict a shock wave that is observed there.

The holographic apparatus is illustrated in Figure 1. A single rotor blade balanced by a counterweight is mounted in the object beam with a field of view 2 ft (0.6 m) in diameter. Holographic interferograms of the blade and the surrounding air are recorded on photographic plates, using pulses from a ruby laser having a duration of 20 ns, wavelength of 694.3 nm, and energy of 1 J. At each of 40 azimuthal positions of the blade, two holograms are taken in a double exposure: one when the blade is stationary and one when the blade is rotating at the speed for which the flow is to

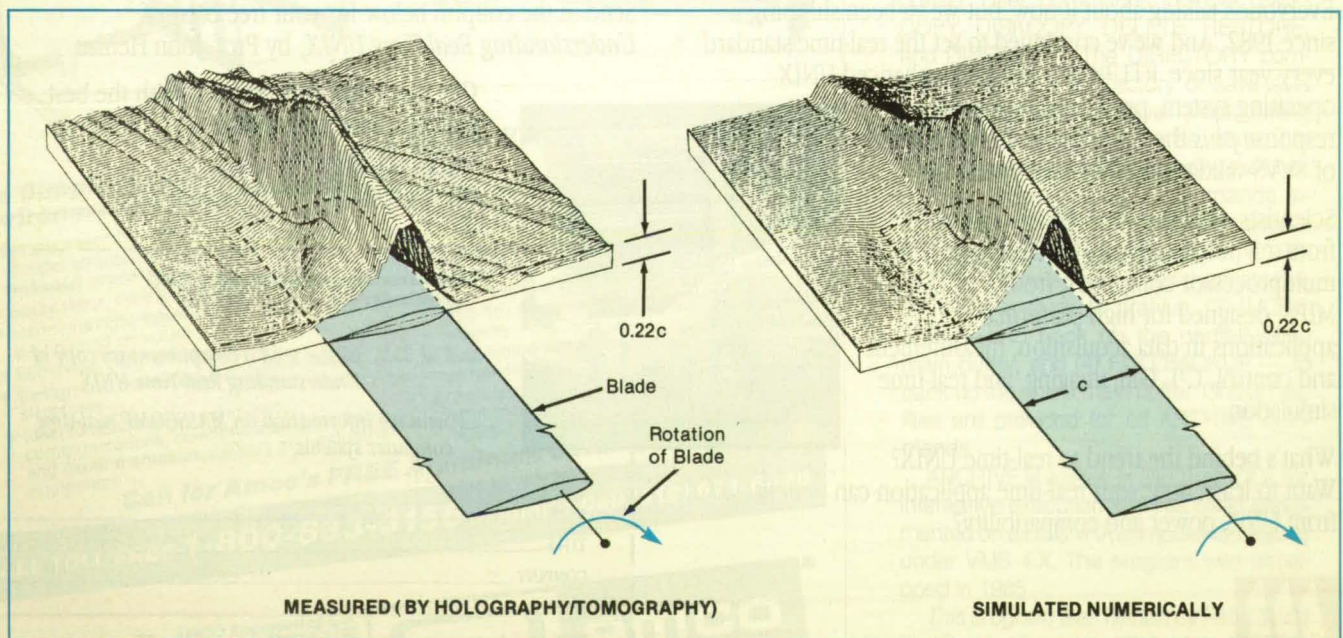
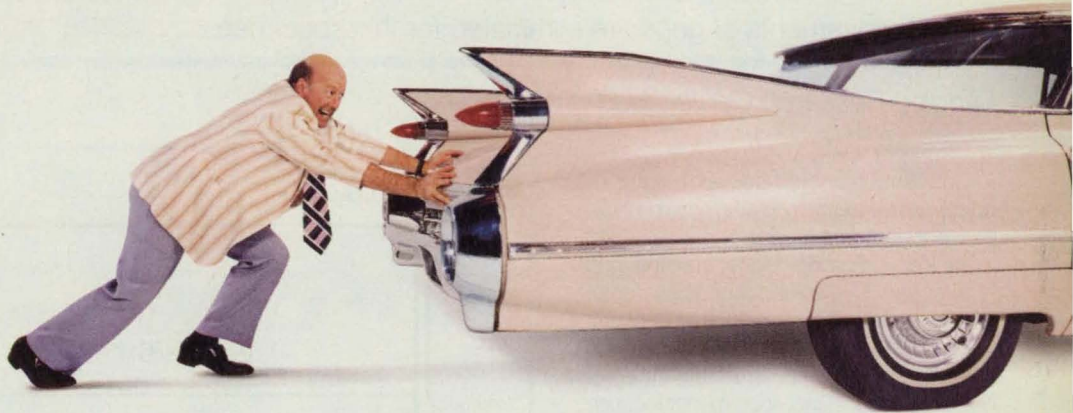


Figure 2. **Perturbation-Velocity Distributions** on a plane above the blade in the tip region were obtained by the holography/computer-aided-tomography method and by numerical simulation of the flow. The greater roughness in the former may be due to vibrations of the measuring instruments, noise, or coarseness of the experimental-data grid.

ARE YOUR SUPPLIERS STILL PUSHING YESTERDAY'S TECHNOLOGY?

If you're tired of retread automotive products and designs, take a look at Airpax automotive products. You'll see how our digital linear actuators revolutionized fuel management systems. You'll see our highly advanced speed sensors improving engine control, anti-skid braking systems, and traction control. And you'll see our stepper motors, brushless DC motors, and other electromechanical and electromagnetic components bringing new technology and greater reliability to all kinds of automotive applications. But most important, you'll see how our extensive automotive design experience comes together with all the technological resources of Philips to produce the kind of automotive products supplier you need today. Don't let old, tired suppliers push old, tired ideas off on you.

Call or write the Airpax Automotive Products Group and ask for our new Capabilities Brochure. Airpax Company, West Johnson Avenue, Cheshire, Connecticut 06410. (203) 272-0301. A division of North American Philips Corporation.



AIRPAX[®]
AUTOMOTIVE PRODUCTS GROUP

Circle Reader Action No. 566

be measured.

The first exposure on each plate contains the interference-fringe pattern that arises from the spatially uniform index of refraction of undisturbed air; the second exposure contains the fringe pattern due to the nonuniform refractive-index distribution of the flowing air. Thus, the local fringe order in the developed photographic plate represents the integral, along the line of sight, of the difference between the refractive indices in the presence and absence of flow, respectively.

The interferograms in the plates are digitized, and the fringe-order numbers and

coordinates are recorded along scans at various heights above the blade. The fringe-order data serve as input for a filtered-back-projection computer-aided-tomography code used to compute the refractive-index field at designated points in a horizontal plane above the plane of the blade. The density field of the flowing air is obtained from the refractive-index field via the simple proportionality between the density and the index of refraction minus 1.

Bernoulli's equation for steady, compressible, isentropic flow in the frame of reference of the moving blade is used to obtain the perturbation-velocity field from

the density field (see Figure 2). These calculations are performed in several planes above the blade to obtain the entire three-dimensional velocity field in the vicinity of the tip of the blade.

This work was done by Yung H. Yu of Ames Research Center and John K. Kittleson of the University of California, Los Angeles. For further information, Circle 134 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 12]. Refer to ARC-11728.

Linear-Alignment Testing Grips

Lateral movements of grips are eliminated for thin specimens.

Langley Research Center, Hampton, Virginia

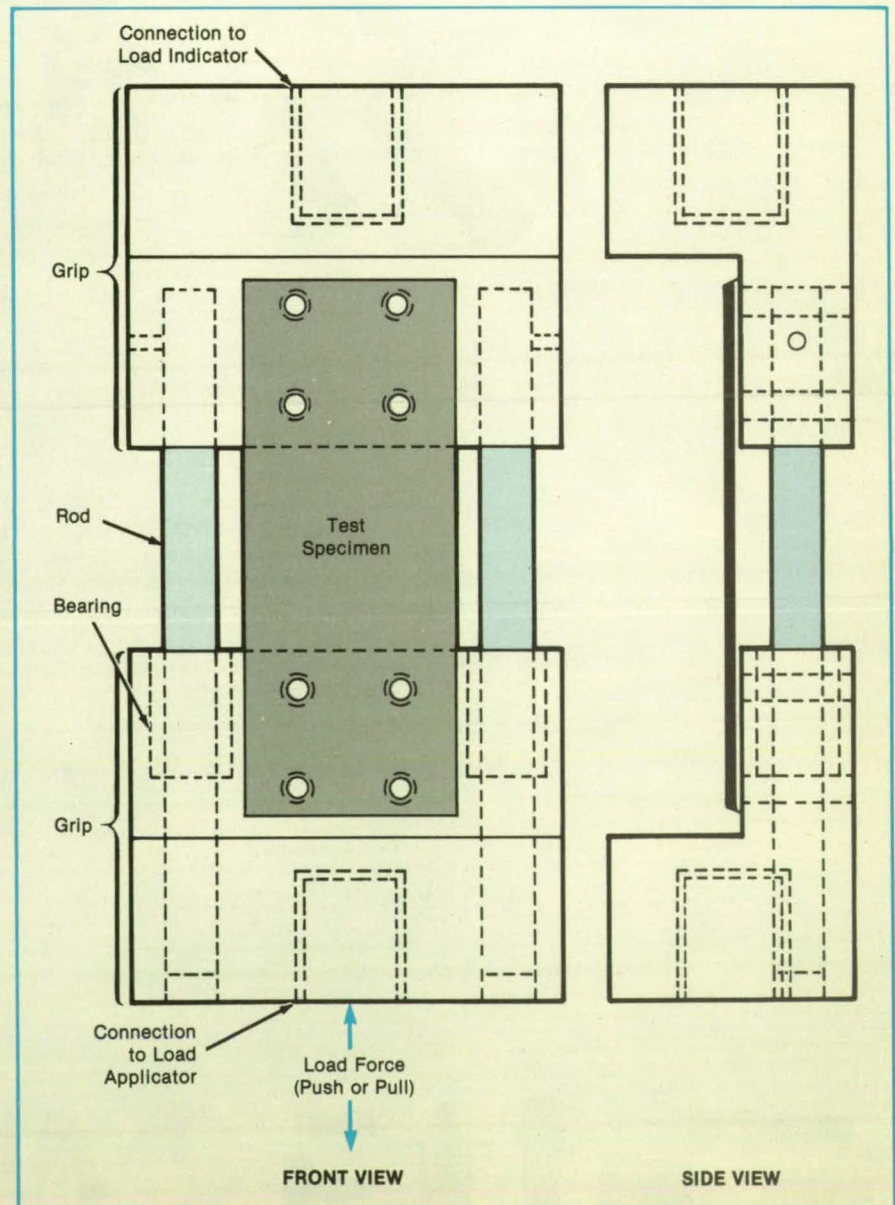
Conventional methods of tensile or compressive fracture testing use the independent grip system: one grip is attached to the load-indicating device, the other grip is attached to the load-producing force, and the test specimen is gripped between the two. These standard grips provide no lateral alignment. This arrangement is acceptable for most test specimens because they are usually quite stiff in the transverse direction, and lateral motion of the grips does not occur. However, this is not the case for thin composite specimens, particularly in compression loading. Lateral motions of the grips during compression tests bend the specimen and, therefore, can substantially affect the data.

To prevent lateral motions, a newly designed set of grips provides lateral alignment by the use of two rods (see figure). The new design integrates linear bearings with close-tolerance matching rods into the gripping chain. The rods are fixed into the load-measurement grip, and the load-applicator grip slides along them. These rods do not interfere with the force being applied but prevent lateral motion of one grip relative to the other.

These grips have been machined and are being used successfully at Langley Research Center in tests of the compressive fracture of thin, notched composites. Additional grips have since been designed with four rods and bearings for greater resistance to lateral motion.

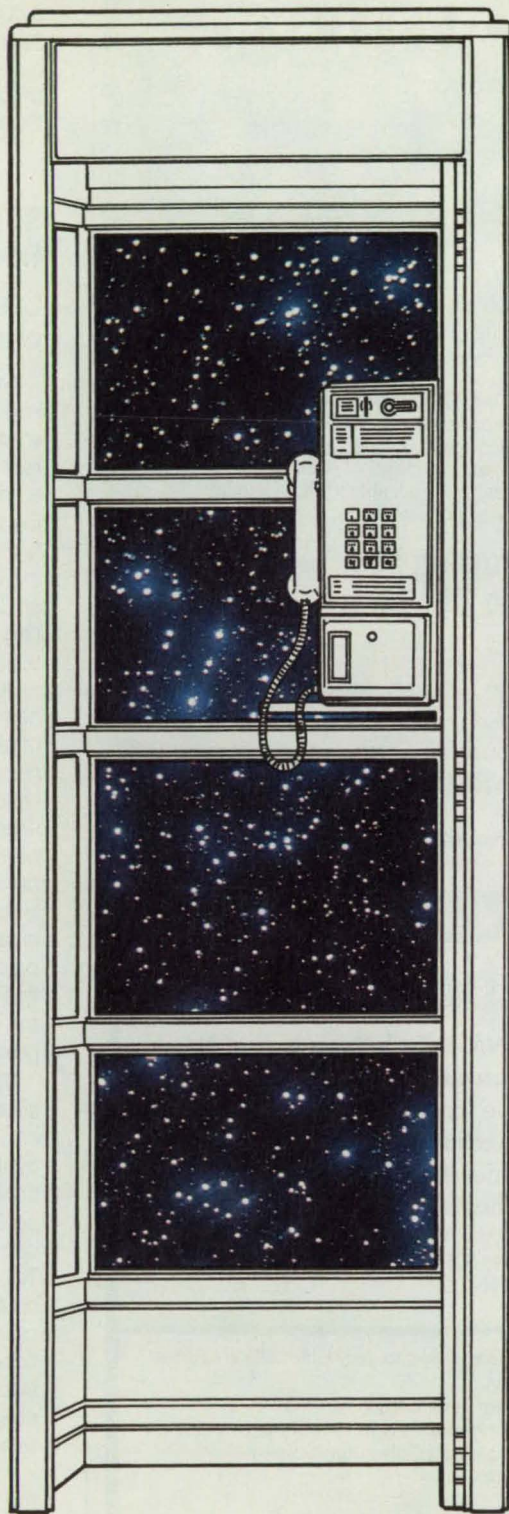
This work was done by Mickey R. Gardner of Langley Research Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 12]. Refer to LAR-13493.



Rods and Linear Bearings keep the grips laterally aligned as they move up or down.

When the call
to TDRSS
doesn't go
through...
there's
no getting
your dime back.



System availability and reliability are the big issues for NASA as it acquires its Second TDRSS Ground Terminal (STGT). Delivery of data to users depends on it.

The Nation's commitment is too great to demand anything less than the objective NASA has established: 0.9999 availability. That's why GE is competing to build STGT; we can respond to the challenge. That's why GE is proposing an all-new distributed data system architecture for reliable operations.

We've designed for low life cycle cost too, by significant reductions in equipment and personnel—to be achieved in hardware, automated operations and proven command and control concepts from current successful programs.

