NASA Tech Briefs

Transferring Technology to American Industry and Government

December 1989
Volume 13 Number 12

1990 Technology Preview

Index Of All 1989 Tech Briefs

We Take Great Ideas...
& Make Them Even Better.™
FLOW AND LEVEL
HEATERS
DATA ACQUISITION
PRESSURE AND STRAIN
PH AND CONDUCTIVITY
TEMPERATURE
THE TEMPERATURE HANDBOOK™
OMEGA
7.632
OVER 3500 FULL COLOR PAGES.
NEW! FREE!
NOW HARDBOUND!
The 1990/91 OMEGA
Complete Measurement and Control Handbooks & Encyclopedias®
"With Over 1,000 Pages of Technical Data"
OMEGA
An OMEGA Technologies Company
One Omega Drive, Box 4047, Stamford, CT 06907
Telex 996404 Cable OMEGA FAX (203) 359-7700
Ask For Your FREE Qualification Form!
DIAL (203) 359-RUSH
(203) 359-7874

Straight Talk on DSOs – from Fluke

While the use of DSOs continues to expand rapidly, many users remain confused about how to measure and compare the performance of these complex instruments. New terms are being touted, and many of the old ones no longer apply quite the way they used to with analog scopes. Adding to the confusion is what appears to be a "specmanship" game by some manufacturers.

With the introduction of Fluke's new PM 3323 digital storage oscilloscope they have avoided the compromises made by some manufacturers with a full 500 MS/s sampling rate, 300 MHz bandwidth, and 10-bit resolution for superior signal capturing performance at a price of only $7,750.

The new PM 3323 dual-channel digital oscilloscope from Fluke offers a 300 MHz bandwidth, together with a 500 MS/s synchronous sampling rate on both channels for 2 ns single-shot resolution.

"Bandwidth" Covers A Lot of Ground

Fluke specifies and clearly states that the PM 3323 captures repetitive signals to 300 MHz, and based on the 500 MS/s sampling rate, single-shot events to 50 MHz are caught at 10 samples per period. This contrasts with some manufacturers that promote a single "bandwidth" figure, implying that they can capture even single-shot signals up to that point. Others confuse the issue by talking about the "bandwidth" of the input amplifiers of their scopes, and implying that single shots can be captured at that frequency. Still others make their performance look better by resorting to interpolation techniques to simulate higher frequency performance.

Horizontal "Resolution" Is A Critical Consideration

Capturing fast, non-repetitive signals precisely is a main attraction of DSOs, and the PM 3323 has the true specifications to do the job. The above quoted 50 MHz @ 10 points per waveform is one way to measure this performance, but it only considers pure sine waves. More important in the digital domain is the time interval between samples, reflecting the time (horizontal) resolution of the scope. In the case of the PM 3323, its 500 MS/s real-time sampling rate results in a resolution of 2 ns. This is true real-time resolution, and the PM 3323 has the short 1.17 ns risetime to take full advantage of this resolution.

In some DSOs, the effective resolution is limited by slow front-ends or limited amplifier frequency response. For instance, a competitive scope with input amplifiers of 100 MHz bandwidth has a 3.5 ns risetime. This implies that the fastest signal transition it can process is 3.5 ns. While quoting a sampling resolution of 2.5 ns (400 MS/s) for such a scope sounds competitive, it really means that it would require 2 complete sampling intervals to show a fast signal's full transition. This results in a best case effective resolution of only 5 ns. Why sample so fast if you can't keep up with fast signals? Compare that to the PM 3323's 2 ns!

Glitch "Detection" vs Glitch "Trigger"

As you measure slower signals, slower timebase settings are used. All DSOs go to slower real-time sampling rates to measure these slow signals. The result is that fast non-repetitive events – glitches – are missed. The PM 3323 overcomes this with a full "glitch detection" function to capture the occurrence and amplitude of such events as short as 3 ns, regardless of timebase setting. Note how this differs from a more simple glitch "trigger," which might only tell you that a glitch occurred, but not where and how high. A big difference!

What About Vertical Resolution?

Another compromise being made in some DSOs today is in the amplitude resolution, or the minimum change in signal amplitude that can be detected and captured. This resolution is usually specified in bits, but sometimes as a %, or in volts. The PM 3323 provides a full 10-bit vertical resolution. This results in a voltage resolution of 0.1% of full scale. A signal detail, such as a 10% overshoot can still be observed with 1% accuracy. It also means that at its maximum sensitivity of 5 mV/div, outstanding 50 µV resolution ([5 mV/div x 10 div full scale] divided by 10 bits) is obtained. Some scopes offer 6-bit capture as reflected by their 1.6% resolution spec. But 1.6% at full scale results in a measuring error of 16% in the 10% overshoot example given before! Along with a less sensitive input amplifier, the actual voltage resolution may be even worse. For example, 10 mV/div with a 6-bit scope can result in only 1 mV resolution, or 10 mV when a 10:1 probe is used!

Built-in Measurement and Analysis Power

Once a signal is captured, the ability to perform a variety of measurement and analysis functions is a key DSO benefit. The PM 3323 has a lot to offer, including cursor measurements of voltage and time differences, calculations like rms, risetimes, frequencies, and advanced analysis functionality like integration, differentiation, and even FFTs. All easily accessible through the instrument's logical menu structure.

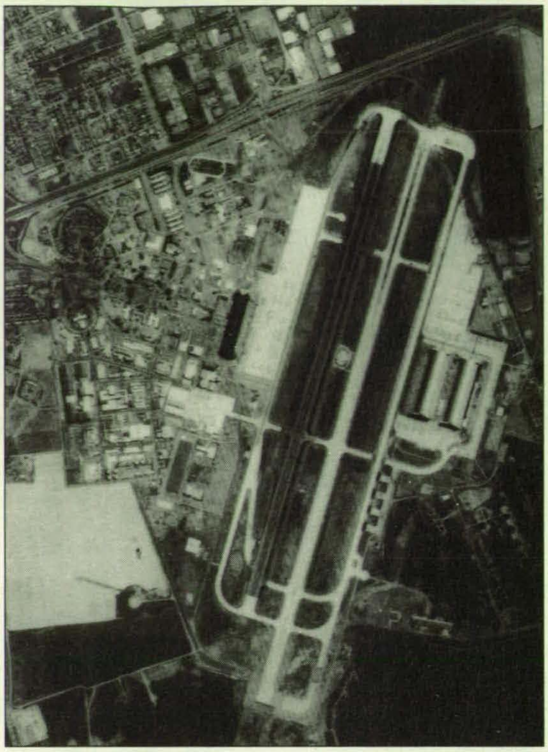
All in all, the PM 3323 from Fluke adds up to a powerful new high-speed DSO that avoids compromises built into many other scopes, providing real acquisition and analysis power making it ideally suited for complex automated measurement tasks. And at a price of only $7,750, it is an exceptional value.

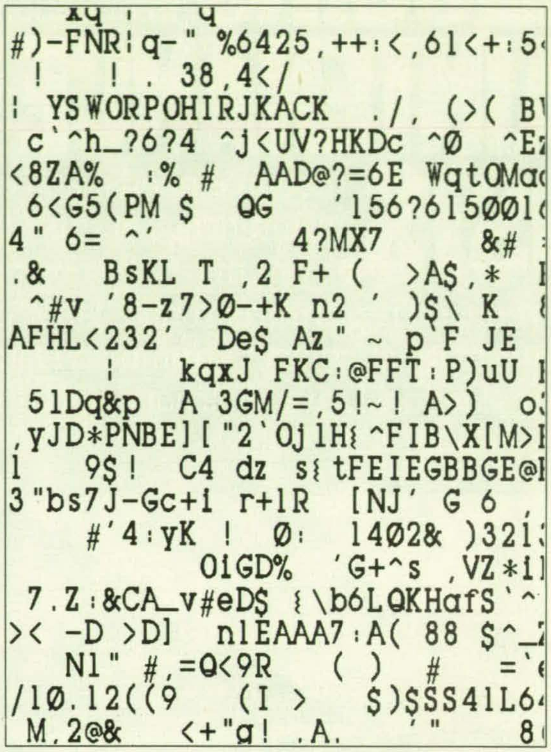
Fluke goes one step further to help you dig out from under the DSO spec confusion by providing a clear guide, "Truth in Digitizing." Request yours by calling **800-44-FLUKE ext. 77.**

John Fluke Mfg. Co., Inc., P.O. Box 9090, M/S 250C
Everett, WA 98206
U.S.: 206-356-5400 CANADA: 416-890-7600
OTHER COUNTRIES: 206-356-5500

FLUKE

Circle Reader Action No. 668





Get the picture? Get the message?

You get both with Raytheon's latest generation TDU-850 Thermal Recorder. The TDU produces continuous tone, high quality images in up to 256 shades of grey. Or — it doubles as an ASCII printer (using Raytheon's new IEEE 488 interface) and turns out crisp, letter quality alphanumerics.

The TDU makes high resolution hard copy recordings at high speeds on paper, plastics and transparencies. Optional interfaces accommodate video, IEEE 488 and other formats. Prints to 8½ inch width. (Inquire about 12-inch version.)

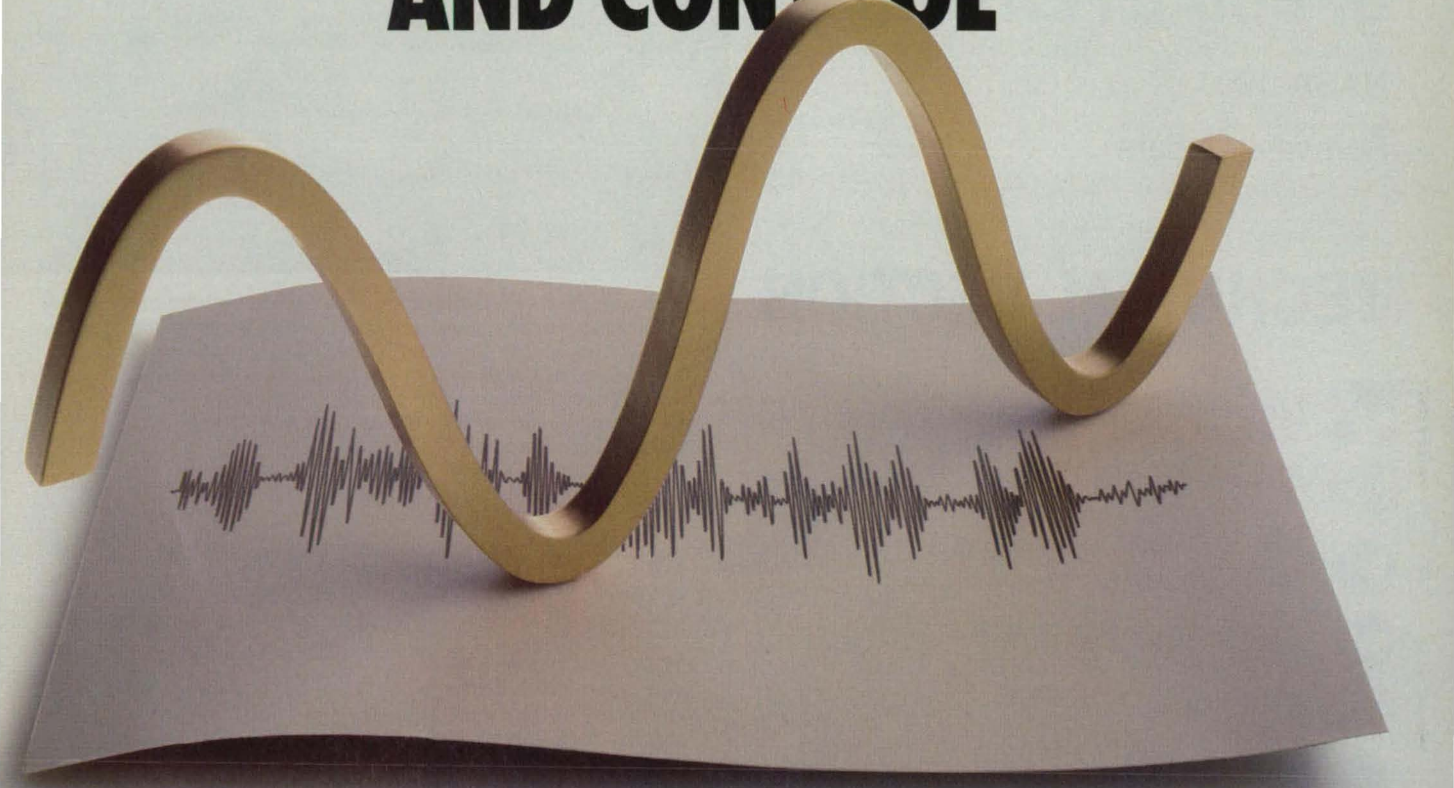
Design modifications are available to meet individual application requirements. Typical uses include: aerial surveillance, equipment testing, hydrographic surveys, security systems, R&D programs and meteorological reporting. Today's most versatile thermal recorder, still for under $5000.