And we've made the human, financial and technical commitment to deliver to NASA on time and within cost.

As the first user of TDRSS, we know how vital STGT is. So, while offering the technical solution that NASA asked for, we're more than just a supplier. We've been there.

STGT will play a key role in Earth/Space communications for years to come...and GE is committed to making 0.9999 availability a reality.



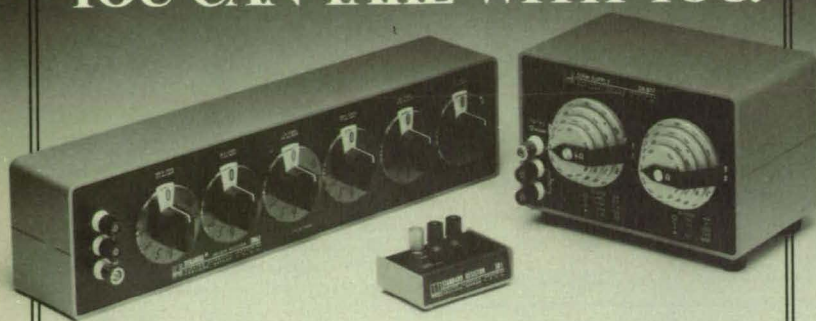
GE Aerospace

Ground Systems Department
Valley Forge, Pennsylvania

Circle Reader Action No. 583

STGT-1

LABORATORY PRECISION YOU CAN TAKE WITH YOU.



ESI's highly stable and transportable Resistance Standards allow routine calibration in the laboratory or in the field.

The SR1 individual resistance standards offer 0.005% long-term accuracy for most values from 1Ω to 10MΩ. Dekabox® DB877 Coaxial Dial and DB62 In-line Decade Resistors provide additional linearity checking capability with virtually continuous resistance between 0.01Ω and 12MΩ at 0.02% accuracy.

When you want to be sure your instruments are performing up to specifications, call ESI, the leading manufacturer of resistance standards traceable to the National Bureau of Standards.

Putting Precision To The Test.



Electro Scientific Industries, Inc.
13900 NW Science Park Drive • Portland, OR 97229
1-800-547-1863 (In Oregon call 503-641-4141)

Circle Reader Action No. 624

NTB:BASE Research Center offers

12,000+ Solutions

NTB:BASE
from NASA TechBriefs

In minutes you can search 25 years of NASA Tech Briefs to find NASA developed innovations that might be related to your current project. On the way to space NASA has had to solve thousands of problems in all engineering fields. Put this wealth of technology to work for you. A database that covers 25 years of NASA developed technology.

- **PC-Compatible database.** Can be used on IBM PC/XT/AT or compatible with 256k-memory, DOS 2.0 or higher, double-sided drive.
- **Subscription cost.** Each category costs \$100.00. All six for \$500.00. Annual updates \$20.00 per category and \$100.00 for all six.

Enclosed is check for \$_____ (for more than one category for all categories; Format: 360K 1.2M) covering the following:

- A Electronics**
- B Physical Sciences**
- C Mechanics**
- D Materials**
- E Fabrication Technology**
- F 3-in-1 (Mathematics & Information Sciences, Life Sciences and Computer Programs)**
- ★ ALL CATEGORIES**

Name _____

Company _____

Address _____

City _____ State _____ Zip _____

Phone _____ Send more information

NTBM Research Center

41 East 42nd St., NY, NY 10017-5391

212-490-3999

NTB:BASE
from NASA TechBriefs

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.

Stiffening Rings for Rocket-Case Joints

Loss of seal may be preventable.

Stiffening rings may help to prevent the loss of seal at joints between segments of solid-fueled rocket motors, according to a report. The rings were developed and tested in response to the catastrophic failure of the *Challenger*, which has been attributed to the rotation of the tang with respect to the clevis and the consequent opening of an O-ring seal in such a joint. The stiffening-ring concept may also be applicable to segmented terrestrial pressure vessels.

A pair of stiffening rings is to be installed near each joint — one on the tang side, the other on the clevis side. The rings are meant to alter the deformation of the case, which occurs under the pressure of rocket firing. The new pattern of deformation is to be such that the rotation of the components of the joint with respect to each other is reversed from that caused by the normal outward bulge at the joint, or else eliminated. Elimination or reversal of the rotation by a suitable amount should prevent the opening of a gap on the O-ring, thus preserving the seal.

The alteration in the behavior of the structure is primarily a function of the stiffness of the rings, which is the product of the hoop modulus and the cross-sectional area of the ring. Graphite-fiber/epoxy composite was chosen as the ring material because of its high ratio of stiffness to weight. Two rings were wound, one near the tang on one segment and the other near the clevis on a mating segment of a test rocket case. The rings and the joints were instrumented to measure stresses and strains. The joint was assembled and tested twice without shims, with custom shims, and with offset shims. In each test, the interior of the case was pressurized to 1,020 psi (7.03 MPa) for 130 s.

The measured hoop strains showed that the rings reversed the rotation to approximately the anticipated degree. In the presence of custom shims, the O-ring gap opening was kept to an average of 0.1 mil (2.5 μm), as compared to 30 to 40 mils (0.8 to 1.0 mm) without the stiffening rings. Although the rings became unbonded from the cases in some areas early in the tests, they continued to work without adverse ef-

NASA Tech Briefs, July/August 1988

fects. The maximum principal stresses behind the pinholes on the clevis were 40 percent lower than the corresponding stresses in the absence of the rings. The hoop strains were nearly identical in all the tests.

This work was done by Bryce W. Thompson, Larry G. Adams, and Meldon J. McIntosh of Morton Thiokol, Inc., for Marshall Space Flight Center. To obtain a copy of the report, "SRM Joint Deflection Referee 2A (Composite Overwrap) Test Report," Circle 160 on the TSP Request Card.
MFS-28269

Acoustical Tests of a Scale-Model Helicopter Rotor

Data are obtained in simulated hovering flight in an open environment.

A report discusses measurements of the sound generated in an outdoor hovering test of a 1/6-scale, four-bladed helicopter rotor. The outdoor environment is relatively well suited to the acquisition of good acoustical data because most of the undesired echoes and streaming effects of wind tunnels are not present.

The report provides information on the delineation between the acoustic near field and far field and on the effect of a simple boundary-layer-tripping device. In addition, the report covers rotor acoustics at low thrust and at high thrust.

Hovering tests yield insight into flow and noise phenomena of forward flight. The acquisition of acoustical data is much simpler in hovering flight because flow noise, shear layers, and Doppler effects are absent. In general, acoustic data obtained during hovering tests tend to be of a higher quality than those from wind-tunnel or flight tests.

The 2.13-m-diameter rotor was mounted in the standard thrust-up, wake-down configuration at a height of about 6 m above the ground, with a large unobstructed area around it. An array of microphones in a single vertical plane acquired data at a variety of distances and angles. The tip mach number and the rotor thrust coefficient were the primary test variables.

The test showed that a microphone should be positioned no closer than two rotor diameters to measure the far acoustic field of a rotor at all harmonics of the blade-passage frequency. The use of a simple device (strips of adhesive tape) to trip the boundary layer resulted in aerodynamic effects that are not completely understood: the use of tape was tried as a quick and easy alternative to the fairly-involved conventional procedure of attaching small particles of the correct size, spacing, and position to the surface near the

leading edge. The results, however, were inconclusive.

The data obtained at nearly zero thrust indicate that although loading-noise effects are not completely eliminated, they can be reduced enough to enable the identification of thickness noise. This knowledge will be useful in future efforts to correlate predictions of thickness noise with measurements.

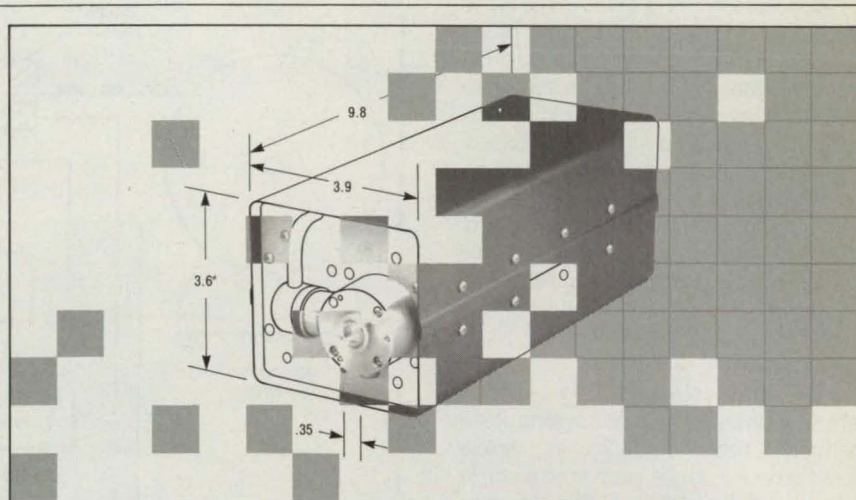
As the thrust coefficient rises from 0.09 to 0.11, the noise emitted by the rotor changes abruptly from a buzz-saw sound to a roar. This effect probably results from the interaction of the unsteady wake with the support apparatus; it does not seem to

be related to rotor-stall phenomena.

This work was done by Cahit Kitaplioglu of Ames Research Center and Christopher Kinney of H. S. Robinson, Inc.

Copies of the report, "A Study of Helicopter Main Rotor Noise in Hover," 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.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 12]. Refer to ARC-11773.



CUSTOMIZED X-RAY SOURCES

Customized x-ray sources provide uncompromising performance to new technical applications.

Projects often use conventional x-ray sources because the application or project technology has been around for years. However new applications are surfacing that are based upon specific x-ray source performance criteria not commonly found in existing source designs. X-ray lithography, residual stress analysis, and plating thickness gauging are a few examples.

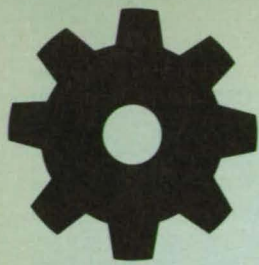
To fulfill the market needs, our engineers have successfully designed sources using rotating focal spots, microfocal spots, ring anodes, and pulsable cathodes.

KeveX's philosophy is to design x-ray sources for specific applications no matter how unique or dedicated the product is. Recently KeveX was contracted to design a portable x-ray source that was lightweight, and operational from batteries. KeveX delivered a 70kV, 3mA self-contained source, weighing less than nine pounds total.

Contact KeveX to find out the latest development in x-ray source technology before sacrificing your product design.



KeveX X-Ray Tube Division
P.O. Box 66860 Scotts Valley, CA 95066 408-438-5940



Machinery

Hardware Techniques, and Processes

- 66 Coding Ropes for Length and Speed Measurements
- 66 Predicting Temperatures in Ball Bearings
- 72 Spark Igniters Fit in Correct Locations Only

- 74 Continuous-Flow Centrifugal Separator
- 74 Large-Angle Magnetic Suspension (LAMS)

- Books and Reports
- 75 Nonlinear Analysis of Rotor Dynamics

Coding Ropes for Length and Speed Measurements

Ferromagnetic staples would serve as markers.

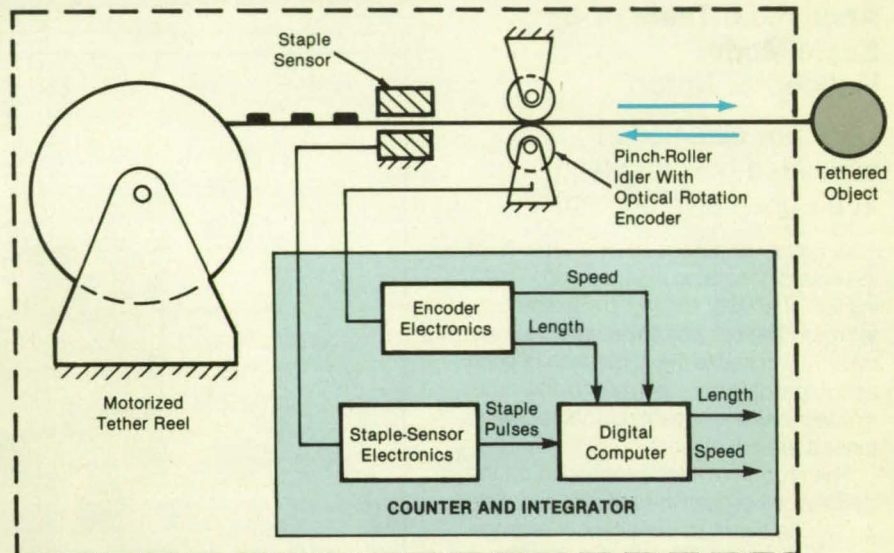
Marshall Space Flight Center, Alabama

A concept for coding space tether ropes would give instantaneous readings of the length of line deployed and the speed of deployment. The concept may be adaptable to such terrestrial tasks as laying submarine cables and the construction of suspension bridges. According to the concept, steel staples would be inserted in the rope with a predetermined pattern and spacing. As the rope is unreeled, a sensor would produce a pulse each time a staple passed it. Logic circuits would interpret the pulses to determine the length, speed, and direction of the line.

The staples could also be used by a vehicle such as an elevator traveling along the rope. A sensor on the moving vehicle would produce pulses each time a staple was passed. From the pulses, the speed, direction, and position of the vehicle would be determined.

After the rope has been manufactured, it would be transferred from its storage reel to a takeup reel a short distance away. The rope would pass a stapler, which would insert staples at preset intervals. The staples would be designed to minimize compression of the line. After stapling, a protective coating would be applied to the line. The distances between staples may range from centimeters to hundreds of meters, depending on the intended use.

An electronic controller and a system of pulleys would maintain the expected operating tension on the rope so that the distance would be nearly the same as in the stretched line. Locally, the staples would be grouped according to a code to provide



Like a Crude Magnetic-Tape-Playback Head, a sensor would detect the ferromagnetic staples as the rope is unwound or wound. The pulses from the staples would be analyzed electronically; the numbers of pulses and the intervals between them would be interpreted in terms of the velocity of the rope and the length payed out.

data on the direction of motion and speed. A verifying unit after the stapler would test the stapled codes. It would compare a code with the stapler program and stop the drive in case of error.

In use, the codes would be read out by a sensor of ferromagnetic material. The sensor pulses would be analyzed by a counter and integrator (see figure).

The concept promises greater accuracy than is offered by conventional methods of measuring payout. For example, the measurement of deployed length by a rotating idler wheel is subject to error be-

cause of slippage and stretching of the line, and marking the line with stripes for optical recognition tends to produce unreliable results because of the small diameter of the line.

This work was done by Charles C. Rupp and Georg von Tiesenhausen of Marshall Space Flight Center. For further information, Circle 79 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 12]. Refer to MFS-28226.

Predicting Temperatures in Ball Bearings

Computer simulations speed design studies.

Marshall Space Flight Center, Alabama

The thermal analysis of high-speed, rolling-contact bearings has matured so much that computerized numerical simulations can sometimes replace expensive, time-consuming full-scale experiments. With currently-available computer pro-

grams, engineers can now obtain false-color graphical maps of transient and steady-state temperature fields in bearings and races, even in the presence of such complicating factors as cooling by convection. With the help of these plots, the ef-

fects of changes in design or in operating conditions can be visualized quickly and easily.