Make hard copy easy. Call or write Marketing Manager, Recorder Products, Raytheon Company, Submarine Signal Division, 1847 West Main Road, Portsmouth, RI 02871-1087. Phone: (401) 847-8000.

Raytheon

Left. High altitude surveillance.
Right. Alphanumeric data presented in a random format.

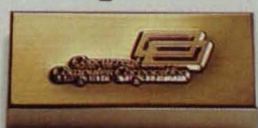
THERE'S A NEW STANDARD IN REAL-TIME COMPUTING FOR MEASUREMENT AND CONTROL



Find the 24-karat solution for your measurement and control applications at Concurrent Computer Corporation, the world leader in real-time computing.

Cost-effective real-time computing power coupled with standards like VMEbus,™ X Window system,™ DECnet,™ and a real-time enhanced UNIX® operating system are just a few of the solid-gold competitive advantages you get from Concurrent. With Concurrent you can shorten your software development cycle, lower your support costs, and get your new projects up and running faster. And our gilt-edged product line, ranging in price from $10,000 to more than $1 million, is backed by a world wide support organization.

Go for the gold! For your real-time information starter kit for measurement and control applications, send in the coupon today or call **1-800-631-2154** toll-free. Concurrent Computer Corporation—the company that sets the standards for real-time computing.



Send to Concurrent Computer Corp., Dept. MC-2,
106 Apple Street, Tinton Falls, NJ 07724

☐ Send me my information starter kit for measurement & control applications

☐ Send me information on the Concurrent real-time UNIX operating system

Name ______

Title ______

Company ______

Address ______

City ______ ST ______ Zip ______

Phone ______

My application is ______

Concurrent Computer Corporation

VMEbus™ is a trademark of Motorola Corporation. X Window system™ is a trademark of MIT. DECnet™ is a trademark of Digital Equipment Corporation. UNIX® is a trademark of AT&T.

Circle Reader Action No. 581

NASA Tech Briefs
Transferring Technology to
American Industry and Government

DECEMBER 1989
Volume 13 Number 12

Illustration courtesy NASA

1990 will mark the Galileo spacecraft's first looping orbit around the sun as it gains enough momentum to swing outward to Jupiter. When it reaches the giant planet in December 1995, Galileo will release a probe (illustrated above) that will descend by parachute and make the first direct measurements of Jupiter's fast-spinning atmosphere. See page 12.

SPECIAL FEATURES

TECHNICAL SECTION

DEPARTMENTS

***On The Cover:** This striking view of the solar corona was prepared from data supplied by NASA's Solar Maximum Mission satellite. Next year NASA will launch a new spacecraft called Ulysses that will study the sun's immense energy fields from a three-dimensional perspective for the first time. Turn to page 12.* (Photo courtesy NASA)

Illustration courtesy NASA

Slated for launch next June, the Gamma Ray Observatory will investigate stellar and intergalactic phenomena in deep space. The 15-ton craft is managed for NASA by the Goddard Space Flight Center in Greenbelt, MD.

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright © 1989 in U.S., is published monthly by Associated Business Publications Co., Ltd. 41 E. 42nd St., New York, NY 10017-5391. The copyrighted information does not include the individual Tech Briefs which are supplied by NASA. Editorial, sales, production and circulation offices at 41 E. 42nd Street, New York, NY 10017-5391. Subscriptions for non-qualified subscribers in the U.S., Panama Canal Zone, and Puerto Rico, $75.00 for 1 year; $125.00 for 2 years; $200 for 3 years. Single copies $10.00. Remit by check, draft, postal or express orders. Other remittances at sender's risk. Address all communications for subscriptions or circulation to NASA Tech Briefs, 41 E. 42nd Street, New York, NY 10017-5391. Second-class postage paid at New York, NY and additional mailing offices.

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

NASA Tech Briefs

National Aeronautics and Space Administration

ABP BPA

NASA Tech Briefs:

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

Briefs & Supporting Literature:
Provided to National Aeronautics and Space Administration by **International Computers & Telecommunications, Inc.**, NY, NY with assistance from **Logical Technical Services**, NY, NY
Technical/Managing Editor .... **Ted Selinsky**
Art Director .... **Ernest Gillespie**
Administrator .... **Elizabeth Texeira**
Chief Copy Editor .... **Lorne Bullen**
Staff Writers/Editors .... **Dr. James Boyd, Dr. Larry Grunberger, Dr. Theron Cole, Jordan Randjelovich, George Watson, Oden Browne**
Graphics .... **Luis Martinez, Vernald Gillman, Charles Sammartano**
Editorial & Production .... **Bill Little, Ivonne Valdes, Frank Ponce, Susan Finelli**

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

Associated Business Publications
41 East 42nd Street, Suite 921, New York, NY 10017-5391
(212) 490-3999 FAX (212) 986-7864
President .... **Bill Schnirring**
Executive Vice President .... **Frank Nothaft**
Vice President .... **Domenic A. Mucchetti**
Operations Manager .... **Rita Nothaft**
Controller .... **Felecia Lahey**

Advertising:
New York Office: (212) 490-3999 FAX (212) 986-7864
National Sales Manager .... **James G. McGarry**
Regional Sales Manager (Mid-Atlantic) .... **Michelle Larsen**
Account Executive .... **Debby Crane** at (201) 967-9838
Account Executive (Midwest) .... **Paul Lesher, C.B.C.** at (708) 501-4140
Account Executives (Eastern MA, NH, ME, RI) .... **Paul Gillespie** at (508) 429-8907; **Bill Doucette** at (508) 429-9861
Account Executives (Western MA, CT, VT) .... **George Watts** or **David Haggett** at (413) 253-9881
Account Executives (Southeast) .... **Newton Collinson** or **Jonathan Kiger** or **Lawrence Mischik** at (404) 939-8391
Account Executives (Calif., AZ, NV, NM)
for Area Codes 818/213/805 —**Thomas Stillman**
and for Area Codes 408/415/916/209 —**Patric Donaghy**
and for Area Codes 619/714 —**Karen Mock** at (213) 372-2744

NTBM-Research Center
Account Supervisor .... **Lourdes Del Valle**

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 24). NASA's patent-licensing program to encourage commercial development is described on page 24.

Internal Correction of Errors in a DRAM

A 256K dynamic random-access memory circuit incorporates a Hamming error-correcting code in its layout. In comparison with the use of separate error-detecting and error-correcting circuit chips, this feature provides faster detection and correction of errors at less cost in amount of equipment, operating time, and software. (See page 30).

Compliant Prosthetic or Robotic Joint

A rotating joint behaves much like a knee, knuckle, or hip-to-leg joint. The joint can be used in a prosthetic device to replace a diseased or damaged human joint or in a robot linkage to limit movement and cushion overloads. (See page 51).

Multiple-Cantilever Torque Sensor

High stiffness, high resolution, and ease of fabrication are among the features of a specially designed torque sensor. The device is flexible and sensitive to torque about its cylindrical axis and stiff enough to be insensitive to bending about any perpendicular axis. (see page 50)

Planar Antennas on Thick Dielectric Substrates

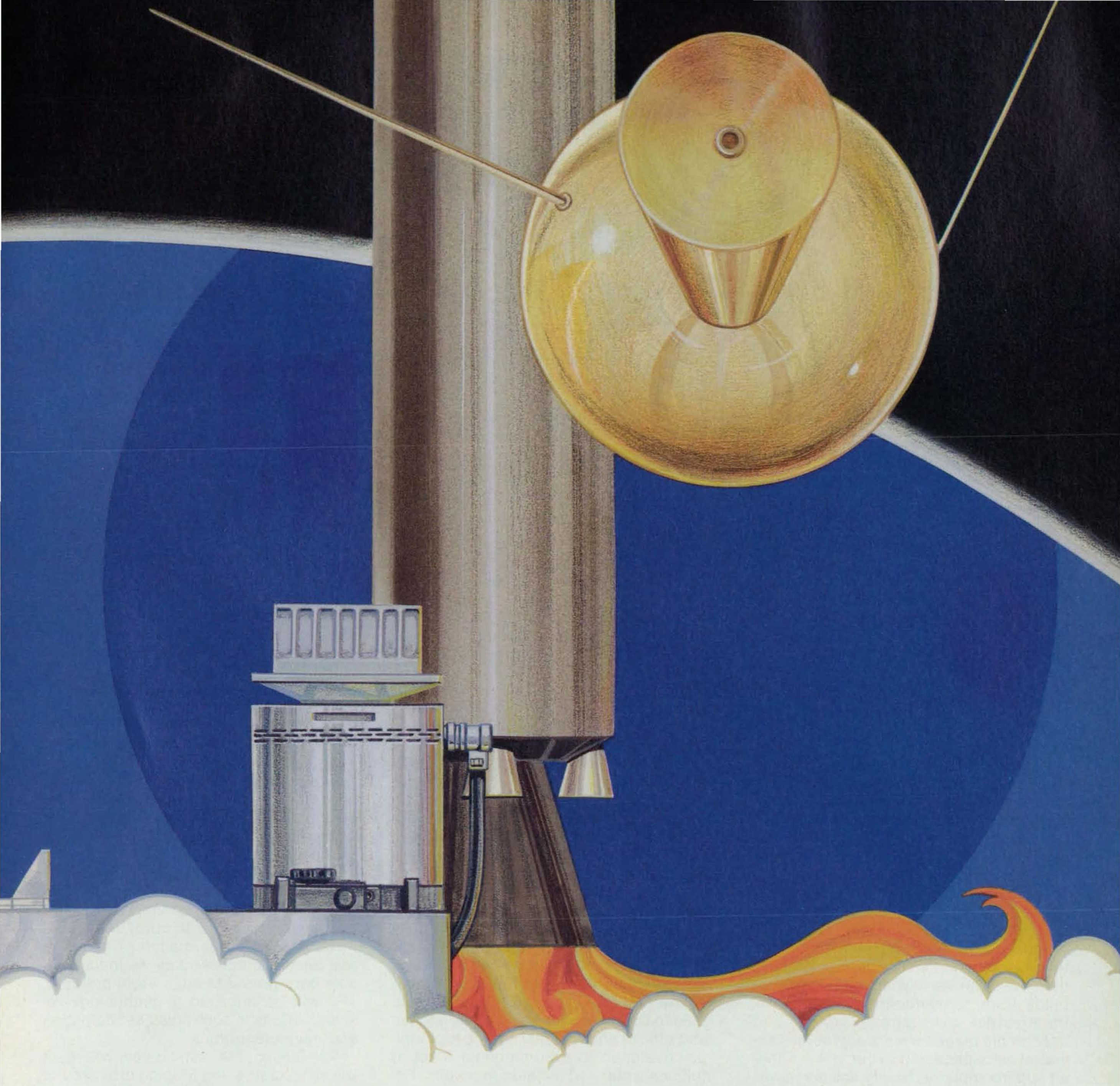
Planar antennas on thick dielectric substrates have been built for use at millimeter wavelengths from 40 to 400 GHz. Antennas of this type are quasi-optical structures for which expensive, precisely machined waveguides are not required. (See page 26).

Ground-Sensing Circuit for Arc Welders

A ground-sensing circuit for an arc-welding power supply prevents arc burns at loose ground connections on the workpiece. The welding power supply is connected to the workpiece via four ground leads; if any of these connections is broken, the protective circuit turns off the input power. (See page 32).

Optical Matrix•Matrix Multiplier

A proposed apparatus for the optical multiplication of two matrices would be based on the Stanford optical vector•matrix multiplier. Unlike previous matrix•matrix optical processors, this one does not require the redundant representation of one of the matrices. (See page 42).



NASA 1990
The View From The Field Centers

In the following articles, the directors of NASA's nine field centers provide an inside look at the agency's planned research projects and missions for 1990 and beyond. For more information on a particular project, contact the Technology Utilization Officer at the center sponsoring the research (see page 24).

A New Era Begins At NASA Ames

Dale Compton, Director
Ames Research Center
Moffett Field, CA

As Ames Research Center enters a new decade, we also are preparing to enter our second half century of service as a premier national laboratory. This year, we celebrated our 50th anniversary and our many discoveries and accomplishments in the fields of aerodynamic research, computational fluid dynamics, infrared astronomy, and human factors studies.

Today the demand on us for technology to fuel the nation's economy is stronger than ever. Our aerodynamic research extends from conventional aircraft to extraterrestrial atmospheric probes and hypersonic planes. We fly computer-generated aerospacecraft in our state-of-the-art supercomputing facility and maneuver rotorcraft in sophisticated flight simulators. Another research effort looks at how computers, linked with machines, can use artificial intelligence technology to augment human activities on Earth and in space.

We are particularly excited about three new facilities that will be completed in the early 1990s. One is the reconstructed Twelve Foot Pressure Wind Tunnel (12′ PWT). The original 12′ PWT came into service in 1946 and provided extremely clean, uniform aerodynamic flow with wind velocities nearing the speed of sound. The tunnel's hallmark, however, was the combination of these characteristics with the ability to operate at pressures up to six atmospheres. This high pressure was needed to model the airflow properly on the scale model aircraft tested in the tunnel.

Illustration of Ames' Twelve Foot Pressure Wind Tunnel

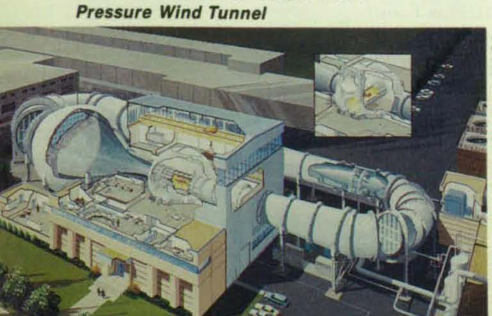


Photo Courtesy NASA

In response to increasing national demands for high-pressure operation, Ames has undertaken a project to modernize the 12′ PWT. The replacement tunnel will boast the same fine flow characteristics as its predecessor, but will also feature improvements in measurement systems, model preparation areas, and test section access.

A new Ames facility due to enter service in March 1990 is the Human Performance Research Laboratory (HPRL), which will house the Aerospace Human Factors Research Division. Just as certain dimensional standards are necessary in the home for us to live comfortably, so does human factors research attempt to find the "standards" that will help astronauts, pilots, and air traffic controllers work safely and efficiently. Human factors studies require the collaboration of scientists, engineers, psychologists, behaviorists, and sociologists. These professionals work together to optimize flight crew schedules, arrangements for living quarters, and equipment design.

The HPRL is a two-story facility containing 65,000 square feet for laboratories and offices and a 12,000-square-foot high bay designed to accommodate a set of full-scale manned mission mockups. Researchers will use the mockups to develop technologies vital to space station Freedom and to lunar and Mars missions.

The third new facility at Ames is the Automation Sciences Research Facility (ASRF), scheduled for completion in 1991, which will support the Information Sciences Division. This division is studying the dynamic new field of artificial intelligence (AI). Of special interest is the technology of machine intelligence, which involves the use of computer power to create systems that can adapt to new situations and perform complex tasks with a minimum amount of direction by the human user. Employing tactile, visual, or other sensory feedback, these automated systems will work with, or in place of, humans. In space, intelligent systems will construct orbiting stations, perform extraterrestrial exploration, and operate aerospace installations. America's space program goals depend on continuing advances in AI. □

The "Second Act" Of Planetary Exploration

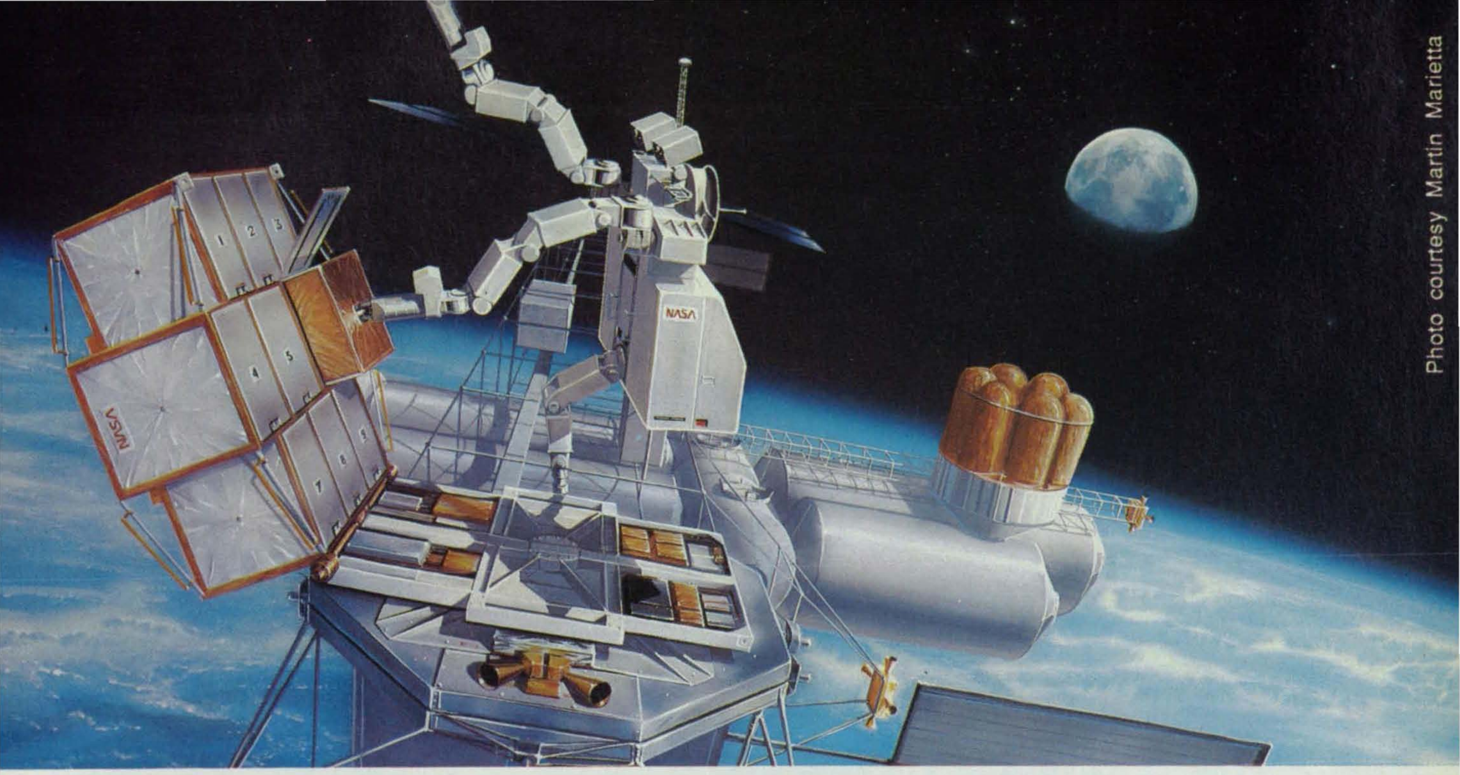
Dr. Lew Allen, Director
Jet Propulsion Laboratory
Pasadena, CA

The year now drawing to a close has been an eventful and moving one for us at the Jet Propulsion Laboratory (JPL). In 1989 Voyager 2 made its historic flyby of Neptune, concluding what might be regarded as the the first act of planetary exploration — the initial wave of missions that, from the 1960s onward, afforded us our first close look at the rest of the solar system. At the same time, NASA was busy returning the space shuttles to full operating status. In the process the agency launched two spacecraft whose missions have been keenly awaited by planetary scientists — Magellan to Venus, and Galileo to the Jupiter system.

These developments leave JPL poised for a brisk year in 1990. In the months ahead Galileo and Magellan will execute key events in their missions. We also will be moving forward with other unmanned missions in various stages of planning and development. And as an indispensable background to such flight projects, JPL will be engaged in technology research efforts in such areas as computing and microelectronics.

For Galileo, the coming year will mark the spacecraft's first looping orbit around the sun as it gains enough momentum to swing outward to Jupiter. Galileo formerly was to take a direct trajectory to the giant planet, but a change in upper-stage boosters made it necessary for the craft to fly by Venus once and Earth twice to borrow energy from "gravity assists." Galileo will encounter Venus in February 1990, and then will make its first Earth flyby in December. As a dividend, both flybys offer the opportunity to perform science operations. Following a second Earth flyby in December 1992 and one or possibly two asteroid encounters, the Galileo orbiter and its atmospheric entry probe will reach Jupiter in December 1995.

A crucial event in mid-year will be Magellan's arrival at Venus. Magellan is equipped with a synthetic-aperture radar to make high-resolution maps of Venus through the planet's dense cloud cover. Magellan's orbit insertion in August will be followed by 243 days of mapping operations.



Flight Telerobotic Servicer

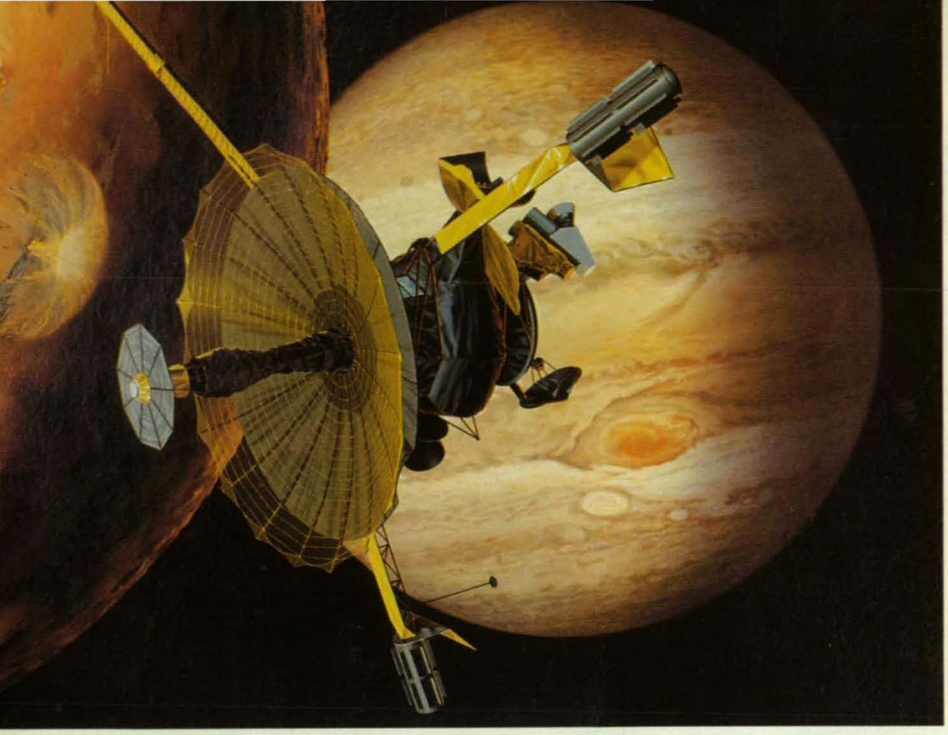


Photo Courtesy NASA

In this artist's concept, the Galileo orbiter is passing Jupiter's satellite Io on its way into its first orbit around Jupiter.

October will see the launch of another exploration craft, Ulysses. Built by the European Space Agency (ESA), Ulysses will be launched by NASA on the space shuttle. It will travel first to Jupiter, whose gravity will bend Ulysses's trajectory up and away from the plane in which the planets orbit the sun. This unique solar orbit will enable the craft to study the sun's immense energy fields from a three-dimensional perspective for the first time.

Throughout 1990, a number of other JPL flight projects will continue in development. Topex/Poseidon, an Earth satellite to map world ocean levels, is planned for a 1992 launch on a French Ariane rocket. Also slated for launch in 1992 is the Mars Observer, an orbiter which will relay highly detailed photo maps and climatological data on the red planet.