Analyses can be performed in two or three dimensions. The sizes and shapes of components are approximated by zones

THE CHALLENGE: "DEMONSTRATE HOW HIP ENHANCES THE PERFORMANCE AND IMPROVES THE FATIGUE STRENGTH OF ADVANCED COMPONENTS."

This is a challenge our Whitehall HIP Department meets every day. Here we operate one of the largest toll Hot Isostatic Pressing facilities in the world. In partnership with our customers, we provide quality service to a broad range of industries, including aerospace. So when Textron Lycoming wanted to strengthen the AMS 4225 aluminum heads on their reciprocating aircraft engines, they came to Howmet. Together we were able to develop a HIP program that significantly improved the performance of their components.

EXTENSIVE APPLICATIONS FOR HIP.

HIP subjects components to a high gas pressure and elevated temperature sufficient to reduce shrinkage porosity and close internal voids. Many engineers are learning that HIPed cast components deliver the consistency and mechanical properties expected of forgings. In addition to titanium and superalloys, performance improvements are also seen in steel, bronze, cast iron,

ceramics and aluminum. We also HIP powder metal components.

HIP lowers life cycle costs, and not just for the aerospace industry. HIP is used for high performance automotive pistons, rods, crankshafts and engine blocks. It also has applications for electronics, ceramic products, medical implants and pump and valve components for the oil, food and chemical industries.

HIP PIONEERS.

We began production HIPing in 1975 and now have one of the largest capacities in the world, with capabilities from small developmental-size presses to 57" in diameter and 80" in height, pressures to 45,000 psi and temperatures to 4000°F.

This extensive range enables us to answer virtually any challenge.

THE IMPOSSIBLE MADE POSSIBLE.

Another service that sets Howmet apart is our 80,000 square foot research, development and engineering center. Here metallurgical teams and laboratory specialists come up with breakthrough solutions to seemingly impossible challenges. They are always available to you as a Howmet customer.

WE INVITE YOUR CHALLENGES.

At Howmet, we will work as a partner with you, engineer to engineer, from concept through design to finished product. Whether your problem requires a cost-effective solution or state-of-the-art technology for complex applications, we can help. Impossible? Challenge us.

For more information, write our Sales Department, Howmet Corporation, 475 Steamboat Road, Greenwich, CT 06836-1960. Or contact the manager of the Whitehall HIP Department, 1600 South Warner Road, Whitehall, MI 49461, telephone (616) 894-5686.

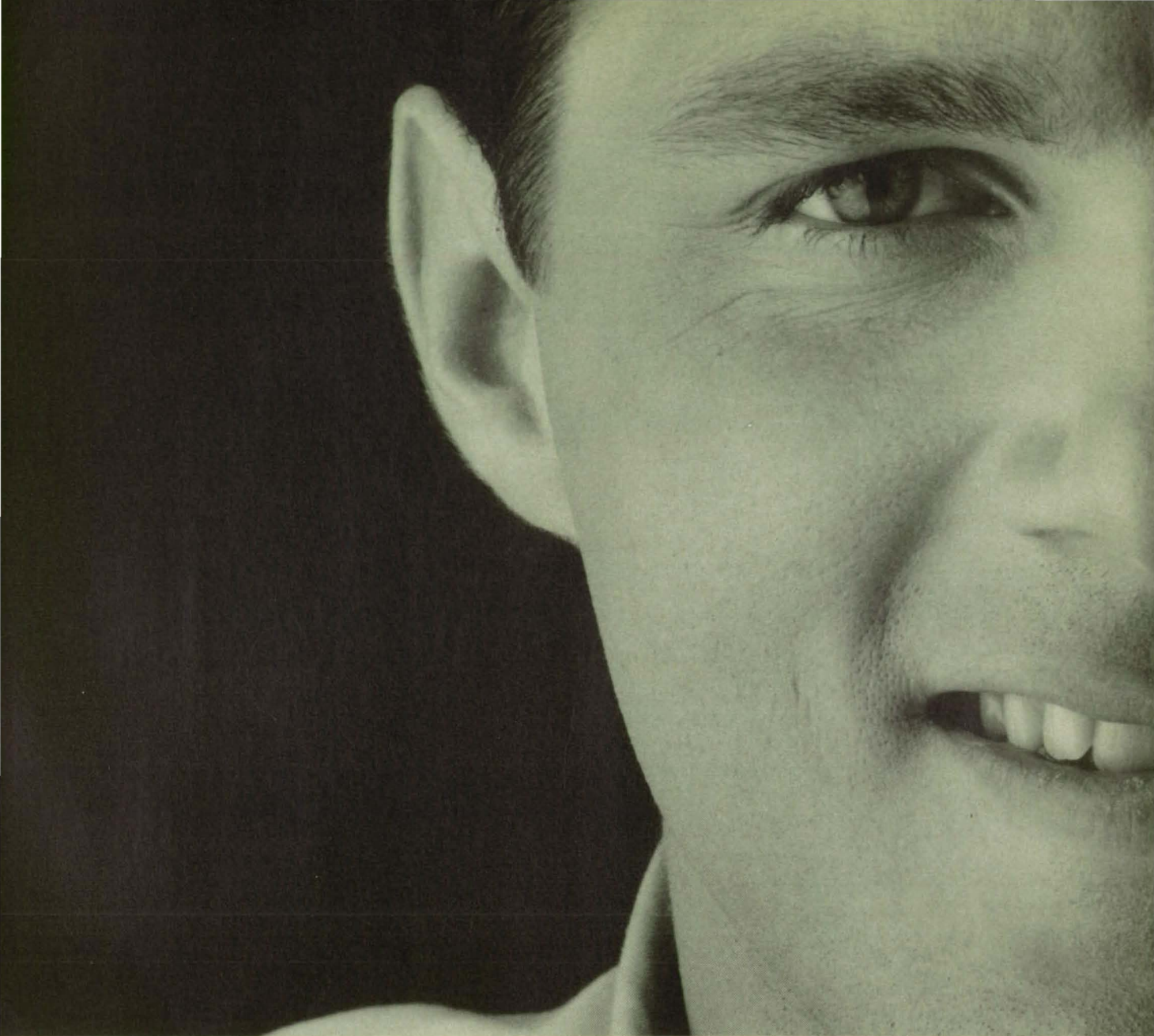


Partners. Challenge by Challenge.

WHITEHALL HIP DEPARTMENT, WHITEHALL, MI



Circle Reader Action No. 335



For the first time, users of UNIX[®] System

Announcing ETA System V.

Until today, if you used a system based on the real AT&T UNIX System V operating system, your lips were sealed when it came to working with a supercomputer. Making the move to true supercomputing meant having to learn a complicated proprietary operating system.

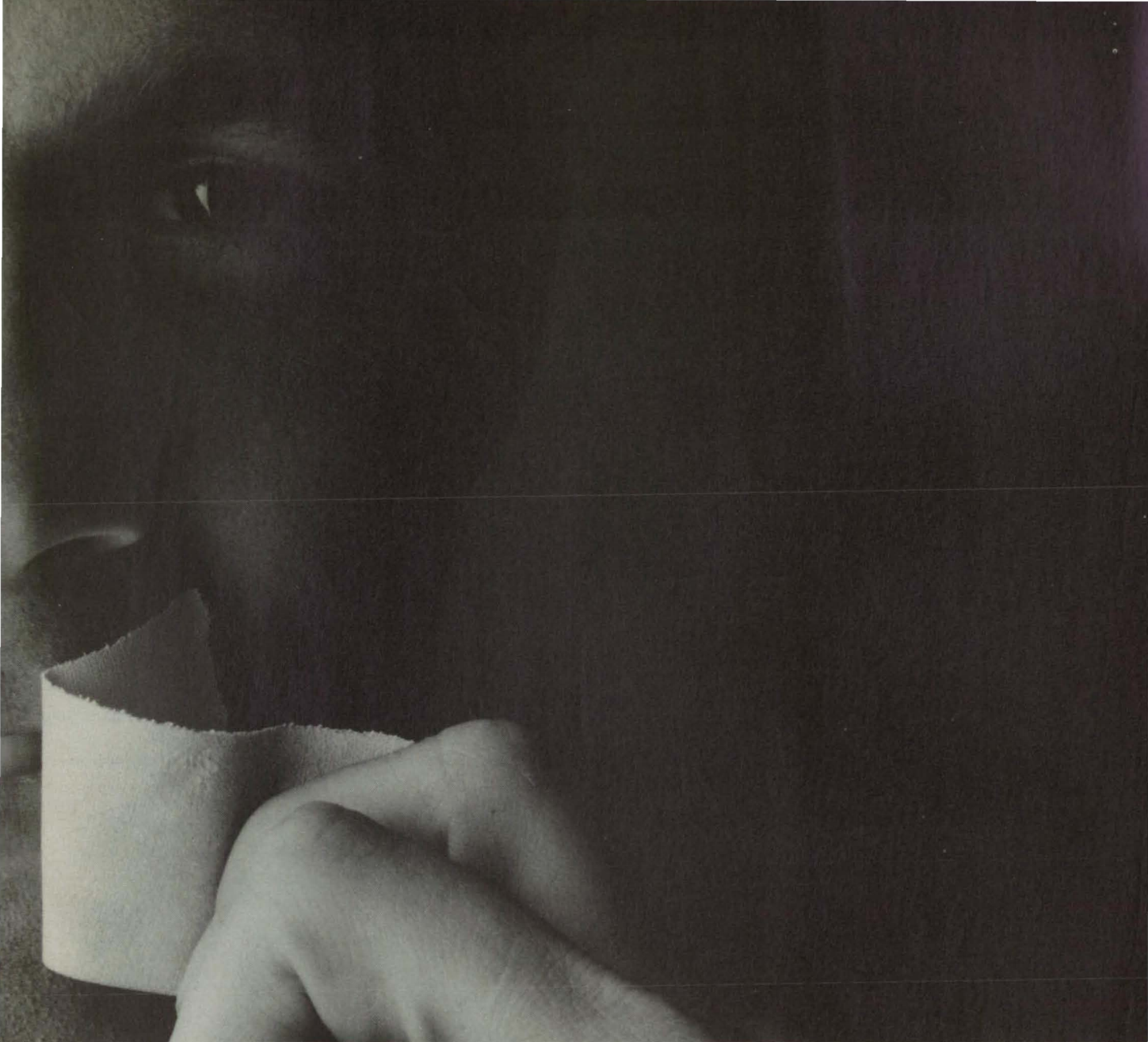
Those days are over. Because the first native operating system for a supercomputer based on AT&T's UNIX System V has arrived — ETA System V.

For the first time, users can work with the most powerful

computers in the world using familiar commands.

ETA System V meets all the requirements of AT&T's System V Interface Definition (SVID) Release 3.0. It has passed all 5,500 tests in the System V Verification Suite. It is also the only supercomputer operating system to support features like ipc, semaphores and shared memory. Unlike non-standard operating systems, ETA System V has the advantages of byte addressability, virtual memory support, BSD sockets and r-commands.

ETA System V makes it possible to develop applications on industry-standard workstations compatible with AT&T's



System V can talk to a true supercomputer.

UNIX System V and then compile and run them on any ETA10 Supercomputer — from the affordable ETA10-P, the ETA10-Q and ETA10-E to the world's most powerful supercomputer, the ETA10-G.

Now, all your present applications based on AT&T's UNIX System V can be ported easily to ETA10 Supercomputers. Programs that once took months to port now take hours. Because programs based on AT&T's UNIX System V don't have to be rewritten.

ETA is also developing a library of applications specifically for AT&T's UNIX System V users in higher education environ-


ments. These applications include SPSS, IMSL and DI3000.

If you know AT&T's UNIX System V, you now have a voice in supercomputing. Beginning today.

Talk to your Control Data representative, or: ETA Systems, Inc., 1450 Energy Park Drive, St. Paul, MN 55108. Phone: (612) 642-3460.



ETA10 SUPERCOMPUTERS.

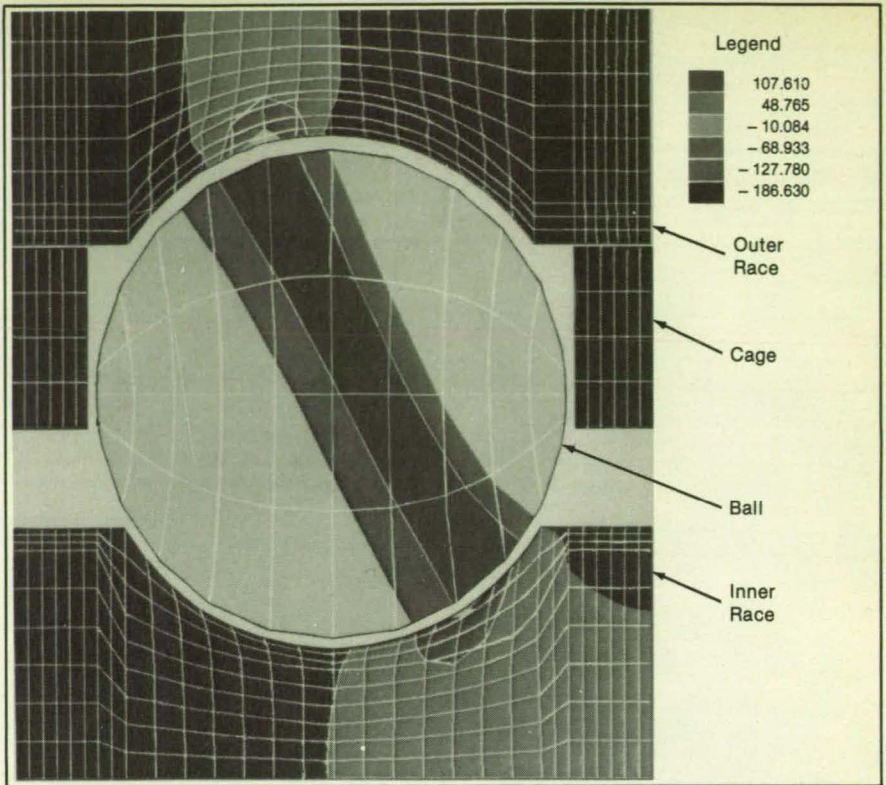
 CONTROL DATA

Circle Reader Action No. 626

or nodes connected by gridlines. From the geometric information about the grids and from boundary conditions, the properties of the bearing and lubricant materials, and other information supplied by users, the thermal-analysis programs generate mathematical models for thermal transport. These models resemble electrical circuits, with thermal capacitance, thermal resistance, temperature, and the flow of heat as the analogs of electrical capacitance, electrical resistance, voltage, and current, respectively. The differential equations of the models are solved by finite-difference techniques.

The figure shows the results of a steady-state analysis of a ball and the races in a thrust bearing designed to operate in liquid oxygen. The ball is modeled as five concentric spherical shells. Each of the four inner shells is represented as one node. The fifth shell, which depicts the outer surface of the ball, contains 55 nodes. Each surface node is connected to the adjacent nodes, and all are radially connected to the fourth node.

As the ball rolls around the races, frictional heating at the two contact spots forms heated bands on the races and on the ball. The band on the ball does not spread all over the surface because the ball rolls along the same great circle on its surface over a relatively long time.



Isothermal Bands are depicted in color on the computational grid that represents a thrust bearing. The numbers denote the temperatures at the edges of the color bands.

This work was done by William R. Wagner and Brad R. Hemmings of Rockwell International Corp. for **Marshall**

Space Flight Center. For further information, Circle 147 on the TSP Request Card. MFS-29285

Spark Igniters Fit in Correct Locations Only

Pins create interference if incorrect assembly is attempted.

Marshall Space Flight Center, Alabama

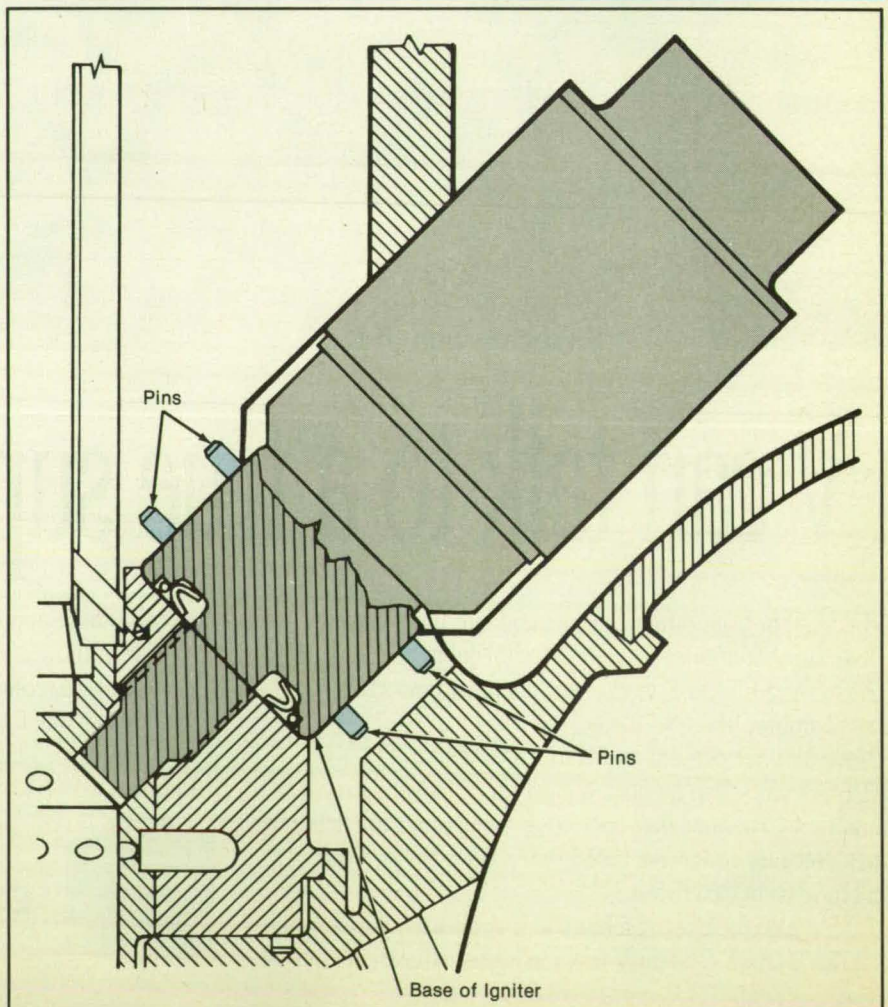
When two different types of spark igniters must be used on the same engine, a simple expedient ensures that each igniter is inserted in the correct hole. Damage to the engine and consequent failure are thereby avoided.

A set of four solid or roll pins is added to the base of one type of spark igniter but not to the other type. The pins are oriented in such a way that they will interfere with the engine structure if the base is inserted in the wrong socket.

The base of an igniter can be reworked at minimal cost to accommodate the pins. The wall of the base is heavy enough that blind holes can be drilled in it for the pins.

This work was done by Fred J. Wendland of Rockwell International Corp. for **Marshall Space Flight Center.** No further documentation is available. MFS-29370

Pins in the Base of a spark igniter allow the part to be inserted in only one type of hole.



● *Apollo, H-P, and Sun Users;
and now, for the MAC II, too.*

AdaNow

● ● ● **New Alsys Toolset For 68000 Ada
Builds Unique Project Environment**

Organizations serious about the 680X0 architecture, and serious about working with the government, want a lot more than just validated Ada compilers. They want quality solutions; production quality compilers and quality programming tools.

Just what Alsys offers. Alsys' new 68000 Ada Developer's Toolset includes:

- **AdaProbe**, a unique source-level symbolic debugger and program viewer;
- **AdaXref**, an inter-unit cross-referencing utility;
- **AdaReformat**, a pretty printing tool for reformatting source files to selectable conventions; and
- **AdaMake**, an automatic recompilation facility.

Consider, too, all those special Ada "manager tools" that are part of the Alsys Version 3 compilation system: the Family Manager, the Unit Manager, and the Library Manager.

Together, they implement the new Alsys Multi-Library Environment that allows teams of programmers to share thousands of logically organized compilation units.

Alsys 68000 compilers are in a class by themselves; highest code quality, maturity, reliability, robustness, superior optimization technology, unexcelled error messages... And now, with the new development tools, they are at the core of an Ada project environment unique in the industry.

Alsys 68000 compilers and our new 68000 Ada Developer's Toolset are now available for the Apollo Domain, Sun 3, Apple Macintosh II, and H-P 9000/ Series 300.

Ada is NOW. Alsys solutions are NOW.
Call or Write.

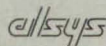


In the US: Alsys Inc., 1432 Main St., Waltham, MA 02154 Tel: (617) 890-0030

In the UK: Alsys Ltd., Partridge House, Newtown Rd., Henley-on-Thames, Oxon RG9 1EN Tel: 44 (491) 579090

In the rest of the world: Alsys SA, 29 Avenue de Versailles, 78170 La Celle St. Cloud, France Tel: 33 (1) 3918.12.44

The Many Facets of
Quality



_____ YES, Send more information on the Toolset
and your 68000 compilers.

_____ Send me your free brochure, *The Many Facets of Quality*.

Name _____

Company _____

Address _____

City _____ State _____ Zip _____

Phone _____

Alsys, Inc. • 1432 Main Street • Waltham, MA 02154

Circle Reader Action No. 341

Continuous-Flow Centrifugal Separator

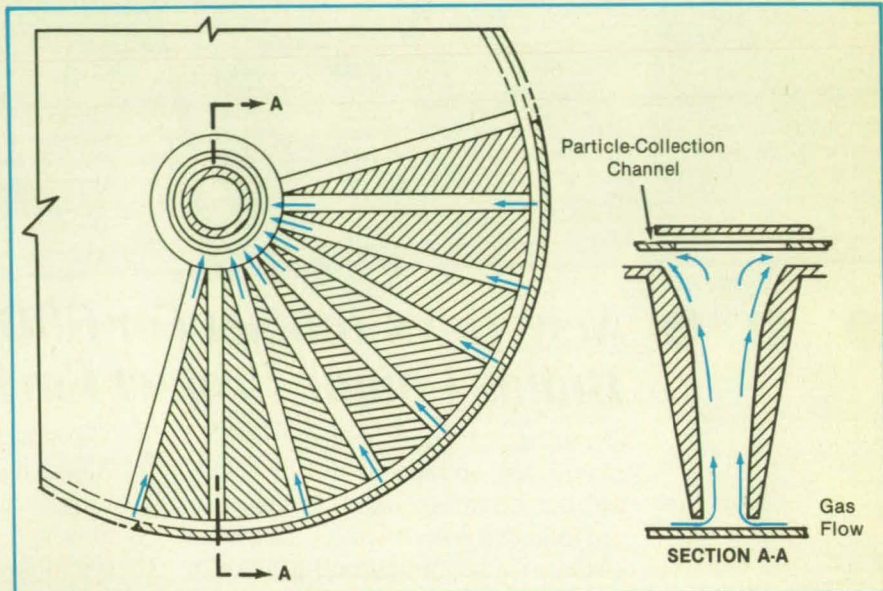
Rotational speed, flow, and pressure are adjusted to achieve separation.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed apparatus would combine some of the operating principles of centrifugal and cyclone separators to control the movement of solid or liquid particles suspended in a flowing gas. It would stratify the particles or move them with or against the gas flow while segregating them according to size or mass.

The apparatus would include a rotating disk containing radial channels, the cross section of each of which would decrease with the distance from the center of rotation (see figure). Particle-bearing gas would flow from the periphery of the disk toward the center. The rotational speed, the rate of flow, and the gas pressure at the inlet would be adjusted so that the particles would move with or against the flow or remain in place depending on their size or mass. The particles would thus be separated. The particles would be introduced or collected by tubes on the axis of the disk and at its periphery.

The separation scheme might be used in low-gravity manufacturing processes or in the collection of dusts or aerosols in normal gravity. It might also be used to remove volatile components from a liquid; in this case, the liquid would flow from the center of the disk outward. Gas bubbles formed at



The Spinning Disk Would Contain Radial Channels, the width of which would vary as a function of distance from the center. Gas would flow from an outer ring around the disk toward the center. Particles — either liquid or solid — in the gas would be collected at the periphery, the center, or both.

the periphery would flow against the current toward the center, where they would be collected.

This work was done by Robert D.

Waldron of Rockwell International Corp. for Johnson Space Center. For further information, Circle 70 on the TSP Request Card. MSC-21173

Large-Angle Magnetic Suspension (LAMS)

Two degrees of angular freedom are provided within a single magnetic-suspension system.

Langley Research Center,
Hampton, Virginia

The spherical LAMS is a new magnetic suspension that provides the dual functions of a magnetic bearing and a rotor-gimbal system. It provides two degrees of angular freedom within a single magnetic-suspension system. The approach employs spherically-shaped magnetic-gap surfaces to achieve much-larger angular freedom than that available from previous suspensions.

The demand for power is satisfied by increasing or decreasing the rotor speeds symmetrically. The demand for attitude-control torque is satisfied by gimbaling the rotors. The applications of the LAMS in spacecraft include gimballed reaction wheels, control-moment gyroscopes, advanced systems for the storage and transfer of angular momentum, energy-storage wheels, integrated power and attitude-control systems (IPACS's), vibration isolators, and precision vernier pointing systems.

The LAMS concept was originally de-

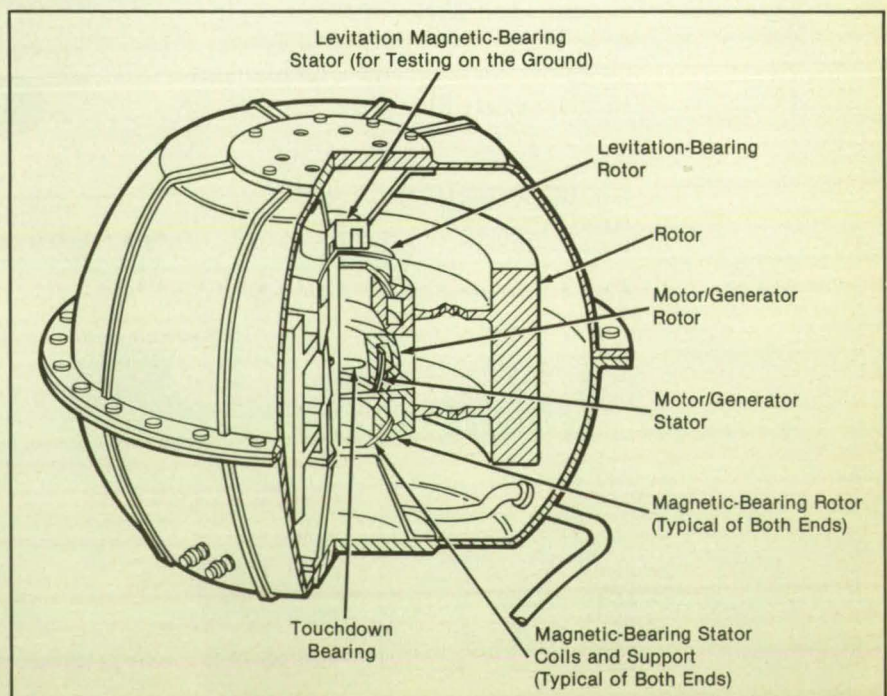


Figure 1. The Spherical LAMS includes both magnetic bearings and a rotor-gimbal system.

NASA Tech Briefs, July/August 1988

veloped for an advanced IPACS for the Space Station and is illustrated in Figure 1. This version of the LAMS employs a Lorentz-force magnetic suspension and permits gimbaling of the rotor spin axis up to approximately 23° relative to the armature, with only a small mass penalty. Although the limitation on the gimbal constrains the capacity for the transfer of angular momentum, the IPACS rotor has an abundance of capacity, and the requirement for transfer of angular momentum in the Space Station can be met with gimbal angles within this range. Figure 2 shows one of eight stator-mounted coils that is used to produce five-degree-of-freedom actuation when it interacts with the nominally-radial magnetic field produced by the rotor-mounted magnetic circuit of the Lorentz-force LAMS.

The primary advantage of a magnetic suspension for a satellite flywheel is the lack of physical contact between the rotor and the stator. Reductions of vibrations and structural interactions can also be obtained through active control. Because

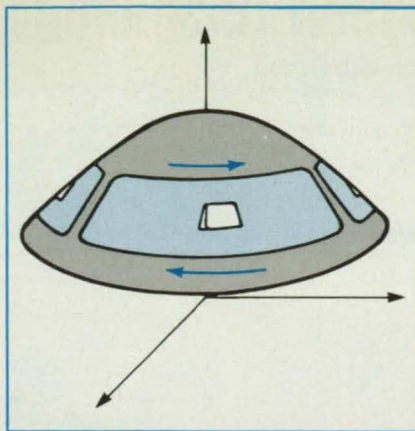


Figure 2. Stator-Mounted Coils enable actuation in five degrees of freedom.

magnetic suspensions require no lubricant, they are well suited for use in a vacuum. The magnetic suspension is required to exert control torques on the spacecraft and to cause the flywheels to precess. The flywheels, however, are allowed to operate on touchdown bearings

during severe maneuvers. The magnetic suspension must allow the rotor sufficient angular freedom (precession and nutation) to transfer the required angular momentum between the flywheels and the Space Station. In some configurations, the LAMS must also allow sufficient angular freedom to reconfigure the flywheels to a nominal zero net angular momentum in the event of the failure of a single wheel.

This work was done by Ronald E. Oglevie of Rockwell International Corp. and David B. Eisenhaure and James R. Downer of Charles Stark Draper Laboratory, Inc., for Langley Research Center. Further information may be found in NASA CR-3912 [N86-15338/NSP], "Advanced Integrated Power and Attitude Control System (IPACS) Study."