This fall, congress approved a new JPL/NASA flight project called the Mariner Mark II. In 1990 we will move forward with two missions planned under this project. The Comet Rendezvous Asteroid Flyby (CRAF) spacecraft, to be launched in 1995, will encounter an asteroid on its way to meeting Comet Kopff near the orbit of Jupiter. CRAF will then fly alongside Kopff for at least three years as the comet moves inward toward the sun. The second mission under Mariner Mark II is Cassini, scheduled for launch in 1996. A joint project with the ESA, Cassini will go into orbit around Saturn for extended studies of the ringed planet and its moons.

Ground support will be enhanced as more elements are added to the Space Flight Operations Center, a ground-data system supporting many unmanned missions. New ground equipment will also be installed at the various complexes of the Deep Space Network (DSN), the global system of antenna stations which carry out mission tracking, commanding, and telemetry. In addition to its mission support, the DSN conducts solar system radar studies and very long baseline interferometry (VLBI) research.

JPL has a variety of ongoing technology development projects. The Center for Space Microelectronics Technology is researching such areas as solid-state devices based on gallium arsenide, systems to enable optical computation and communication for flight missions, and electronic neural networks. Work in automation and robotics will bring about sophisticated new generations of unmanned spacecraft and greatly simplified ground systems. □

Goddard's Top Priority: Human Resources

Dr. John Townsend, Jr., Director
Goddard Space Flight Center
Greenbelt, MD

At Goddard, we are looking to the future with confidence. We have outstanding missions planned and — with the dramatic reduction of launches characterized by the post-Challenger era now at an end — we foresee a revitalization of our programs which will strengthen our human resources, expand our facilities, and rekindle the pride we all have felt in being active participants in the space program.

Approved missions we are looking forward to include the Roentgen Satellite, an x-ray telescope and imaging system slated for launch next year which will conduct a sweeping survey of x-ray sources; the Hubble Space Telescope, the management of which will be transferred to Goddard after launch next March; the Broad Band X-Ray Telescope, a Spacelab astronomy mission scheduled for April 1990; the Gamma Ray Observatory, a 15-ton craft that will provide information about the nature and distribution of matter near the center of the Milky Way galaxy; the Extreme Ultraviolet Explorer, a 1991 mission that will study the entire celestial sphere in the extreme ultraviolet spectrum; and the Upper Atmosphere Research Satellite, which will investigate the middle and upper atmosphere.

Goddard will continue to be responsible for Tracking and Data Relay Satellite System launches, as well as for the launches of the National Oceanic and Atmospheric Administration (NOAA) polar-orbiting satellites and geostationary meteorological spacecraft. And we will proceed with our scientific research using balloons and sounding rockets, a program managed by our facility at Wallops Island, VA.

In coming years, Goddard will manage the Earth Observing System (EOS) program, a cooperative effort with the European Space Agency and the Japanese Space Development Agency to understand the Earth as an integrated system. Unmanned platforms equipped with remote sensing instruments will be launched into polar orbit so that all parts of the Earth can be viewed and studied. EOS instruments will track global environmental change and document the complex interactions among the land, sea, and air. The platforms will make measurements for 15 years, beginning in the latter half of the 1990s.

As is the case throughout NASA, Goddard has lost many middle managers and experienced technicians. Thus, as we look towards new missions, we must also recognize the need to strengthen our human resources. In my estimation, people remain our most important asset and the top priority of our current and future planning is to nurture the center's human resources. The second priority is to reinforce, and in some cases to rebuild, the technology base in instruments, spacecraft, and ground systems. □

JSC's Technology Strategy

Aaron Cohen, Director
Johnson Space Center
Houston, TX

With the President's establishment of a long-term U.S. space strategy, the Johnson Center now has a focus — a long-term goal to which we can all work — and we're ready to step out and accomplish great things.

To support the Human Exploration Initiative, the Johnson Center will be concentrating on three areas in 1990: regenerative life support, human performance, and EVA (extravehicular activity). All three areas are key to future manned exploration. And all three are areas in which JSC has a wealth of expertise and experience.

I believe that we must have a highly reliable regenerative life support system if we're going to be able to build and sustain a lunar base or undertake a manned Mars mission. Regenerative life support technology is necessary, for example, to meet the water and air revitalization needs of a crew during a long flight to and from Mars. Without regenerative systems, the storage and weight demands for water, oxygen, and carbon dioxide removal systems would be prohibitive.

iscover
arallel
rocessing!

onoputer/2™

e World's Most Popular
ansputer Development System

ce 1986, the MicroWay **Monoputer** has come the favorite transputer develop-nt system, with thousands in use world-de. Monoputer/2 extends the original sign from 2 to 16 megabytes and adds enhanced DMA powered interface. The ard can be used to develop code for nsputer networks or can be linked with other onoputers or Quadputers to build a transputer twork. It can be powered by a 20 or 25 MHz 00 and is priced from $1295.

arallel Languages

rtran and C Make Porting a Snap!

croway stocks parallel languages from 3L, Logical Systems and nos. These include one Fortran, two Cs, Occam, Pascal, and a. We also stock NAG libraries for the T800 and ParaSoft's bugger, profiler, and Express Operating Environment. A single 00 node costs $2,000, yet has the power of a $10,000 386/1167 stem. Isn't it time you considered porting your Fortran or C plication to the transputer? It's easier than you think!

r further information, please call MicroWay's Technical Support ff at (508) 746-7341.

Quadputer™

Mainframe Power For Your PC

MicroWay's **Quadputer** is the most versatile multiple transputer board on the market today. Each processor can have 1, 4 or 8 megabytes of local memory. In addition, two or more Quadputers can be linked to build large systems. One MicroWay customer reduced an 8 hour mainframe analysis to 15 minutes with five Quadputers, giving him realtime control of his business. Quadputer is priced from $1995.

COSMOS™/M

Finite Element Analysis Running on the Quadputer

One of the most fruitful areas for parallel processing is finite element analysis. Problems which can be broken into small pieces run naturally on systems built up of many processors. **COSMOS/M** running on a Quadputer took just 300 seconds to solve a problem which ran in 12,000 seconds on an AT. Even very large mainframe problems run fast on the Quadputer: a system with 12,000 degrees of freedom took just 806 seconds while another that had 23,000 DOF ran in just 40 minutes. Contact MicroWay for information on COSMOS/M.

Circle Reader Action No. 566

Micro
Way

World Leader in PC Numerics

Corporate Headquarters: P.O. Box 79, Kingston, MA 02364 USA (508) 746-7341
32 High St., Kingston-Upon-Thames, U.K., 01-541-5466

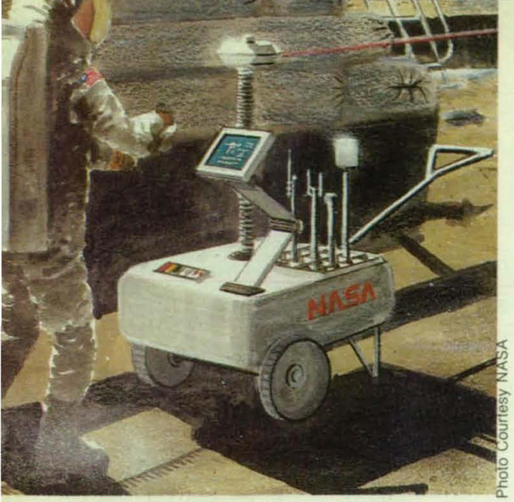


Photo Courtesy NASA

The Johnson Center is investigating a number of technologies to support future EVA activities. This illustration shows a proposed tool cart which would support surveying and construction work on the moon.

Human performance is another area requiring special emphasis. We don't know how man will be affected by long-duration zero-gravity, or even long-duration one-third gravity on Mars or one-sixth gravity on the moon. We also have much to learn about the psychological and social aspects of long-duration missions, health maintenance and trauma treatment in space, and radiation protection. There are many technical issues in human performance; we will develop our detailed plans to address and resolve these issues in 1990.

EVA, the widely-known acronym for spacewalks, is a third critical area for technology research and development at JSC. Even though we have already used EVA suits on the moon during Apollo and have a new suit planned for the space station, it will take an advanced lightweight suit designed for walking and climbing to support lunar and Mars exploration. Having a space suit on the Martian surface, where the astronaut is nine months away from getting a replacement suit and is working in one-third gravity, will require ease of maintenance and high reliability.

JSC has established teams of experts in each of these areas to assess the current and desired states of the technology and to develop implementation plans to ensure that we achieve our goals. The Special Emphasis Technology teams have made substantial progress in a very short time. The Regenerative Life Support Team, for example, has identified four broad areas of technology focus and is creating a plan to implement activities in these areas. In addition, they are developing a test bed in one of JSC's test chambers to analyze the interactions between biological and physical-chemical life support systems.

JSC has also instituted a center-wide technology management process designed to regularly assess and provide direction for the development, transitioning, and use of technologies. It includes a means to strengthen the technologies base and the planning capability of JSC down to the division level. Most importantly, it provides a way to coordinate technology development activity across the center and with other centers and outside organizations. □

Kennedy Prepares For Nine Shuttle Flights In '90

Lt. Gen. Forrest McCartney, Director
Kennedy Space Center
Florida

We begin the new decade at the Kennedy Space Center with dedication to our mission and pride in our past accomplishments. Since September 29, 1988, KSC has processed and flown all three orbiters in America's fleet. This included the successful processing of two Tracking and Data Relay satellites, two major scientific spacecraft — the Magellan Venus mapper and the Galileo Jupiter probe — plus important Department of Defense (DOD) cargo. Numerous secondary payloads were also processed and flown to increase our understanding of Earth and our own physiology.

In August of this year, the world marveled as the Voyager 2 spacecraft, launched from KSC in 1977, sent home pictures that revealed the mysteries of Neptune and its moon, Triton. Today we stand poised on the brink of a golden age of science, one in which we will probe the history of our galaxy and unknown vistas beyond.

The Hubble Space Telescope, the largest astronomical instrument ever placed into orbit, will be launched as the second payload of 1990. (The first flight will be dedicated to a DOD payload.) Working above Earth's atmosphere and pollution, Hubble will expand the volume of visible space by 350 times over Earth-bound observatories. It will enable us to see objects an estimated 14 billion light years away, giving scientists a chance to explore the mysteries of pulsars, quasars, black holes, and other phenomena of a turbulent universe.

Astronomical sciences will again be the focus as a later mission carries two advanced star-searching devices: Astro-1 and the Broad Band X-Ray Telescope (BBXRT). Astro-1, the first in a series, will make measurements of Supernova 1987A, the closest observable supernova in 400 years. The BBXRT will probe the mysteries of stellar coronae, binary stars, and clusters of galaxies.

Next, the Gamma Ray Observatory will study stellar and intergalactic phenomena in deep space. On the same mission, slated for June, astronauts will perform a second Solar Backscatter Ultraviolet Experiment to study ozone trends. The first of these critical experiments was flown in late 1989 on STS-34.

Following another DOD mission, the Spacelab Life Sciences will be launched. The first space shuttle flight dedicated wholly to life sciences, the SLS-01 will investigate the effects of weightlessness on both man and animals. Four major study areas are planned: cardiovascular and cardiopulmonary, metabolic and hematology, vestibular, and general biology.

Scientific research will next focus on the sun with the October deployment of the Ulysses spacecraft. Its planned four-and-a-half-year mission will probe many of the sun's mysteries.

A November mission will transport the German-developed SPAS platform. SPAS is a free-flying platform designed to carry a variety of experiments away from the shuttle and then return to be lifted back onboard by the remote manipulator arm for the trip home.

The final 1990 shuttle mission will loft into space the International Microgravity Laboratory to study the effects of microgravity on material and life sciences processes. From plant physiology to vestibular (inner ear/balance) research, this unique lab will gather data vital for living and working in space.

But not all the science will be taking place overhead. Although KSC is primarily a launch facility, carefully focused research efforts push the leading edge of technical knowledge in areas ranging from artificial intelligence to developing ways to grow plants in colonies away from Earth.

In the latter project, called the Controlled Ecological Life Support System (CELSS), experimenters are learning how to grow edible food in the absence of soil, gravity, and normal sunlight. Using a computer-controlled "closed" environment and a nutrient feeding system, the team has successfully grown three good crops of dwarf wheat. That knowledge may be essential to the success of long-duration space flight or a lunar colony.

Other ongoing research focuses on the rapidly-expanding field of robotics. As humans begin to live in space, robots will become increasingly important in supporting processing, flight, and space habitat requirements. KSC researchers are currently studying robotics applications in hazardous ground operations during Shuttle processing. Also under study is the automation of repetitive and critical processes that support the ground processing of the orbiters and their payloads.