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-13587

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.

Nonlinear Analysis of Rotor Dynamics

Progress is made toward understanding rotor vibrations.

A study explores the analytical consequences of the nonlinear Jeffcott equations of rotor dynamics. The analyses should eventually lead to better understanding of excessive vibrations in rotating machinery.

Section 1 of the report includes a summary of previous studies. Section 2 begins with the Jeffcott equations, which describe the lateral displacement of the center of the rotor from the equilibrium position in an inertial, Cartesian coordinate system. The Jeffcott equations are nondimensionalized, then combined by transformation to the complex plane to simplify the subsequent analyses. The complex, nondimensional equations are generalized by the inclusion of multiple forcing functions, which include such special cases as mass imbalance, side force, rubbing, and any combination of these. The second section concludes with the application of the method of multiple scales, which is an asymptotic-expansion method, to approximate the solutions to the Jeffcott equations.

A previous study had shown that the nonlinear frequency that arises when the

homogeneous Jeffcott equations provide a part of the total steady-state solution can be absent or present, depending on the magnitude of the forcing function. Section 3 of the report proves two theorems that provide inequalities on the coefficients of the differential equations and the magnitude of the forcing function in the absence of side force. These inequalities are useful in deciding a priori whether a given set of equation parameters will produce a steady-state response that depends solely on the forcing function (yielding a circular displacement trajectory) or a response that also includes a nonlinear frequency term (yielding a displacement trajectory that occupies an annulus). Several numerical examples along with frequency-response curves are then studied in light of these theorems.

Section 4 begins the numerical investigation of the multiple-forcing-function problem by introducing both side force and mass imbalance; this combination is the most intensely studied special case. The addition of the side force to the nonlinear problem is predicted to cause a constant shift of displacement in the solution of the corresponding nonlinear problem without side force and to deform circular trajectories and annuli to elliptical trajectories and annuli, respectively. This prediction is confirmed by examination of a previous study of the effects of bearing deadbands on bearing loads and instabilities of rotors.

Section 5 presents examples of numerical solutions of the complex, generalized Jeffcott equation with two forcing functions of different frequencies f_1 and f_2 . The power spectral densities of the calculated

displacements contain not only f_1 and f_2 but also some or all frequencies

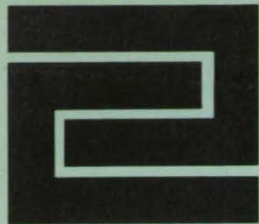
$$|n_1 f_1 + n_2 f_2 \pm \beta|,$$

where β is the nonlinear frequency from the homogeneous portion of the Jeffcott equation, and n_1 and n_2 are integers. Which of these frequencies appears depends on the relative magnitudes of the coefficients of the homogeneous equation and the amplitudes of the forcing functions.

Section 6 deals with the boundedness and stability of solutions. Two theorems along with a novel mathematical representation of the Jeffcott equations are presented. New boundedness results are also studied by comparing the behavior of the nonlinear solution with that of the corresponding linear problem. Finally, numerical results are included to illustrate the conjecture that the boundedness of the nonlinear solution is predicted by that of the linear solution.

Section 7 concludes the report by reviewing the analytical results and their significance. It also calls many solutions, including those of this report, into question by observing that heretofore the initial conditions have been ignored as a vital factor in determining the analytic solution. Therefore, the authors suggest further examination of the effects of initial conditions.

This work was done by William B. Day and Richard Zalik of Auburn University for Marshall Space Flight Center. To obtain a copy of the report, "Nonlinear Rotor Dynamics Analysis," Circle 76 on the TSP Request Card. MFS-26051



Argon Welding Inside a Workpiece

Canopies convert a large, hollow workpiece into an inert-gas welding chamber.

*Marshall Space Flight Center,
Alabama*

A large manifold serves as its own welding chamber for the attachment of liner parts in an argon atmosphere. Every crevice, opening, and passageway is provided with an argon-rich environment. Weld defects and oxidation are thereby dramatically reduced; welding time is also reduced considerably.

The manifold is part of the Space Shuttle main engine. The liner creates a space for coolant to flow around the manifold. The liner is constructed by welding together panels and tubes of assorted shapes inside the manifold shell (see Figure 1). Ample quantities of gaseous argon must be directed against all sides of a piece as it is welded. This is difficult to do in the confined space between the shell and the liner piece.

An argon atmosphere is assured by the installation of flexible gloved canopies on the manifold openings used by the welding operator for access to the work. All unused openings are sealed, and argon is supplied through the manifold coolant inlets (see Figure 2).

The flowing gas, which escapes through small holes in the gloved canopies, purges air from the interior of the manifold so that oxidation cannot degrade the weld quality. Maintained at a gauge pressure of 1 to 2 inches of water (250 to 500 N/m²), the argon puffs out the clear plastic-film canopies. With hands placed in the gloves, the operator manipulates the welding gun, which is placed inside the manifold before the canopies are attached. This welding technique should be useful in the fabrication of heat exchangers, pump bodies, and other complicated, enclosed assemblies containing flow passages.

This work was done by Gene E. Morgan of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available.
MFS-29167

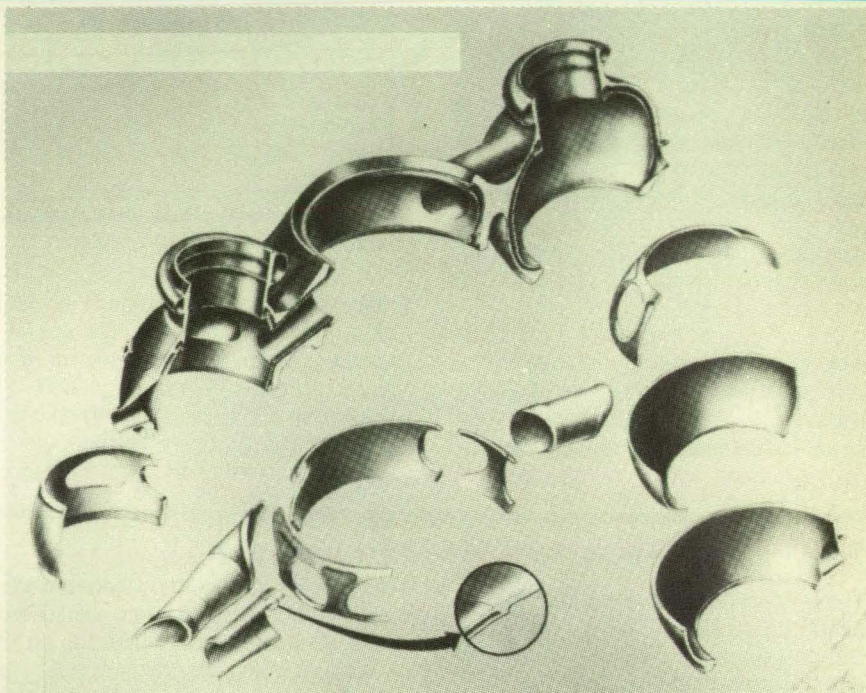


Figure 1. The **Manifold Liner** is made from smaller pieces that are welded in place inside the manifold.

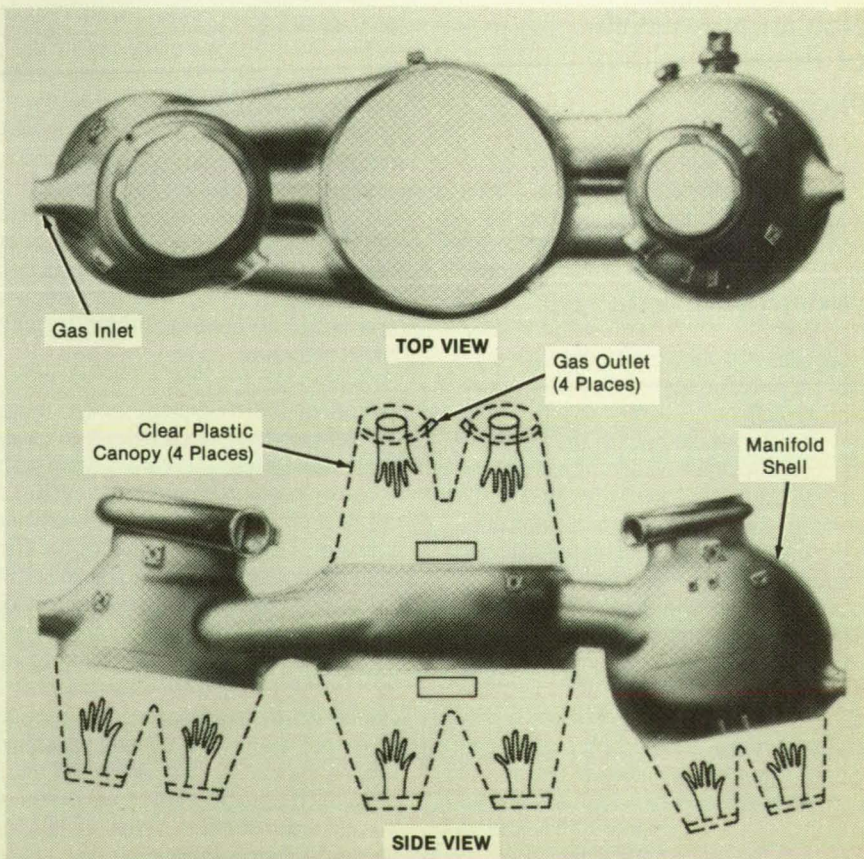
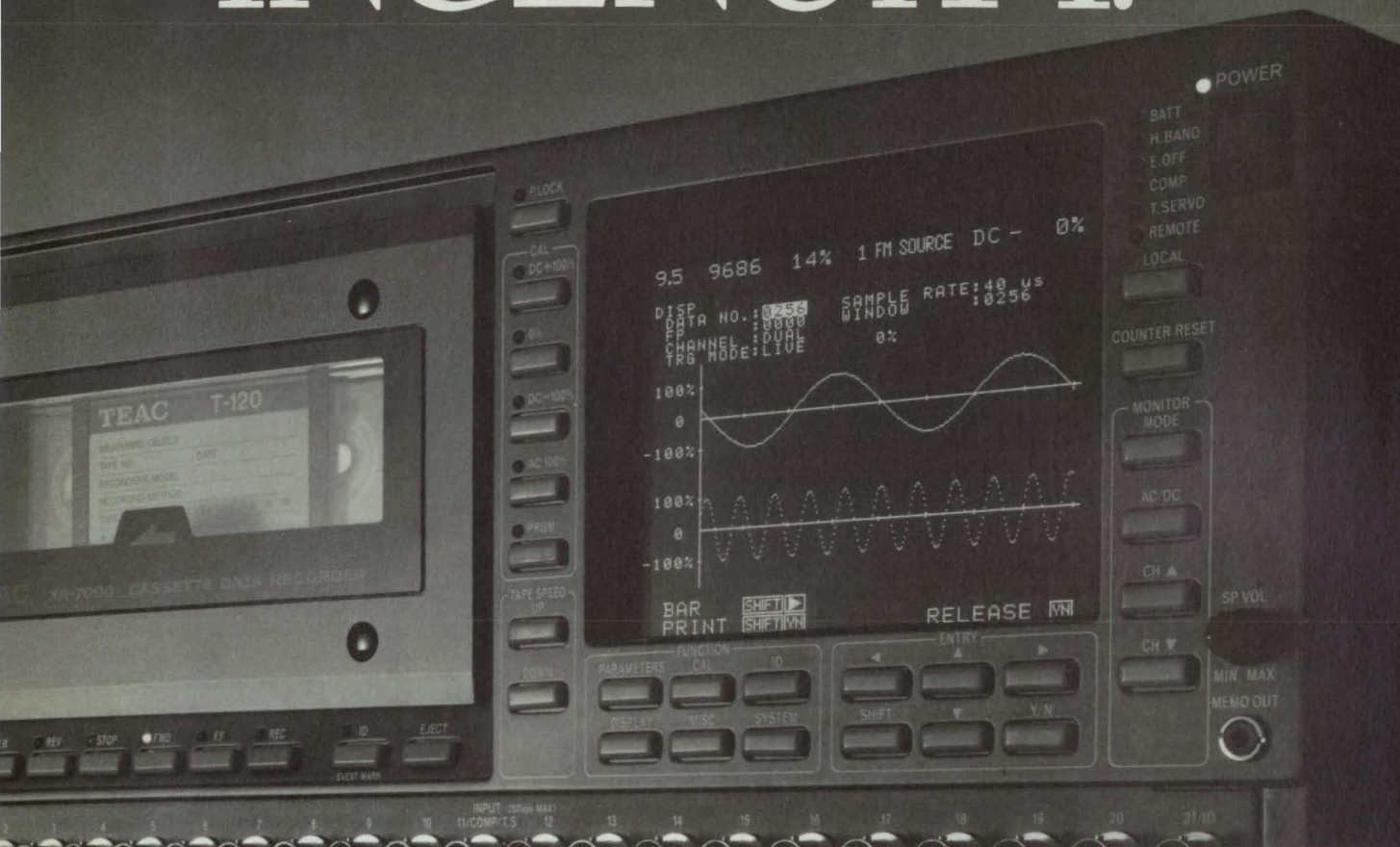


Figure 2. **Gloved Canopies** over large openings retain an atmosphere of flowing argon inside the manifold. Other openings are sealed during welding, except for the argon inlet.

TEAC DISPLAYS ITS INGENUITY.



Our new 21-channel XR-7000 and 14-channel XR-5000 VHS data recorders make it easy for anyone to quickly set up for data recording. You just watch the pictures. Their menu-driven, on-screen display provides simple step-by-step set-up procedures so even beginners can start out with complicated data recording.

Not only are our recorders well versed in communicating with humans; they talk with computers as well. Your computer can command the data recorder via a GP-IB interface and its A/D converter allows you to feed recorded data directly into your computer, eliminating time consuming manual transfers.

TEAC's exclusive VHS format puts the features and benefits of reel-to-reel recording into a simplified cost-efficient package. And VHS cassettes provide almost six full hours of recording.

To make sure things run smoothly

we've built in a number of automatic functions including a self-test program with on-screen analysis and an error correction menu.

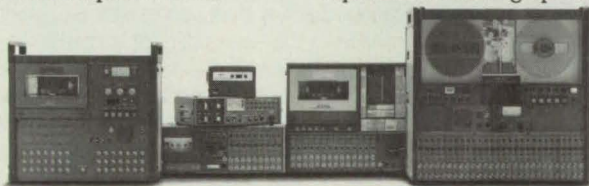
ID information such as title, file number, event number, tape counter code, time code, channel status and other data can be recorded and displayed during playback to identify the recording conditions.

We've provided a wide range of options tailored to meet specific requirements including a printer for hard copies of on-screen displays

such as wave form graphs, ID information, and parameter settings.

Leave it to TEAC to build the most advanced, yet the easiest to operate data recorders around, including the only VHS data recorders.

For the most complete line of data recorders available call (213) 727-7682. TEAC Corporation of America, 7733 Telegraph Road, Montebello, California 90640.

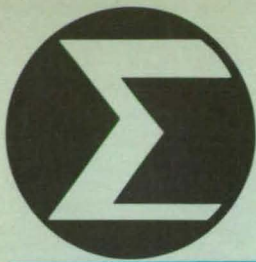


Count on TEAC for the most complete line of data recorders available, from 1 to 28 channels, including the world's only VHS data recorders.

TEAC®

Instrumentation and Computer Products Division

Circle Reader Action No. 344



Mathematics and Information Sciences

Hardware Techniques, and Processes

78 Least-Squares Frequency-Acquisition Algorithm

Books and Reports

78 Networks of Executive Controllers for Automation

Computer Programs

58 Archival-System Computer Program

Least-Squares Frequency-Acquisition Algorithm

Performance rivals that of the FFT algorithm.

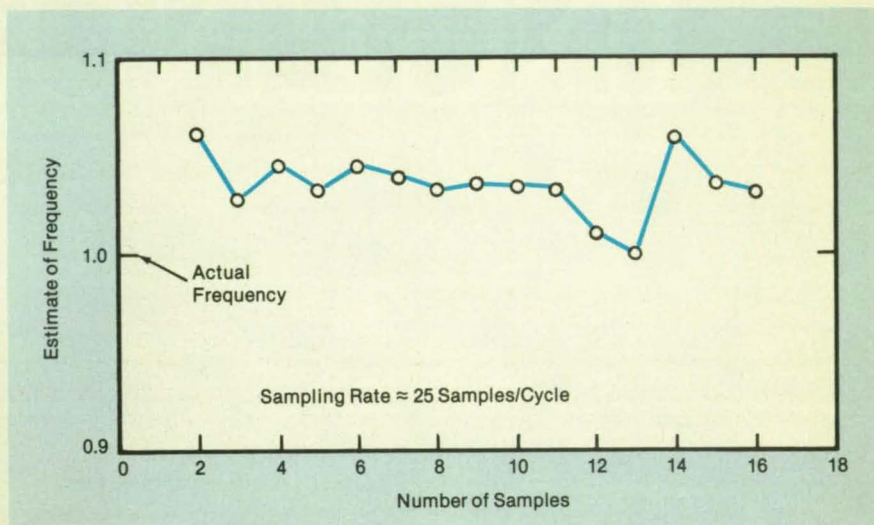
NASA's Jet Propulsion Laboratory, Pasadena, California

A least-squares algorithm finds the frequency and phase of a sinusoidal signal in the presence of noise (see figure). The algorithm is a special case of more-general, adaptive-parameter-estimation techniques. The computational requirements of the new algorithm are comparable to those of the corresponding fast-Fourier-transform (FFT) algorithm. The new algorithm works directly in the time domain, whereas the FFT algorithm transforms the data into the frequency domain for estimation and detection and requires a secondary algorithm to interpolate between frequencies.

The received signal is assumed to be demodulated by a carrier reference signal of known frequency and phase and by its 90°-phase-shifted version. The problem is to determine the frequency and phase of the received signal from the noise-corrupted in-phase and quadrature samples of the demodulated signal plus noise.

The basic equations for the measurements express the noisy samples as a truncated (n -th-order) series involving the unknown frequency and phase, the sampling times, and the noise samples. The equations can be put in linear form involving a matrix of parameters that depend on the frequency and phase and from which, in principle, the frequency and phase can be extracted.

The algorithm obtains the matrix of parameters from a sequence of N pairs of measurements. It involves the inverse of an $n \times n$ matrix (the "state-vector" matrix)



In a Numerical Simulation without noise, the algorithm gave an estimate close to the actual frequency in a fraction of the signal period.

that contains terms dependent on the sampling times and that can be precomputed, multiplied by a matrix formed from the measurements. The state-vector matrix has a special structure that makes it possible to use a rapid inversion algorithm: as a result, the desired matrix of parameters can be obtained in about $6n \log_2(n)$ operations, much fewer than the number of operations required for the "brute-force" calculation of a general matrix equation of similar form.

Initially, the estimation error of the least-squares algorithm approaches zero as the reciprocal of the factorial of the number of

measurements. As the number of observations increases, the algorithm converges even faster — at an exponential rate. The computational requirements of the least-squares algorithm are determined predominantly by the product of the signal frequency and the observation period, whereas those of the FFT algorithm depend predominantly on the number of samples.

This work was done by Rajendra Kumar of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 49 on the TSP Request Card. NPO-17104

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.

Networks of Executive Controllers for Automation

Important issues for designers of artificial-intelligence systems are reviewed.

A paper discusses principal issues that must be resolved in development of an autonomous executive-controller shell for the Space Station. Such a shell represents a major increase in the complexity of automated systems. Previously, the technology of artificial intelligence and expert systems focused on separate functions like planning, scheduling, monitoring, the diagnosis of faults, and simple feedback control. More-complex control tasks, however, require a system that can deal with many different goals, each requiring sequences of tasks that change the state of the system world in complex ways. This requires the

integration of all the functions.

The system must generate plans to achieve the goals, execute the plans, sense the environment to monitor the effects of its actions on the world, recognize obstacles and other problems, diagnose the causes of the problems, and interactively replan and continue on toward the goals. Such a system is called an intelligent autonomous system. Intelligent autonomous systems that can interact with other autonomous systems as well as with the external world are called executive controllers.

The many potential applications for ex-

ecutive controllers in the Space Station program include communications, tracking, life support, data-processing support, guidance, navigation, control, power, ground support, crew activity, support systems for the crew, support of payloads and experiments, and the control of thermal and structural subsystems. A demonstration scheduled for the year 1990 will focus on the combination of these components into an integrated executive controller with cooperative sharing of data and commands with a second executive controller on a peer level. Later demonstrations will focus on building full-fledged hierarchical networks of executive controllers, with lower-level autonomous systems providing support to complete space systems and higher level executives providing overall management and guidance.

One of the first considerations to be addressed in the design of an intelligent autonomous system is the degree of autonomy supported. A system that must be completely autonomous presents, to the designer, problems different from those presented by a system that must interact with a human user. Because of the wide range of potential problem domains and applications, the demonstration project can define the degree of autonomy for a given system only on a case-by-case basis. Hence, an intelligent autonomous system shell must support a full range of potential degrees of autonomy.

A problem in the real world involves three dimensions of complexity: regional, functional, and hierarchical. As an example, separate habitable modules on the Space Station might each have a life-support executive (regional), managed by a higher-level life-support supervisor (hierarchical), which, with other executives for controlling power, thermal, and other systems (functional), is managed by a top-level supervisor executive (also hierarchical).

Regardless of the dimension of complexity, each executive controller in a network should be as independent from the others as possible. This independence reduces the load on the underlying communication network and simplifies coordination of the activities of the various component executives.

Each executive in a network of executive controllers can have a different view of the world, depending on its particular goals. This can result in problems in sharing information. One executive may have the data for deducing the information desired by a second executive but, because of differing world views, may not have the data in a form that the second executive can use. It may therefore be necessary to augment each executive so that it translates information from its own world model to those of the executives that request the information. Alternatively, a global model

may handle the details of translation of information from the world model of one executive to the world model of another.

While executing the first part of a plan, an intelligent autonomous system can be simultaneously monitoring the environment and developing a later part of the same plan. To support this capability, the functional modules should be implemented as separate processes, running either on a single processor in a multitasking environment or on different processors. Because of the high demand on computing resources made by functional modules, the multiple-processor alternative seems the most viable for an operational execu-

tive, although prototype versions could be developed on a single processor.

This work was done by William K. Erickson of Ames Research Center and Peter C. Cheeseman of the Research Institute for Advanced Computer Science. To obtain a copy of the report, "Issues in the Design of an Executive Controller Shell for Space Station Automation," Circle 83 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 12]. Refer to ARC-11780.

MTS Lets You Build Your Own System for Fatigue and Durability Mechanical Testing.



The test objectives of many engineers require a flexible system that can be reconfigured to their changing test set-ups.

MTS Systems gives you that flexibility in both electronic and mechanical test system components.

For example, its 458 series of test controllers give you Microprocessor-based performance, and plug in modules capable of controlling a very wide range of tests and test systems. It's perfect for upgrading existing test systems, or integrating into new modules.

MTS also provides the widest range of mechanical products for servohydraulic testing. You can select the hydraulic actuators, servovalves, pumps, fixtures, load frames and accessories to fit your requirements.

MTS Testline components are engineered for easy mixing and matching. This makes your expansion and reconfiguration tasks easy and economical, too. **Contact MTS Today!**

MTS

MTS SYSTEMS CORPORATION
BOX 24012, MINNEAPOLIS, MINNESOTA 55424
TELEPHONE 612-937-4000 TELEX 28-0521 MTS SYSTEM ENPE
FAX 612-937-4515



Life Sciences

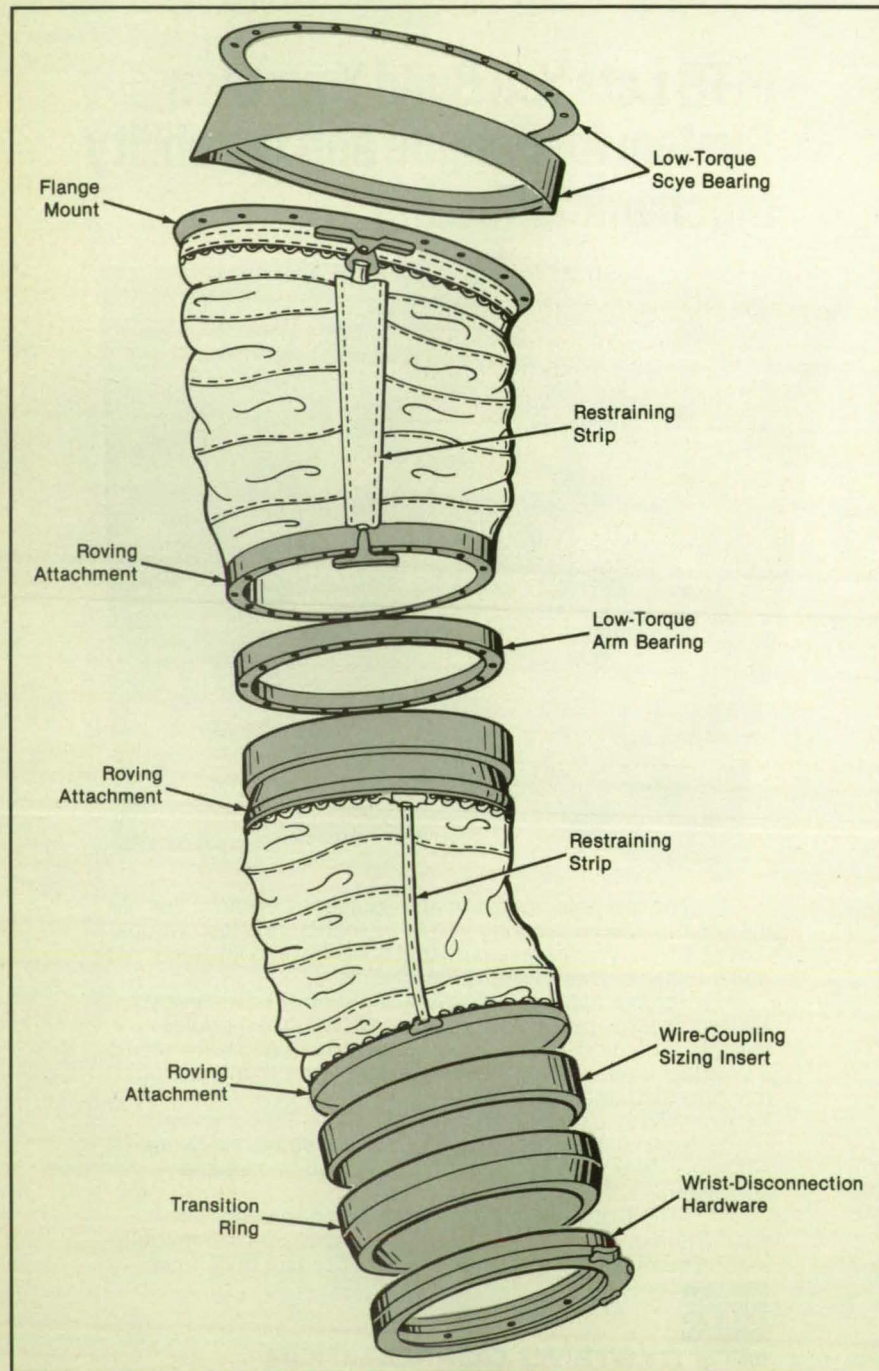
Hardware, Techniques, and Processes

80 Pressurized Sleeve

Pressurized Sleeve

A garment part sustains a pressure differential without unduly restricting the user.

Lyndon B. Johnson Space Center, Houston, Texas



A fabric sleeve withstands a pressure difference of 8 lb/in.² (55 kPa) while allowing the wearer fairly easy movement. Developed as a replacement for a space-suit sleeve rated only to 4.3 lb/in.² (30 kPa), the new sleeve gives greater range of movement with lower restrictive torques. The sleeve offers the same advantages in such terrestrial applications as protective clothing and sleeves for manipulation of objects in isolation chambers.

The sleeve consists of upper and lower fabric sections fitted with shoulder, elbow, and wrist hardware (see figure). Longitudinal strips of fabric on the upper and lower sections restrain the sleeve so that it does not balloon axially under its internal pressure.

The sleeve is made of a polyester biaxial-weave fabric like that used previously in this type of space suit. The patterns of the sewn fabric sections have been modified to yield improved mobility. The restraint strips are made of a new material woven of high-strength, low-elongation polyethylene fibers. The hardware joints feature ball bearings for low torque. The center joint has a quick-connect and quick-disconnect coupling.

The sleeve was subjected to a series of tests of fabric properties, endurance of flexure cycles, torques, and ranges of movement during its development. A final group of tests by wearers gave subjective evaluations of comfort, range, and torque.

This work was done by Amy Lerner of ILC Dover, Inc., for Johnson Space Center. For further information, Circle 2 on the TSP Request Card. MSC-21280

**Win A Free
Trip to the
United States
Space Camp.
See page 14 for details.**

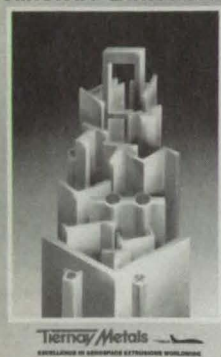
The **Pressurized Sleeve** consists of low-torque joint hardware, sewn fabric sections, and lengthwise strips of fabric that restrain the sections.