With about $12 million in funding, KSC's research program is also an outreach effort. A major goal is to share knowledge and challenges with not only other NASA centers, but also with universities, industry, the medical field, and the state of Florida. Recently, Florida Governor Bob Martinez signed a technology transfer agreement at KSC that will aid the state in tapping into the center's ongoing technology utilization (TU) program. □

Kennedy Center engineers test the electrical actuators, control assemblies, and ground support equipment of the ASTRO 1 Instrument Pointing System.

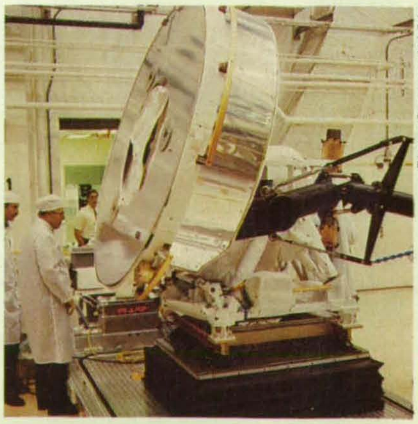
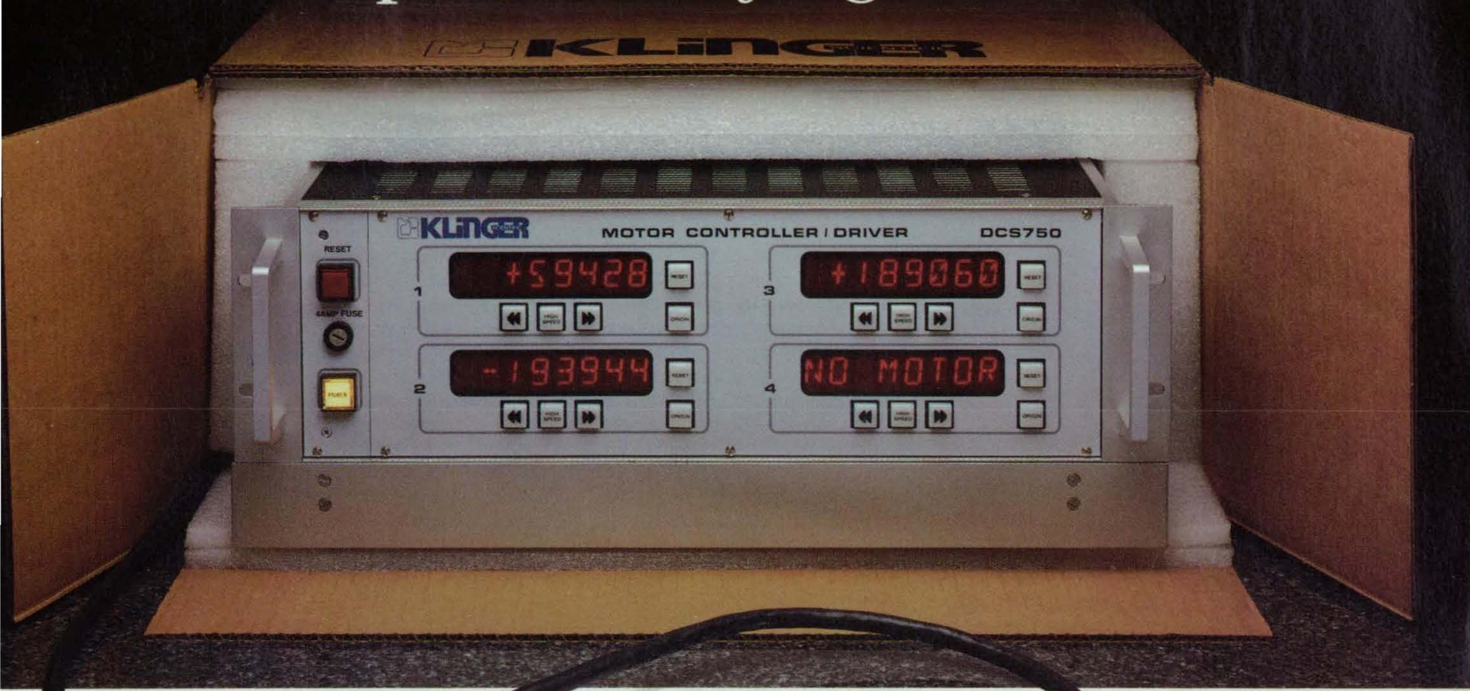


Photo Courtesy NASA

Our DCS750 is so user-friendly it enhances productivity right out of the box.



Set-up is simple. Plug in the cables and you're up and running. Klinger's DCS750 Motor Controller/Driver is completely integrated with controller modules, power supplies and amplifiers.

What's more, with its advanced programming power and ergonomic design, the DCS750 is a breeze to operate. It can simultaneously control up to four DC motor driven positioners in closed loop operation with pinpoint precision and minimal effort.

So when you want to step up the sophistication and performance of your application, the DCS750 steps up productivity as well. Right out of the box!

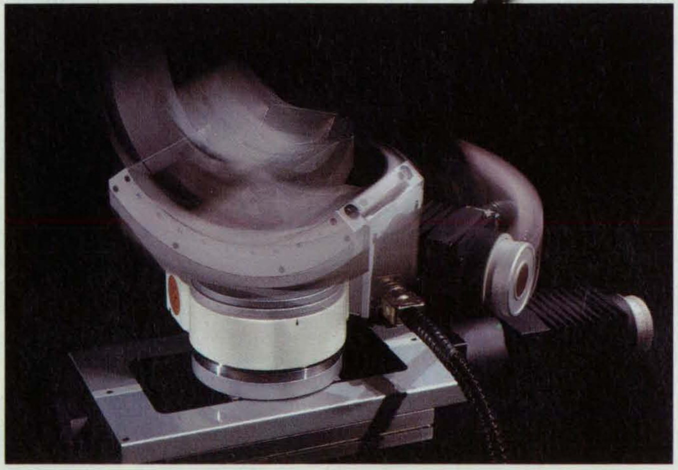
A NEW DIMENSION IN PERFORMANCE.

Equipped with both RS-232-C and IEEE-488 ports, the DCS750 interfaces with virtually any host computer or operates through its complete array of front panel controls to enhance performance. A command buffer relieves communication bottlenecks. And the system accepts and executes new commands on any axis from either interface, even while running a program.

The DCS750 allocates 16K bytes of non-volatile memory for program storage. All velocity, acceleration and PID parameters are programmable, preserved and automatically restored after power-up or reset.

THE VERY BEST IN PROGRAMMING.

The DCS750's instruction set includes 60 powerful commands that make programming easy.



And an on-board editor and compiler reduces software development and debugging time.

In addition, the DCS750 can be programmed with "soft" travel limits for the positioner. Repeatability is assured by Klinger's unique home-seeking Origin Search function.

And the DCS750 works with most DC motors and over 1,000 Klinger micropositioners and mounts.

To learn more about the DCS750 and the thousands of other Klinger micropositioners and systems, write or call for our free micropositioning handbook and motor controller brochure. Klinger Scientific Corporation, 999 Stewart Avenue, Garden City, NY 11530. (516) 745-6800 FAX: (516) 745-6812.

KLINGER SCIENTIFIC

Building better positioning systems, piece by perfect piece.

U.S.A. Headquarters: 999 Stewart Avenue, Garden City, NY 11530 (516) 745-6800 Fax (516) 745-6812.
Regional Offices: Northern California (415) 969-0247; Southern California (714) 999-5088. **In Canada:** Longueuil, Quebec (514) 442-4666.
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

Lewis: Building For Tomorrow's Achievements

Dr. John Klineberg
Director
Lewis Research Center
Cleveland, OH

At Lewis Research Center we are excited as we begin the last decade before the year 2000. As NASA's lead center for aircraft propulsion, space propulsion, and space power, we know that the work we do today will have an enormous impact on our nation's ability to meet its goals for air and space travel in the 21st century.

In the year ahead, we expect to make major progress in our propulsion research for high-speed aircraft, the development of the Advanced Communications Technology Satellite (ACTS), the application of high-temperature superconductors, and the development of space power and propulsion systems for future missions to the moon and Mars.

High-Speed Aircraft

The growing need to travel quickly to the economic centers of the Pacific Basin is expected to create the need for as many as 1500 supersonic airliners by the year 2025. To help prevent the United States from losing this significant market to aggressive foreign competitors, NASA's High-Speed Civil Transport (HSCT) technology initiative will help U.S. aircraft manufacturers determine the feasibility of building and marketing economical, environmentally acceptable aircraft that could fly at two to four times the speed of sound. This type of aircraft could carry 350 passengers from New York to Tokyo in four hours.

As part of the HSCT initiative, Lewis researchers are evaluating a variable cycle propulsion concept that will provide noise levels acceptable to the community, a substantial reduction in fuel consumption, and extended life at sustained high operating temperatures. Research is also continuing on the supersonic through-flow fan concept that may significantly improve the economics of future supersonic transport engines.

Moreover, our engineers are designing air-breathing propulsion systems for hypersonic/transatmospheric cruise vehicles that can take off and land on conventional runways, cruise at more than six times the speed of sound in the atmosphere, or accelerate into space.

For the National Aero-space Plane (NASP) Program — which seeks to build an experimental hypersonic vehicle by the end of the decade — we will continue to provide support in low-speed propulsion, high-temperature materials and structures, propulsion controls, computational fluid dynamics, and cryogenics. We plan to activate the Hypersonic Wind Tunnel at our Plum Brook site and have modified a cryogenic facility to manufacture the slush hydrogen that will fuel the experimental flight vehicle.

ACTS

In conjunction with U.S. industry, Lewis engineers are preparing the Advanced Communications Technology Satellite (ACTS) for launch aboard the Space Shuttle in 1992. ACTS will make satellites more economical and accessible by serving as a "switchboard in the sky." ACTS will feature onboard digital processing, storage, and switching using multiple hopping spot beams. It will enable satellites to efficiently send signals simultaneously to thousands of very small ground terminals. Corporations, universities, and government agencies who could benefit from advances in satellite communications have been invited to design experiments that will evaluate the key ACTS technologies.

High-Temperature Superconductivity

Lewis scientists in cooperation with researchers at Argonne National Laboratory, are exploring how high-temperature superconductors can benefit aerospace technology. Earlier this year, Lewis researchers used yttrium barium copper oxide to produce the first electronic circuit able to operate at 33 to 37 gigahertz, a frequency range more than three times higher than currently-used circuits. These super-high frequency circuits will allow satellites to triple the number of link-ups they can handle and may dramatically improve communications and data systems here on Earth.

Space Power For Future Missions

With space station Freedom scheduled to be operating by the year 2000, we are entering the final stages of the development and testing of its power system. Much of what has been learned in creating this power system will be used to design components and systems that will assure sufficient, reliable power for future NASA missions such as the lunar outpost and piloted mission to Mars. In the year ahead, space power researchers at Lewis will begin developing very lightweight nickel-hydrogen batteries for applications on geosynchronous spacecraft, fuel cells for planetary missions, and ultra-lightweight photovoltaic solar cells for new NASA missions.

Photo Courtesy NASA

Artist's conception of the National Aero-Space Plane

Work is continuing on the free-piston Stirling engine, a dynamic conversion subsystem for solar or nuclear space power systems. And we are further refining components such as radiation tolerant indium phosphide solar cells and lightweight carbon composite radiators.

Space Transfer Vehicle Propulsion

This will be an especially exciting year in the area of space propulsion. We will begin developing a test bed liquid hydrogen/oxygen engine which could launch excursion vehicles from low-Earth orbit to the orbits of the moon or Mars. And for cargo vehicles needed for future NASA missions, our scientists are exploring high-performance electric propulsion systems. □

Towards Future Flight

Richard Petersen,
Director
Langley Research Center
Hampton, VA

Langley Research Center plays a leading role in the development of advanced aeronautics and space technology, largely attributable to the quality of our staff and to our unique research facilities, currently valued at over $1.5 billion.

In 1990 Langley's technology thrusts will include transatmospheric research, Earth Observing System experiments, and the Aeroassist Flight Experiment.

Transatmospheric Research

The transatmospheric research program seeks to demonstrate, by the mid-1990s, the potential for aerospace vehicles to take off and land horizontally from conventional runways, sustain hypersonic cruise and maneuver in the atmosphere, and accelerate to orbit and return to Earth.

Assuming adequate funding, by the end of 1992 a technology base will be established to determine whether sufficient progress has been made to proceed with design and development of the X-30 research vehicle, under the National Aero-space Plane (NASP) Program. In support of NASP, a major effort in the theory, analysis, and measurement of laminar to turbulent boundary layer transition will be completed in 1990. This work, providing design criteria for both generic vehicle drag prediction and heat transfer at hypersonic speeds, utilizes the available low-disturbance wind tunnel facilities at LaRC. This data is needed by the NASP contractors to accurately and consistently predict engine and airframe performance in their X-30 designs.

Earth Observing System (EOS)

Langley researchers have proposed four flight experiments for the first EOS mission: SAFIRE (Spectroscopy of the Atmosphere Using Far Infrared Emission), an effort to improve understanding of atmospheric ozone by conducting and analyzing global-scale measurements of important chemical, radiative, and dynamical processes; SAGE III (Stratospheric Aerosol and Gas Experiment), which will provide global profiles of aerosols, trace gases, cloud top height, and air density in the middle atmosphere; TRACER (Tropospheric Radiometer for Atmospheric Chemistry and Environmental Research), an experiment to measure multi-level global distributions of carbon monoxide, presenting a global view of this important chemical species; and CERES (Clouds and the Earth's Radiant Energy System), designed to expand knowledge of radiative effects of cloud processes and their interaction with the Earth's climate.

In 1990 Langley will focus on instrument definition and preliminary development along with definition of necessary data facilities, system engineering, and payload accommodation studies.

Photo Courtesy NASA

Aeroassist Flight Experiment

An important phase of future space transportation operations is the transfer of cargo and personnel from low- to high-Earth orbit. A class of craft known as aeroassisted orbital transfer vehicles (AOTVs) has been proposed for this task. By using the vehicle's aerodynamic lift and drag forces to capture an orbit, payloads would be increased over an all-propulsion braking orbital transfer vehicle (OTV). Because of the lack of flight data at the high altitudes and velocities of the AOTVs, a precursor experiment called the Aeroassist Flight Experiment (AFE) will be performed.

The AFE will investigate critical design issues for aeroassisted space transfer vehicles. Aerodynamic braking maneuvers will occur in upper regions of the Earth's atmosphere, at or near geosynchronous return velocities, producing aerothermodynamic environments that cannot be readily simulated or modeled. The generically-shaped spacecraft will be delivered to low-Earth orbit by the shuttle. After separation, the AFE's solid rocket motor will drive the craft into the upper atmosphere to simulate speeds for returning from geosynchronous orbit and near that of lunar return. Data will be obtained during the high-altitude pass through the upper atmosphere and the vehicle will then return to low-Earth orbit, where it will be retrieved by the shuttle and transported back to Earth.

In addition to designing the mission, Langley is responsible for ground-based tests and development of the integrated flight experiments package. □

Space Station On Target At Marshall

Thomas Lee, Director
Marshall Space Flight Center
Alabama

In 1990 Marshall Center employees expect to "hit the ground running," stepping up the work tempo on space station Freedom and meeting deadlines for the launch of the Hubble Space Telescope in March, while maintaining progress in many other critical programs and projects.

America's next big program, space station Freedom, remains on target at Marshall, where the U.S. modules are being designed and assembled. These structures are to be used for the living area, the laboratory, logistics, and four resource nodes required to interconnect the pressurized elements and provide key control functions. Marshall will also have a large part of the responsibility for integration of the Japanese and European modules into the overall assembly, and for the station's environmental control systems.

A national goal which has been under consideration for years, the U.S. space station is scheduled to begin operation in the 1990s in low-Earth orbit where it will be permanently manned.

The Hubble Space Telescope is scheduled for action in 1990 and will allow us to see planets, stars, galaxies, and other celestial objects with ten times finer detail than we now can with our best optical telescopes on Earth. Marshall has managed the design and development of the telescope, and will verify that, after attaining Earth orbit, the telescope and ground support systems operate properly. . . a task expected to last several months.

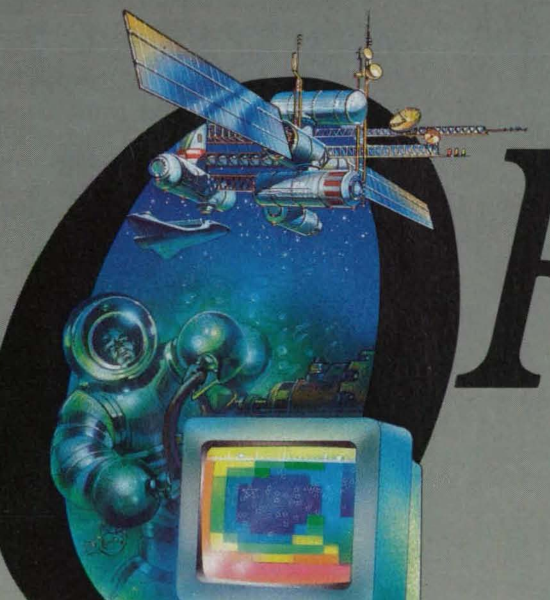
Marshall will continue to provide the main engines, external tank, solid rocket boosters, and Advanced Solid Rocket Motor for the space shuttle, and will investigate new ways to meet the nation's future space transportation needs. As NASA's lead center for propulsion systems development, Marshall constantly studies and reviews the types of space vehicles which will best serve the nation.

President Bush, in a major space policy address in July, proposed " . . . a long range, continuing commitment. First, for the coming decade space station Freedom — our critical next step in all space endeavors. And next — for the new century — back to the moon. Back to the future. And this time back to stay. And then — a journey into tomorrow — a journey to another planet — a manned mission to Mars."

Marshall's studies of Heavy Lift Launch Vehicles will be vital to these plans.

Concepts being studied include both evolutionary vehicles such as the Shuttle-C and new vehicles envisioned in the Advanced Launch System. Shuttle-C uses the shuttle propulsion system and existing launch facilities but replaces the manned orbiter with an unmanned cargo carrier. If approved for production, it could be flying relatively quickly. It is designed to boost payloads of 100,000 pounds or more into low-Earth orbit and would give NASA an unmanned test bed for use in the first flight of an Advanced Solid Rocket Motor. Advanced Launch System studies envision both expendable and reusable vehicles with a payload capability ranging from 40,000 to 300,000 pounds.

THERE'S ONLY ONE THING TO SAY ABOUT TOTAL INFORMATION SOLUTIONS.



RACLE

Whether the application involves space exploration, earthquake detection, oceanic engineering, or just about anything related to information management, Federal information resource managers know who to turn to.

Oracle.

That's because Oracle software performs on virtually all types of hardware and operating systems. Fully compatible with industry standards, Oracle software makes information transparent, and helps you avoid costly conversions.

But there's more to Oracle than simply software. Our staff and consultant network support you every step of the way, from requirements analysis and training to system and network design and implementation. That's what total solutions are all about.

For more information and a free brochure, call **1-800-345-DBMS, ext. 6768.**

By the way, there's one more thing to say about total information solutions: Authorized ADP Schedule Price List Contract No. GS00K 88 AGS 5937.

ORACLE®

FEDERAL DIVISION

Compatibility. Portability. Connectability. Capability.

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

Emphasis is on significantly reduced costs.

Upper stages to be used on space shuttle or other expendable launch vehicles are in various stages of operation and development at Marshall. The Inertial Upper Stage (IUS) is a solid propellant vehicle capable of supporting planetary missions and boosting heavy payloads from low- to high-Earth orbit. Its first use on the shuttle was to launch NASA's Tracking and Data Relay satellite. In the future it will support planetary and other missions involving large and heavy loads. PAM, or Payload Assist Module, is also used for inserting satellites into higher orbits. A third upper stage is the Transfer Orbit Stage, which fills the performance gap between the PAM and the IUS.

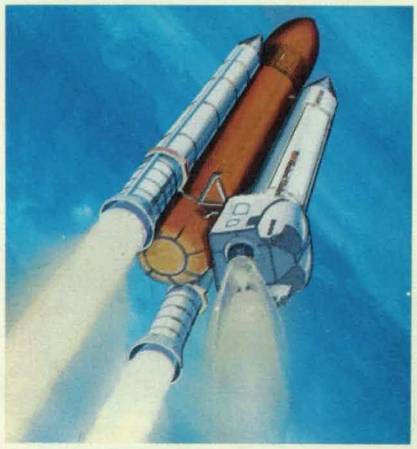


Photo Courtesy NASA

An unmanned shuttle cargo vehicle called the Shuttle-C is being studied at the Marshall Center.

Marshall is also managing a special type of upper stage — a reusable, remotely-controlled, free-flying vehicle that can perform many on-orbit services in support of spacecraft, including retrieval, reboost, and controlled de-orbit. It is called the Orbiting Maneuvering Vehicle and it is planned as an extension of shuttle and Freedom station capabilities.

Along with the Hubble Space Telescope, Marshall in 1990 will continue to manage development of another in NASA's series of great observatories — the Advanced X-Ray Astrophysics Facility. It is designed to observe the universe in the x-ray region of the electromagnetic spectrum. A free-flying observatory, it will have a 15-year lifetime and will explore energetic sources such as quasars, black holes, pulsars, and active galactic nuclei. The development schedule calls for a launch in the 1996 time frame.

In cooperation with the Air Force, Marshall in 1990 will investigate the environment hundreds of miles above the Earth. The Combined Release and Radiation Effects Satellite (CRRES) will perform investigations in the ionosphere and magnetosphere using chemical tracer releases to help researchers gain new insights into conditions that influence the Earth's magnetic field. CRRES will be lofted into the upper atmosphere on an expendable launch vehicle.

Marshall has pioneered in a unique concept to join its engineers with others from private industry and from the educational community. In the center's Productivity

(continued on page 98)

HOW YOU CAN BENEFIT FROM NASA's TECHNOLOGY UTILIZATION SERVICES

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

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

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

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

Aerospace Research Applications Center (ARAC)
Indianapolis Center for Advanced Research
611 N. Capitol Avenue
Indianapolis, IN 46204
Dr. F. Timothy Janis, Director
(317) 262-5036

Central Industrial Applications Center/NASA (CIAC)
Rural Enterprises, Inc.
P.O. Box 1335
Durant, OK 74702
Dickie Deel, Director
(405) 924-5094

North Carolina Science and Technology Research Center (NC/STRC)
Post Office Box 12235
Research Triangle Park, NC 27709
H. Lynn Reese, 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
Box 24
Progress Ctr., One Progress Blvd.
Alachua, FL 32615
J. Ronald Thornton, Director
(904) 462-3913
(800) 354-4832 (FL only)
(800) 225-0308 (toll-free US)

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

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

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

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

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

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

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

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

Ames Research Ctr.
Technology Utilization Officer: Laurance Milov
Mail Code 223-3
Moffett Field, CA 94035
(415) 694-4044
Patent Counsel: Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 694-5104

Lewis Research Center
Technology Utilization Officer: Anthony F. Ratajczak (acting)
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5568
Patent Counsel: Gene E. Shook
Mail Code 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-PMO-A
Kennedy Space Center, FL 32899
(407) 867-3017
Patent Counsel: James O. Harrell
Mail Code PT-PAT
Kennedy Space Center, FL 32899
(407) 867-2544

Langley Research Ctr.
Technology Utilization Officer: John Samos
Mail Stop 139A
Hampton, VA 23665
(804) 864-2484
Patent Counsel: George F. Helfrich
Mail Code 279
Hampton, VA 23665
(804) 864-3523

Goddard Space Flight Center
Technology Utilization Officer: Donald S. Friedman
Mail Code 702.1
Greenbelt, MD 20771
(301) 286-6242
Patent Counsel: R. Dennis Marchant
Mail Code 204
Greenbelt, MD 20771
(301) 286-7351

Jet Propulsion Lab.
NASA Resident Office
Technology Utilization Officer: Gordon S. Chapman
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
Patent Counsel: Paul F. McCaul
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
Technology Utilization Mgr. for JPL: Dr. Norman L. Chalfin
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

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

Lyndon B. Johnson Space Center
Technology Utilization Officer: Dean C. Glenn
Mail Code IC-4
Houston, TX 77058
(713) 483-3809
Patent Counsel: Edward K. Fein
Mail Code AL3
Houston, TX 77058
(713) 483-4871

NASA Headquarters
Technology Utilization Officer: Leonard A. Ault
Code CU
Washington, DC 20546
(202) 453-8377
Assistant General Counsel for Patent Matters: Robert F. Kempf, Code GP
Washington, DC 20546
(202) 453-2424

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

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

MATLAB™ Version 3.5

INTRODUCING THE SIGNAL PROCESSING TOOLBOX

- FASTER MATRIX COMPUTATION
- DIGITAL FILTER DESIGN
- SPECTRUM ESTIMATION
- PARAMETRIC MODELLING
- TIME SERIES ANALYSIS
- NEW 2-D AND 3-D GRAPH TYPES

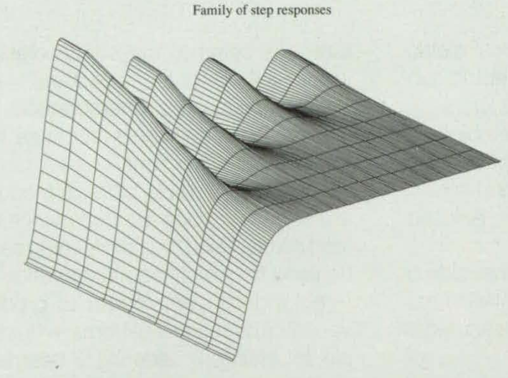
MATLAB v3.5 is the latest version of the premier interactive system for numerical analysis and signal processing. Problems and solutions are expressed just as they are written mathematically — ***without traditional programming***.