New on the Market



The world's first **plastic laser** has been created by Amoco Laser Company, Naperville, IL. Amoco's new solid-state microlaser features a resonator made from an injection-molded high-performance polymer. This innovation paves the way for future low-cost, mass production of microlasers, according to company officials. **Circle Reader Action Number 792.**

AIRCRAFT EXTRUSIONS



Tiernay Metals, Redondo Beach, CA, is offering a free 1200 page **catalog** that lists, cross references, and provides technical data on virtually all **aluminum extrusions** found on airframes world-wide. The catalog lists extrusion shapes and alloys by customer and/or mill, and contains a comprehensive Army-Navy index. **Circle Reader Action Number 800.**



The Zero Corporation of Los Angeles, CA has developed a new line of **shock-mounted cases** designed for the safe transportation and field operation of delicate electronic instruments. The Val-An Series 900 cases are available with removable front and rear covers for easy access and equipment installation, and feature an interlocking design for secure stacking. **Circle Reader Action Number 796.**

BRAINSTORMER, a **software tool** for finding solutions to difficult science and engineering problems, is now available from Soft Path Systems, Eugene, OR. Using a technique called Morphological Analysis, BRAINSTORMER provides a way to list and examine the possible combinations that might be useful in solving a given problem. The user refines ideas with program commands that recombine portions of the problem to trigger new solution strategies. Applications include new product development, process and product improvement, and generation of marketing plans. BRAINSTORMER can be used on MS/PC-DOS microcomputers with at least 512K memory. **Circle Reader Action Number 782.**

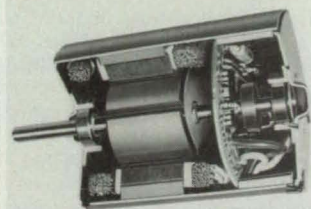


The AXIOM 2/20 **Laser Measurement System** from the Zygo Corp., Middlefield, CT, provides laser interferometer accuracy for the measurement of linear displacement, angle, straightness, and refractive index of air. Targeted at manufacturers of precision positioning equipment, the AXIOM 2/20 features velocity up to 1.8m/sec, measurement update rates of 7-13 MHz, and unlimited acceleration. The system consists of a two-frequency laser head, beam directing and splitting optics, receivers, wavelength compensators, and electronics. **Circle Reader Action Number 786.**



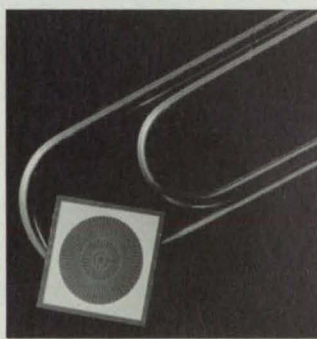
ANVIL-5000pc™ from Manufacturing and Consulting Services Inc., Irvine, CA, is the first **3D CADD/CAM software system** to provide complete mainframe capability on a personal computer. The system features a 64-bit floating point design and an open architecture. ANVIL-5000pc consists of six software modules that run on most 80386-based PCs. **Circle Reader Action Number 794.**

The 3M Company's Aerospace Materials Department has developed a new **graphite prepreg composite material** called Scotchply Brand SP-500. The new composite's advanced resin system provides superior hot/wet strength properties and damage tolerance, as well as low moisture absorption. SP-500 is designed for primary airframe construction, and can be processed using conventional layup, tooling, and autoclave equipment. **Circle Reader Action Number 790.**



Two new **brushless DC motors** from Fasco Industries Inc., St. Louis, MO, offer a ceramic-magnet rotor design for higher power outputs and greater efficiency in a smaller package. Units are available in 12 to 48 volts, with speeds from 1,000 to 5,000 RPM and power levels to ¼ H.P. **Circle Reader Action Number 784.**

A new **Wide Word/VMEbus Host Interface** from the Dataram Corp., Princeton, NJ, allows system designers to apply Dataram's Wide Word 2000 memory on the VMEbus at 640MB capacity per Wide Word unit. This makes it easy to combine super-computer memory depth and speed with the flexibility of the open VMEbus architecture. Wide Word's eight-port capability permits data capture at rates up to 200MB/sec. The captured data can be transferred to other devices at the same rate or downloaded to a VME system at VMEbus maximum rates. **Circle Reader Action Number 780.**



A **gallium arsenide solar cell** that converts sunlight to electricity with 28.1 percent efficiency has been developed by Varian Associates, Palo Alto, CA. The single-junction cell, one-quarter the size of a postage stamp, offers applications in both terrestrial power systems and orbiting satellites. The silicon cells currently used on satellites are only about 14 percent efficient. **Circle Reader Action Number 798.**



MASSCOMP, Westford, MA, has introduced the 6000 Family of **real-time computer systems**. Based on the Motorola MC68030, the four new systems are binary-compatible, share a multiple processor architecture, and offer up to five custom VLSI floating point accelerators and four vector accelerators. The systems implement the UNIX® operating system and feature industry standards such as the VMEbus™, Multibus™, NFS™, and the X Window System™. **Circle Reader Action Number 788.**



The System-40 **Logic Analysis System** from Bitwise Designs Inc., Troy, NY, features 25 MHz synchronous or asynchronous sampling, 125 MHz timing analysis, 256 state pass counting, and memory mapped word recognition. A menu-driven windowing environment can simultaneously display multiple timing diagrams, state tables, disassembled code, trigger setups, and system configuration. The portable system is XT-compatible with a 10 MHz 8088 microprocessor. **Circle Reader Action Number 778.**



Equipto Electronics Corp., Aurora, IL, is offering a **free electronic enclosure design kit**. Included in the kit are samples of the company's Heavy Duty and Challenger frames, an EMI/RFI technical guide, a galvanic compatibility chart, vertical and sloped front enclosures order/quote forms, and a 304 page full line catalog. **Circle Reader Action Number 774.**

New on the Market (continued from previous page)

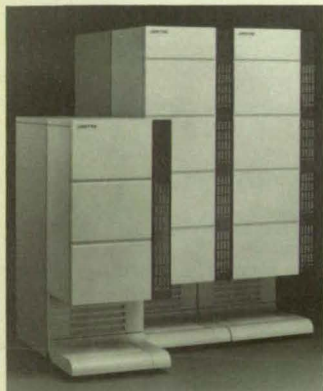


The Formulated Systems Group of CIBA-GEIGY Corp., Madison Heights, MI, has introduced the Araldite® adhesive application gun. The gun accepts a dual cartridge with separate compartments containing resin and hardener and dispenses adhesive through the static mix tip as the handle is depressed. Bead size is controlled by adjusting handle pressure. **Circle Reader Action Number 766**



The V-Store instrumentation tape recorder, a portable, VHS-based unit with up to 24 channel capability is now available from Racal Recorders Inc., Irvine, CA. The V-Store can record signals from all types of sensors with electrical output from DC to 100 KHz. Soft keys allow access to such features as automatic channel set-up, dynamic bargraph and waveform displays, and built-in track sequencing for extended record/replay times. **Circle Reader Action Number 754.**

A new polyimide resin that can withstand higher temperatures than current commercial plastics has been developed by the Du Pont Company, Wilmington, DE. Parts formed with the resin show excellent thermal stability at temperatures up to 650°F, and can take excursions to 900°F. Potential applications include automotive and aerospace parts as well as components for heating systems, business machines, and electronics. **Circle Reader Action Number 750.**



The Series 2010 parallel processing system from the Ametek Computer Research Division, Monrovia, CA, offers peak performance figures of over four billion instructions per second (4000 MIPS) and 20 billion floating point operations per second (20 GigaFLOPS), and can interface more than four trillion bytes of online storage (4000 Gigabytes) for parallel data access. The system's Automatic Message Routing Devices™ free computing resources from the burden of message routing, thereby significantly increasing performance over previous generations of massively parallel systems. **Circle Reader Action Number 758.**

Eclipse Logic Inc., Huntington Park, CA, has introduced the ELI-41™, a professional scientific calculator software package that allows users to perform Hewlett-Packard 41 series programs on a PC. The ELI-41 features 15 digits of precision for calculations, disk access for storage and retrieval of programs, and visual displays of the calculator, stack, flags, and registers. ELI-41 runs on an IBM PC/XT/AT or compatible. **Circle Reader Action Number 760.**



Plantronics' new Liteset™ cordless telephone replaces the traditional cordless telephone handset with a three-inch capsule combining both earpiece and microphone. The capsule perches comfortably on the ear, thereby freeing the user's hands for other activities while talking. The capsule is connected to a dial pad that features a mute switch, number redial, and two-position volume control. A base unit provides up to 1,000 feet of cordless mobility and plugs into standard modular wall jacks. **Circle Reader Action Number 748.**



National Instruments, Austin, TX, has announced availability of the AT-GPIB plug-in circuit card, a new IEEE-448 interface for the IBM PC/AT and compatible 16-bit PCs. Data can be transferred between a computer equipped with the AT-GPIB and thousands of IEEE-448 bus-compatible engineering, scientific, and medical instruments. A computer configured with the AT-GPIB becomes an IEEE-448 controller that can be used for numerous applications in laboratory and production testing as well as in process monitoring and control. **Circle Reader Action Number 755.**

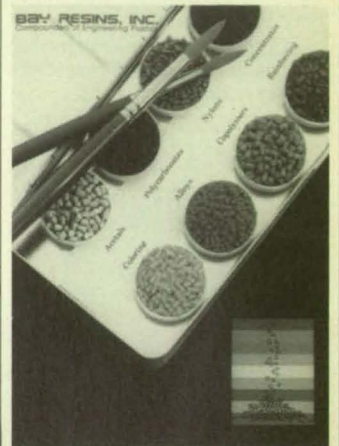


A pocket-size microscope for industrial and laboratory inspections is now available from Edmund Scientific Co., Barrington, NJ. The microscope's clear acrylic base rests directly on the subject for stability and concentrated illumination. The device features a 3/16 inch field-of-view and a 3/4 inch working distance, and is powered by two "AA" batteries. **Circle Reader Action Number 768**

The VX series of high vacuum positioning stages has been introduced by New England Affiliated Technologies Inc., Lawrence, MA. Available in a wide range of axis configurations and travels, the VX series is designed for operation in vacuums up to 1x10⁻⁷ torr. The stages are made from electroless nickel-plated aluminum, and feature stainless steel leadscrews, anti-backlash nuts, and precision ball or crossed-roller ways. **Circle Reader Action Number 762.**

Alslys Inc., Waltham, MA, has developed the first Ada compiler to run under OS/2, the new protected mode operating system developed by Microsoft. The compiler can run on any 286- or 386-based machine with a minimum of two megabytes of main memory, accompanied by the OS/2 system (Version 1.0 of the Standard Edition) provided by the manufacturer. A full set of programmer's tools, including AdaProbe, Alslys' high-level debugger, complement the compiler. **Circle Reader Action Number 764.**

Aptec Computer Systems Inc., Beaverton, OR, has introduced the VSP-1, an integrated vector/scalar processor board for the company's IOC-24 I/O computer. The processor board, which connects directly to the IOC-24 data interchange bus, contains a powerful scalar processor and a vector processor that can perform 20 million 32-bit floating point operations per second. The software package includes VAX-based cross development tools, FORTRAN and C compilers, and an extensive application subroutine library. **Circle Reader Action Number 752.**



A free four-color information packet from Bay Resins Inc., Millington, MD, describes the characteristics and typical uses of all Baylon™ molding and extrusion compounds. The packet also highlights Bay Resins' research and development program and computerized color matching capabilities. **Circle Reader Action Number 756.**



NEC America, Wood Dale, IL, has introduced a new line of CCD cameras that provides sharp images of high-speed objects for playback in slow-motion or stop-action. Equipped with electronic shutters, the cameras are suited for manufacturing or research applications involving high-speed motion analysis, non-destructive testing, image processing, and pattern recognition. **Circle Reader Action Number 770.**



Subject Index

A

ACOUSTIC STREAMING
Acoustical convective cooling or heating page 31 NPO-17278

ADAPTIVE CONTROL
Adaptive receiver for coded communications page 36 ARC-11815

AIRCRAFT CONTROL
Synchronous versus asynchronous flight control page 36 ARC-11799

AIRFOILS
Graphite/epoxy deicing heater page 48 LEW-14551

ALIGNMENT
Linear-alignment testing grips page 62 LAR-13493

AMPLIFICATION
Image-method gain measurement with mismatch page 24 LEW-14555

ANEMOMETERS
Hot-film anemometer for boundary-flow transitions page 26 ARC-11811

ANTENNAS
Image-method gain measurement with mismatch page 24 LEW-14555

ARGON
Argon welding inside a workpiece page 76 MFS-29167

AUTOMATIC CONTROL
Networks of executive controllers for automation page 78 ARC-11780

AUTOMATIC CONTROL SYSTEM
Fault-tolerant software for flight control page 37 ARC-11763

AUTOMATIC FLIGHT CONTROL
Synchronous versus asynchronous flight control page 36 ARC-11799

B

BALL BEARINGS
Predicting temperatures in ball bearings page 66 MFS-29285

BEARINGS
Predicting temperatures in ball bearings page 66 MFS-29285

BOUNDARY LAYER TRANSITION
Hot-film anemometer for boundary-flow transitions page 26 ARC-11811

C

CABLES (ROPES)
Coding ropes for length and speed measurements page 66 MFS-28226

CENTRIFUGES
Continuous-flow centrifugal separator page 74 MSC-21173

CERAMIC COATINGS
Flexible, ceramic-insulated cable page 30 NPO-16917

CLIPS
Quick-change optical-filter holder page 40 GSC-13148

CLOTHING
Pressurized sleeve page 80 MSC-21280

COATINGS
Metal/ceramic bond coatings for high temperatures page 51 LEW-14541

COATINGS
Wear-resistant, thermally conductive coating page 51 LEW-14562

CODING
Coding ropes for length and speed measurements page 66 MFS-28226

COMBUSTION
Simultaneous sampling of two spectral sources page 44 LAR-13756

COMMUNICATION
Adaptive receiver for coded communications page 36 ARC-11815

COMPOSITE MATERIALS
Halogenation enhances carbon-fiber/epoxy composites page 48 LEW-14584

COMPRESSION TESTS
Linear-alignment testing grips page 62 LAR-13493

COMPUTER PROGRAMS
Fault-tolerant software for flight control page 37 ARC-11763

COMPUTERIZED SIMULATION
Simulating instrument helicopter takeoffs and landings page 36 ARC-11813

CONTACT RESISTANCE
Formula gives better contact-resistance values page 28 NPO-17096

CONTROLLERS
Networks of executive controllers for automation page 78 ARC-11780

CONVECTIVE HEAT TRANSFER
Acoustical convective cooling or heating page 31 NPO-17278

CRYSTAL GROWTH
Automatic replenishment of dopant in silicon growth page 52 NPO-17138

D

DATA SAMPLING
Fast synchronization with burst-mode digital signals page 33 NPO-16925

DATA STORAGE
Archival-system computer program page 58 NPO-17129

DATA TRANSMISSION
Programmable data formatter page 32 GSC-13104

DEICERS
Graphite/epoxy deicing heater page 48 LEW-14551

DIODES
Schottky diode with surface channel page 22 GSC-13063

DOPED CRYSTALS
Automatic replenishment of dopant in silicon growth page 52 NPO-17138

SCIENTIFIC/ENGINEERING GRAPHIC TOOLS

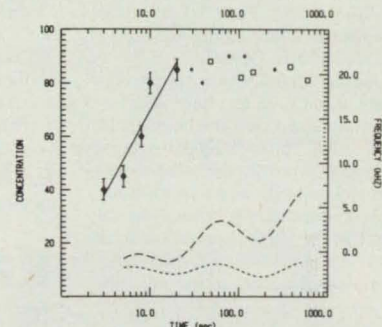
for the IBM PC and compatibles

FORTRAN/Pascal tools: **GRAFMATIC** (screen graphics) and **PLOTMATIC** (pen plotter driver)

These packages provide 2D and 3D plotting capabilities for programmers writing in a variety of FORTRAN/Pascal environments. We support MS, R-M, LAHEY FORTRAN and more. PLOTMATIC supports HP or Houston Instrument plotters. Font module available too!