MATLAB has rapidly become an industry standard for digital signal processing research. Its unique interactive interface, algorithmic foundation, easy extensibility, and speed make MATLAB the software system of choice for ***high productivity*** and ***high creativity*** research at thousands of universities, laboratories, and companies.

Over 200 Built-in Functions

- eigenvalues
- least squares
- cubic splines
- convolution
- complex arithmetic
- IIR and FIR filters
- curve fitting
- 1-D and 2-D FFTs
- matrix arithmetic
- multivariate statistics
- polynomial arithmetic
- nonlinear optimization
- linear equation solving
- differential equations
- singular value decomposition, ***and more***

Version 3.5 adds new 2-D and 3-D plot types, including feather plots, error bars, automatic contour labelling, and optimized VGA support.



The company and product names mentioned above are trademarks of their respective holders.

Computers

- ✓ PC and AT Compatibles
- ✓ 80386 Computers
- ✓ Macintosh
- ✓ Sun Workstations
- *NEW!* ✓ HP 9000 Workstations
- ✓ Apollo Workstations
- ✓ VAX/VMS and Unix
- ✓ Ardent Titan
- *NEW!* ✓ Convex C-Series
- *NEW!* ✓ Alliant FX/Series
- ✓ Other Computers

Open and Extensible

Create functions and programs rapidly — without the time-consuming compiling, linking, and complex syntax of traditional languages. Our open-system philosophy gives you access to algorithms so you can edit functions or add your own.

Optional Toolboxes extend MATLAB with application-specific capabilities, such as control system design, parametric modelling, and chemometrics.

Benchmarks (20 MHz 386-based PC)

50 x 50 matrix multiply	0.71 sec
50 x 50 matrix inverse	1.32 sec
50 x 50 eigenvalues	1.21 sec
4096-point complex FFT	1.16 sec

Fast, Accurate, and Reliable

MATLAB can handle lots of data and do it fast, fully utilizing all available floating point hardware for maximum performance. You won't have to question the results either — the algorithms have been programmed by leading experts in mathematical software and are used by leading researchers around the world.

Please provide additional information!

Name ________________________

Company ________________________

Dept. ________________________

Address ________________________

City, State, Zip ________________________

Country ________________________

Telephone ________________________

Computer ________________________

The MATH WORKS Inc.
21 Eliot Street
South Natick, MA 01760
Tele: (508) 653-1415
FAX: (508) 653-2997

NASA 12/89

Circle Reader Action No. 503

Electronic Components and Circuits

Planar Antennas on Thick Dielectric Substrates

Features include ease of fabrication and wide range of operating frequencies.

NASA's Jet Propulsion Laboratory, Pasadena, California

Planar antennas on thick dielectric substrates have been built for use at millimeter wavelengths. To obtain directional and impedance characteristics nearly independent of frequency from 40 to 400 GHz, the antennas were made in four-lobe log-periodic (see Figure 1), two-lobe log-periodic, and two-arm log-spiral configurations.

Antennas of this general type are quasi-optical structures, for which expensive, precisely machined waveguides are not required. They can be made easily by standard photolithography and integrated with planar mixers or detectors to form arrays. Because such an antenna radiates (or receives) mostly on the dielectric side of the metal conductor, it has enhanced directivity without a back plane. One disadvantage of a thick substrate is the excitation of undesired surface electromagnetic modes. At the cost of additional losses in the dielectric, these modes can be suppressed by the addition of a hemispherical dielectric lens to the side of the dielectric substrate opposite that of the conductors.

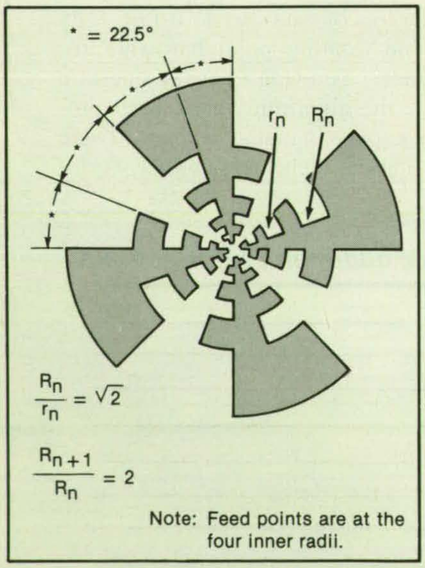


Figure 1. In this **Four-Lobed Log-Periodic Circular Antenna**, the conductors cover half the area of the circle. Because the arc lengths of the teeth are prescribed to be quarter wavelengths, the upper and lower frequency limits are set by the inner and outer radii, respectively.

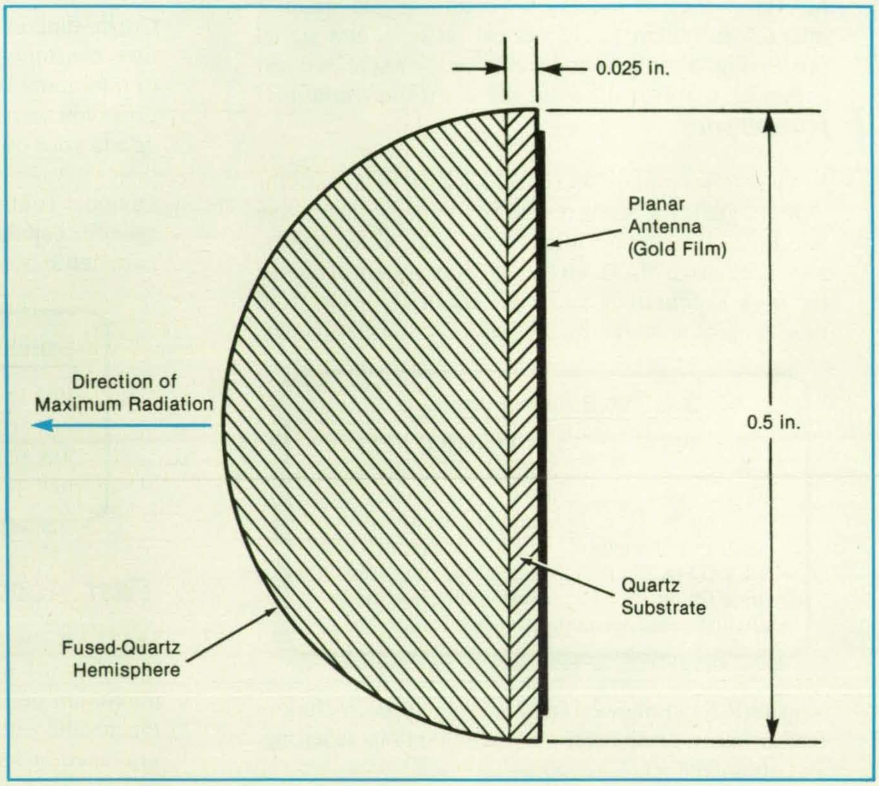


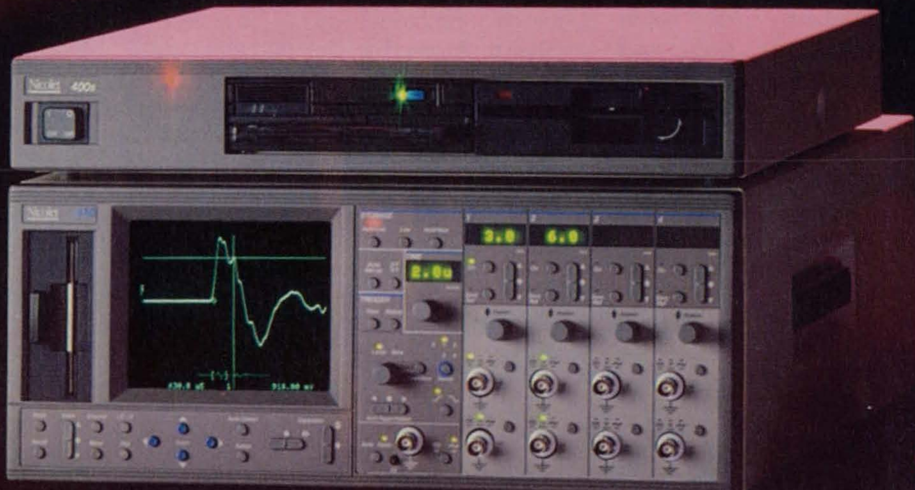
Figure 2. Each **Experimental Planar Antenna** was made of etched gold film on a quartz substrate. The fused-quartz hemisphere on the opposite side of the substrate acted as a dielectric lens.

Each antenna was made by etching the conductor patterns in a gold film on a quartz substrate 0.5 in. (12.7 mm) square and 0.025 in. (0.635 mm) thick. A fused-quartz hemisphere 0.5 in. (12.7 mm) in diameter was mounted on the other side of the substrate (see Figure 2). Antenna patterns for each structure were measured at 67 GHz and 205 GHz.

The log-spiral antenna exhibited circular polarization. The two- and four-lobed log-periodic antennas both exhibited the expected independence of frequency and had similar directional patterns, the major differences being in the cross-polarization levels (−6 dB for four-lobed and −25 dB for two-lobed). This characteristic is encouraging to designers because it indicates that the directional pattern can be retained when multiple pairs of feed points are used to reduce the impedance at the feed points. Such multiple feeding can also be used for simultaneous operation in different independent modes to produce a variety of directional patterns — for example, for electronic steering of beams.

This work was done by K. A. Lee and M. A. Frerking of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 45 on the TSP Request Card.* *NPO-17466*

THE SHAPE OF THE FUTURE



The new Nicolet 400 Series. Complete with 64K-256K expandable memory. Easy upgradability. Even removable hard drive.

Facts are facts.

Only one digital oscilloscope provides 64K-256K expandability. Software that upgrades your unit instantly. And a 44 Megabyte removable disk providing fast, easy data retrieval.

That's the new Nicolet 400 Series—a rare combination of power and speed, flexibility and convenience. It gives you all this *today* . . . so you'll be in better shape *tomorrow.*

Its expandable memory multiplies your ability to record transients over time. And along with on-board calculations, its 32-bit CPU provides waveform processing ten to 100 times faster than a PC.

The 400 takes a fresh look at data collection, too. Disk-downloadable sequences and programs help you transfer and archive data with new-found speed and accuracy. You can even cascade together four channels for memory as long as one MegaSample. And programs can be loaded with the simple touch of a button.

See how much Nicolet has done to improve your future. Send for a new 400 brochure now.

Nicolet Test Instruments Division

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

Circle Reader Action No. 696

Nicolet

INSTRUMENTS OF DISCOVERY

Memory Switches Based on MnO_{2-x} Thin Films

"On"-state resistance is adjustable, and on-to-off transition is irreversible.