Don't want to program? Just ask for **OMNILOT!** Menu-driven, fully documented integrated scientific graphics. Write or call for complete information and ordering instructions.

GRAFMATIC-PLOTMATIC-OMNILOT [S] & [P]



Microcompatibles, 301 Prelude Drive, Silver Spring, MD 20901
(301) 593-0683

Circle Reader Action No. 389

DUST COLLECTORS
Continuous-flow centrifugal separator page 74 MSC-21173

DYE LASERS
Simultaneous sampling of two spectral sources page 44 LAR-13756

DYNAMIC STABILITY
Nonlinear analysis of rotor dynamics page 75 MFS-26051

E

ELECTRIC IGNITION
Spark igniters fit in correct locations only page 72 MFS-29370

ELECTRIC RESISTANCE
Formula gives better contact-resistance values page 28 NPO-17096

ELECTRICAL INSULATION
Flexible, ceramic-insulated cable page 30 NPO-16917

F

FABRICATION
Schottky diode with surface channel page 22 GSC-13063

FIBER REINFORCED COMPOSITES
Halogenation enhances carbon-fiber/epoxy composites page 48 LEW-14584

FLIGHT CONTROL
Fault-tolerant software for flight control page 37 ARC-11763

Synchronous versus asynchronous flight control page 36 ARC-11799

FLIGHT SIMULATION
Simulating instrument helicopter takeoffs and landings page 36 ARC-11813

FLOW MEASUREMENT
Measuring flow by holographic interferometry page 60 ARC-11728

FLY BY WIRE CONTROL
Fault-tolerant software for flight control page 37 ARC-11763

FORMAT
Programmable data formatter page 32 GSC-13104

FREQUENCY MEASUREMENT
Least-squares frequency-acquisition algorithm page 78 NPO-17104

G

GAS WELDING
Argon welding inside a workpiece page 76 MFS-29167

GLOBAL POSITIONING SYSTEMS
GPS satellite multipath range errors page 38 NPO-17020

GRAPHITE EPOXY COMPOSITES
Graphite/epoxy deicing heater page 48 LEW-14551

GYROSCOPES
Large-angle magnetic suspension (LAMS) page 74 LAR-13587

H

HALOGENATION
Halogenation enhances carbon-fiber/epoxy composites page 48 LEW-14584

HELICOPTER PERFORMANCE
Simulating instrument helicopter takeoffs and landings page 36 ARC-11813

HOLDERS
Quick-change optical-filter holder page 40 GSC-13148

HOLOGRAPHIC INTERFEROMETRY
Measuring flow by holographic interferometry page 60 ARC-11728

HOLOGRAPHY
Holographic velocimeter page 44 LAR-13699

HOT-FILM ANEMOMETERS
Hot-film anemometer for boundary-flow transitions page 26 ARC-11811

I

IGNITION
Spark igniters fit in correct locations only page 72 MFS-29370

Classifieds

Classified advertising rates and specifications are as follows: Set in 6 point light type face, with up to five words at beginning of copy in bold caps. Count box numbers as six words.

50 words or less \$ 180
100 words \$ 250

Check or money order must accompany order to: Classified Advertising Manager, NASA Tech Briefs, Suite 921, 41 East 42nd Street, New York, NY 10017-5391.

SALES REPS WANTED!

Dickson Industries, Inc., a leading supplier of custom clothing products and knitted fabrics, is looking for independent sales representatives familiar with laboratory and clean room operating industries to sell TECHWEAR®, a new line of protective clothing featuring nylon and nylon tafetta for controlled environments. TECHWEAR®'s quality construction, range of fabrics, lab-engineered detailed and competitive pricing make it an attractive product line to sell. Positions open nationwide. For more information, write Arthur W. Dickson, Dickson Industries, Inc., 325 Southwest Fifth Street, Des Moines, Iowa 50309, or call (515) 243-0154.

DICKSON INDUSTRIES, INC.

QUALIFY YOUR CAPACITORS MIL-SPEC RELIABLE.



C & D testing multilayer ceramic capacitors isn't enough. Testing the high voltage characteristics of your capacitors is just as important. The Model 5300 Flash Tester provides a Dielectric Withstanding Voltage Test that meets MIL-39014C.

Use the Model 5300's unique constant current flash test technique for incoming inspection and component verification. The technique that provides more peak power to the component than any other flash testing method.

Find your ultimate breakdown voltage. Use the 5300's unmatched breakdown test mode to detect safety margin over your capacitors' operating voltage.

With test fixtures for leaded and surface-mount capacitors, the 5300 is the economic high voltage test solution for ceramic capacitors that adds a new dimension to your capacitor evaluation.

Ask how to qualify your capacitors to MIL-Spec reliability.

Call today: 1-800-547-1863

In Oregon call 503-641-4141.



Electro Scientific Industries
13900 NW Science Park Dr., Portland, OR 97229

Circle Reader Action No. 625

STIFFENING Stiffening rings for rocket-case joints page 64 MFS-28269	THERMOELECTRIC MATERIALS Program collects and analyzes thermoelectric data page 54 NPO-17149
SYNCHRONIZED OSCILLATORS Fast synchronization with burst-mode digital signals page 33 NPO-16925	TRANSONIC FLOW Measuring flow by holographic interferometry page 60 ARC-11728
T	TURBULENT FLOW Holocinematographic velocimeter page 44 LAR-13699
TELECOMMUNICATION Programmable data formatter page 32 GSC-13104	U
TEMPERATURE EFFECTS Program collects and analyzes thermoelectric data page 54 NPO-17149	ULTRASONICS Acoustical convective cooling or heating page 31 NPO-17278
TENSILE TESTS Linear-alignment testing grips page 62 LAR-13493	V
TETHERLINES Coding ropes for length and speed measurements page 66 MFS-28226	VELOCITY MEASUREMENT Holocinematographic velocimeter page 44 LAR-13699
THERMAL ANALYSIS Predicting temperatures in ball bearings page 66 MFS-29285	VIBRATION Nonlinear analysis of rotor dynamics page 75 MFS-26051
THERMAL CONTROL COATINGS Metal/ceramic bond coatings for high temperatures page 51 LEW-14541	W
Wear-resistant, thermally conductive coating page 51 LEW-14562	WATER Device maintains water at the triple point page 42 LAR-13708
	WELDING Argon welding inside a workpiece page 76 MFS-29167

INFORMATION MANAGEMENT
Archival-system computer program
page 58 NPO-17129

INTEGRATED CIRCUITS
RF testing of microwave integrated circuits
page 23 LEW-14639

L
LEAST SQUARES METHOD
Least-squares frequency-acquisition algorithm
page 78 NPO-17104

LENGTH
Coding ropes for length and speed measurements
page 66 MFS-28226

M
MAGNETIC STORAGE
Archival-system computer program
page 58 NPO-17129

MAGNETIC SUSPENSION
Large-angle magnetic suspension (LAMS)
page 74 LAR-13587

MATHEMATICAL MODELS
Formula gives better contact-resistance values
page 28 NPO-17096

MICROWAVE ANTENNAS
Image-method gain measurement with mismatch
page 24 LEW-14555

MICROWAVE CIRCUITS
RF testing of microwave integrated circuits
page 23 LEW-14639

N
NOISE MEASUREMENT
Acoustical tests of a scale-model helicopter rotor
page 65 ARC-11773

NONDESTRUCTIVE TESTS
RF testing of microwave integrated circuits
page 23 LEW-14639

O
OPTICAL FILTERS
Quick-change optical-filter holder
page 40 GSC-13148

P
PHASE SHIFT KEYING
Adaptive receiver for coded communications
page 36 ARC-11815

POWER LINES
Flexible, ceramic-insulated cable
page 30 NPO-16917

PRESSURE SUITS
Pressurized sleeve
page 80 MSC-21280

PROTECTIVE COATINGS
Wear-resistant, thermally conductive coating
page 51 LEW-14562

PULSE COMMUNICATION
Fast synchronization with burst-mode digital signals
page 33 NPO-16925

R
RANGEFINDING
GPS satellite multipath range errors
page 38 NPO-17020

RESISTANCE THERMOMETERS
Device maintains water at the triple point
page 42 LAR-13708

RING STRUCTURES
Stiffening rings for rocket-case joints
page 64 MFS-28269

ROCKET ENGINE CASES
Stiffening rings for rocket-case joints
page 64 MFS-28269

ROTARY WINGS
Acoustical tests of a scale-model helicopter rotor
page 65 ARC-11773

ROTORS
Acoustical tests of a scale-model helicopter rotor
page 65 ARC-11773
Nonlinear analysis of rotor dynamics
page 75 MFS-26051

S
SATELLITES
GPS satellite multipath range errors
page 38 NPO-17020

SCHOTTKY DIODES
Schottky diode with surface channel
page 22 GSC-13063

SEEBECK EFFECT
Program collects and analyzes thermoelectric data
page 54 NPO-17149

SEMICONDUCTORS (MATERIALS)
Automatic replenishment of dopant in silicon growth
page 52 NPO-17138

SEPARATORS
Continuous-flow centrifugal separator
page 74 MSC-21173

SILICON
Automatic replenishment of dopant in silicon growth
page 52 NPO-17138

SINE WAVES
Least-squares frequency-acquisition algorithm
page 78 NPO-17104

SPACE STATION
Networks of executive controllers for automation
page 78 ARC-11780

SPACE SUITS
Pressurized sleeve
page 80 MSC-21280

SPACECRAFT CONTROL
Large-angle magnetic suspension (LAMS)
page 74 LAR-13587

SPARK IGNITION
Spark igniters fit in correct locations only
page 72 MFS-29370

SPECTROSCOPY
Simultaneous sampling of two spectral sources
page 44 LAR-13756

STANDARDS
Device maintains water at the triple point
page 42 LAR-13708

Advertiser's Index

Advanced Products Company	(RAC* 580)	44
Airpax, Inc.	(RAC 566)	61
Alsys, Inc.	(RAC 341)	73
Amco Engineering Co.	(RAC 498)	58
Anrad Corporation	(RAC 508-509)	52
Applied Microsystems Corp.	(RAC 612)	29
Automation Gages	(RAC 453)	8
Canon USA, Inc.	(RAC 623)	8
Cherokee Data Systems	(RAC 607)	34
Clearpoint Research Corp.	(RAC 619-621)	33, 35, 37
David Sarnoff Research Center	(RAC 604)	11
Diversified Technology	(RAC 629)	31
Electro Scientific Industries	(RAC 530, 624, 625)	46, 64, 84
ETA Systems, Inc.	(RAC 626)	70-71
Fluoramics, Inc.	(RAC 541)	43
General Dynamics	(RAC 531)	18-19
General Electric	(RAC 583)	63
GE Plastics Business Group	(RAC 615)	53
Grumman Data Systems	(RAC 363)	39
Harris Government Systems	(RAC 1618)	COV III
Howmet Corporation	(RAC 335)	69
Humphrey, Inc.	(RAC 627)	38
IBM Corporation		2-3, 56-57
Inco Alloys International, Inc.	(RAC 569)	47
Ioline Corporation	(RAC 472)	45
KeveX X-Ray Tube Division	(RAC 430)	65
Klinger Scientific Corp.	(RAC 368)	41
Martin Marietta		COV II-1
MASSCOMP	(RAC 581)	59
MathSoft, Inc.	(RAC 628)	9
McDonnell Douglas	(RAC 501)	COV IV
McDonnell Douglas Space Station	(RAC 373)	16-17
Microcompatibles, Inc.	(RAC 389)	83
MTS Systems Corporation	(RAC 618)	79
National Technical Systems	(RAC 358)	10
Newport Corporation	(RAC 540)	7
Nicolet Test Instruments Div.	(RAC 350)	55
NTBM Research Center		64
Pressure Systems, Inc.	(RAC 378)	5
Quantitative Technology Corporation	(RAC 570)	4
Rockwell	(RAC 379)	25
Systolic Systems, Inc.	(RAC 606)	36
TEAC Corporation of America	(RAC 344)	77
Tektronix, Inc., Instruments Group	(RAC 598)	23
Teledyne Relays	(RAC 572)	27
Teledyne Taber	(RAC 479)	54
T. F. Associates	(RAC 409)	13
University of North Dakota	(RAC 590)	54

*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.

FOLLOWING THE TRACKS NO ONE ELSE CAN SEE



A hundred years ago, no one could match the American Indian for tracking animals or men through the New Mexico desert. Today, NASA's Tracking and Data Relay Satellite System (TDRSS) in White Sands tracks a different quarry—satellites and orbital spacecraft.

Using three satellites and a single ground station, TDRSS "sees" satellites in areas other ground-based systems can't cover. For satellites in low Earth orbit it can provide 85% coverage—70% more than previous tracking systems.

As a major contributor to the original TDRSS project, Harris supplied ground communications, telemetry, and control systems, as well as space-deployable antennas on board the tracking and data relay satellites.

Now Harris heads a team competing to design a new TDRSS installation. Our low-risk, modular approach will lower maintenance costs, improve operability, and upgrade the availability of user services. And thanks to Harris' experience on the most advanced aerospace and communications projects, the new system will employ exciting breakthrough technologies like VHSIC.

Find out how Harris is blazing new trails in satellite tracking technology. Call Harris Government Systems TOLL FREE at 1-800-4-HARRIS, Ext. 2650.

 **HARRIS**



J. Harnelson

© 1988 Harris Corporation

HEADGEAR THAT HOLDS EVERYTHING AN ASTRONAUT NEEDS TO TACKLE SPACE MISSION PROBLEMS.

Keeping track of the millions of instructions needed to maintain a space station, monitor its systems and conduct research will be no easy task. But McDonnell Douglas space flight specialists have found a way to store massive amounts of data on computers linked to a miniature TV mounted on the astronaut's helmet. Detailed instructions needed to get the job done are instantly available at the touch of a button, leaving the astronaut free to move

about the station and tackle intricate space mission tasks. Headgear data displays being developed by engineers at McDonnell Douglas—for spacecraft, aircraft and maintenance—save time and improve performance.

*For more information, write:
Data Display, McDonnell Douglas,
Box 14526, St. Louis, MO 63178.*



MCDONNELL DOUGLAS

Giving America its money's worth.

SPACE SYSTEMS HELICOPTERS DATA MANAGEMENT MISSILES COMMERCIAL & MILITARY AIRCRAFT FINANCING TRAINING HEALTH CARE

Circle Reader Action No. 501