NASA's Jet Propulsion Laboratory, Pasadena, California

Thin films of MnO_{2-x} at intersections between metallic row and column conductors can serve as switching elements for nonvolatile electronic memories. Memory elements made of MnO_{2-x} have high ratios of "off" resistance to "on" resistance ($\gtrsim 10^3$) and high "on" resistances (typically $\sim 10^6$ Ω). The elements are electrically programmable and are especially suitable for use in associative electronic memories based on neural-network concepts.

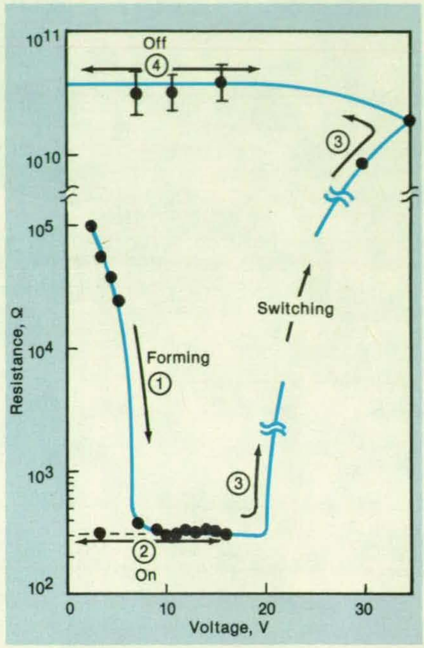
Because many elements of a neural-network memory circuit must operate in parallel, the "on" resistance of each element must be kept high to prevent excessive power dissipation and heating. Previously, such circuits were made with films of amorphous hydrogenated silicon, which switches irreversibly from "off" to "on" and has an imprecise "on" resistance. It was necessary to provide synaptic ballast resistors of $\sim 10^6$ Ω apiece in series, to assure the desired "on" resistance, and this complicated the structure.

Because the new MnO_{2-x} switches have preset "on" resistances, no ballast resistors are required. Films of MnO_{2-x} can be deposited by reactive dc magnetron sputtering. The "on"-state resistivity of a film can be tailored by controlling the amounts of oxygen and argon gases in the sputtering chamber and the subsequent processing temperature. The film is deposited in a low-resistivity "on" state. The resistivity continues to decrease as the temperature rises to $\sim$300 °C. After this formation process, the "on" state remains stable. By subsequent heating up to $\sim$500 °C, the resistivity of the film can be increased to an "off"-state value of $\gtrsim 10^5$ Ω•cm.

The change from a lower to higher resistivity is irreversible. It is due to the transformation of conductive MnO_{2-x} to nonconductive Mn_2O_3. The change can be induced thermally, by applying an appropriate electrical current pulse heating. This feature makes it possible to program memory elements electrically to switch selected elements to the "off" state.

The resistance-versus-voltage curve in the figure illustrates the switching property of an experimental MnO_{2-x} synaptic switch that was not heated after deposition. The initial decrease of resistance with increasing voltage represents the formation of the film into the "on" state. The "on" state remains stable up to about 20 V, beyond which the resistance increases toward the "off" state. Thereafter, the switch remains in a high-resistance "off" state, even after the voltage pulse is removed. Thus, if this switch were used as a memory element, a datum represented by the "off" state could be written into it by the application of a pulse of $\sim$30 V, and the contents of this memory element could be "read" by applying a potential of less than 20 V — preferably at a safe level of $\sim$5 V.

This work was done by Rajeshuni Ramesham, Anilkumar P. Thakoor, and John Lambe of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 80 on the TSP Request Card.*



The **Electrical Resistance of an MnO_{2-x}-Film Switching Element** changes irreversibly as the voltage applied to it is increased.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 301-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-17377, volume and number of this NASA Tech Briefs *issue, and the page number.*

Resistance Welder Using 480-Vac Ground-Fault Interrupter

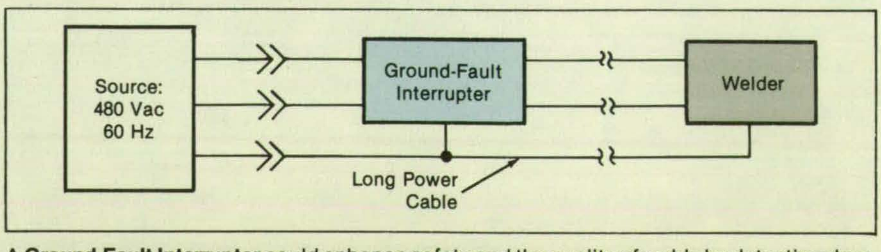
Safety and the quality of weld joints would be enhanced.

Marshall Space Flight Center, Alabama

The use of ground-fault interrupters in the 480-Vac power supplies of portable resistance welding machines has been proposed. Such welding machines are now not equipped with ground-fault interrupters even though they are used outdoors and in factory areas where power cables are subject to damage; for example, by being run over by forklifts and other heavy vehicles.

For safety, ground-fault interrupters are included in the power circuits of most heavy electrical equipment used outdoors. The use of a ground-fault interrupter with a welder (see figure) would not only enhance safety but would also help assure the quality of welds, in that internal damage in a main power cable that is still covered by insulation can cause defective welds, and a ground-fault interrupter can detect such damage.

This work was done by Steven W. Huston, Ralph E. Kroy, and Douglas I. Macfarlane of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29582



A **Ground-Fault Interrupter** could enhance safety and the quality of welds by detecting damage in the long power cable to a portable resistance welder.

Internal Correction of Errors in a DRAM

An error-correcting Hamming code is built into the circuit.

NASA's Jet Propulsion Laboratory, Pasadena, California

A 256 K dynamic random-access memory (DRAM) circuit incorporates a Hamming error-correcting code in its layout. In comparison with the use of separate error-detecting and error-correcting circuit chips, this feature provides faster detection and correction of errors at less cost in amount of equipment, operating time, and software. The on-chip error-correcting feature also makes the new DRAM less susceptible to single-event upsets (changes of logic states in memory cells caused by ionizing radiation).

The words of the Hamming code are formed within the chip and are not externally addressable. Each code word contains 8 data bits and 4 check bits. As shown in Figure 1, the code words are organized on the circuit chip into an expanded array of 512 rows by 768 columns of bits.

The code can correct only one error in a code word, but an incident high-energy ion can induce bit errors in several adjacent memory cells. Therefore, it is desirable to reduce the probability of multiple bit errors within each code word by separating the memory cells of each word to distances beyond which the charge tracks left by incident ions are not likely to spread. In this design, the bits of each code word are stored at positions four columns apart in two rows from two separate sections of the array.

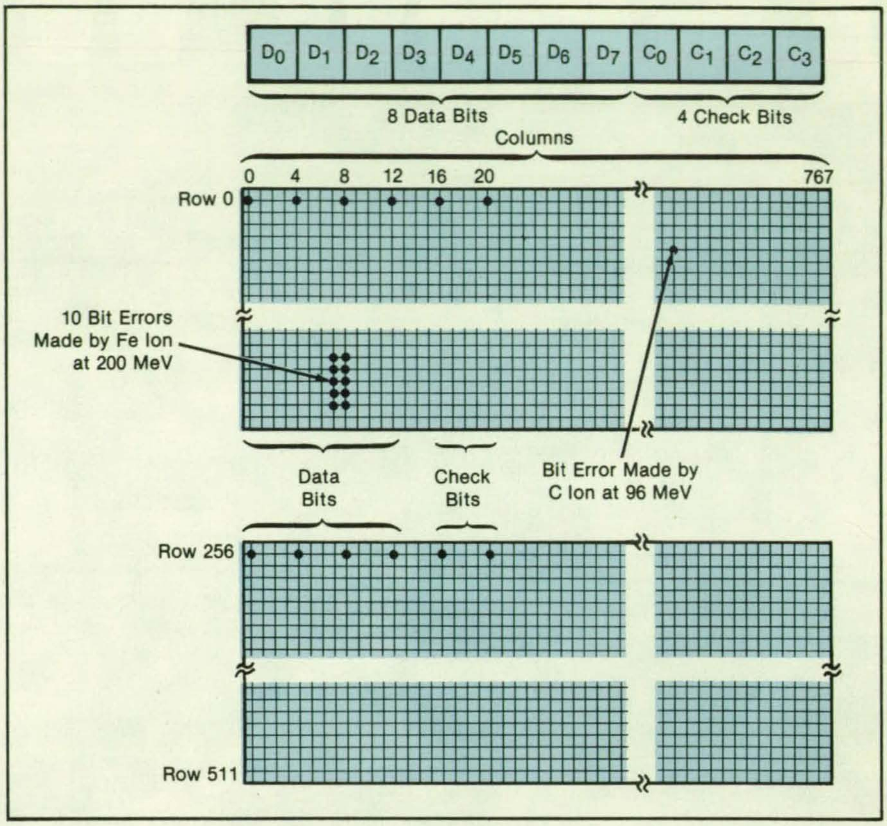


Figure 1. The **Data Bits on the DRAM Array** are organized into code words of 8 data bits and 4 check bits each. The bits of each word are distributed to separated points in the 512-by-768 array to decrease their vulnerability to adjacent bit errors caused by incident energetic ions.

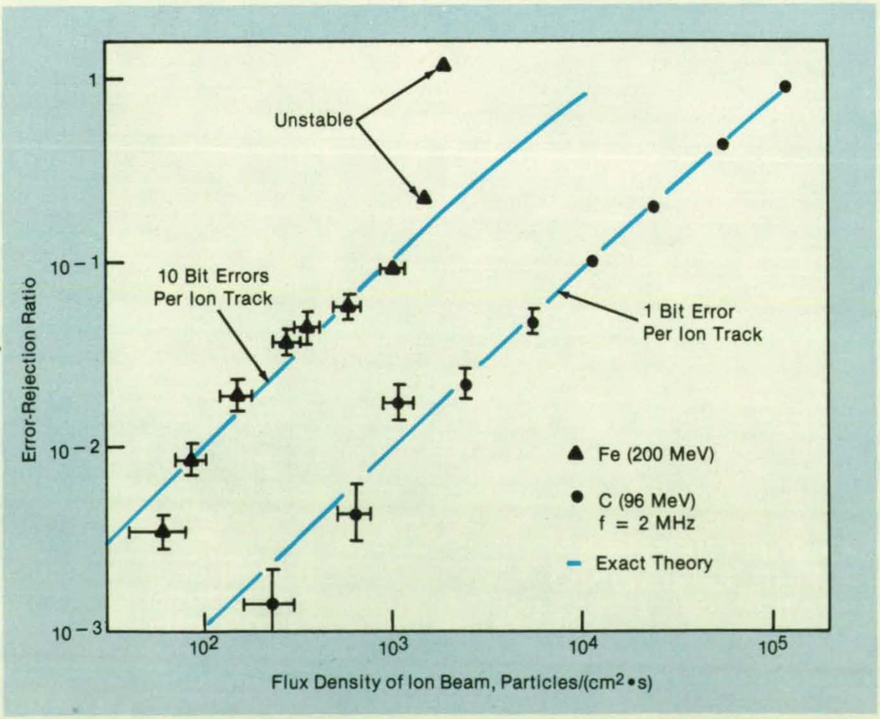


Figure 2. **Error-Rejection Ratios** were measured and calculated as functions of flux densities of incident ions. The vertical error bars represent the statistical errors in the counts of output errors, and the horizontal error bars represent fluctuations of the ion-beam fluxes.

An important measure of performance is the error-rejection ratio, which equals the number of errors detected at the output pins divided by the total number of errors induced in the memory cells. A lower ratio indicates greater immunity to errors. A theoretical analysis shows that this ratio is directly proportional to the total number of bit errors that occur during a data-storage-cycle period and inversely proportional to the number of error-correcting-code words into which the memory array is divided. Thus, the error-correcting capability can be increased by breaking the circuit chip down into a large number of small code words (at the cost of increased size and complexity) or by increasing the frequency of the data-storage-cycle clock to reduce the time available for the accumulation of errors during each cycle.

The circuit was tested by exposure to ion beams generated in a van de Graaff accelerator. Because the circuit chip is designed to indicate both each uncorrected bit error and each error in the output, it provides the means to measure its performance with and without the error-correcting capability. Figure 2 shows experimental error-rejection ratios as functions of the

fluxes of iron and carbon ions. The carbon ions were able to upset only one memory cell per ion-track event, as evidenced by the error-flag data-bit maps. By contrast, the heavier iron ions were able to upset 10 adjacent memory cells, as also evidenced by the error-flag bit maps. Except at the two points labeled "unstable," which indicate the onset of erratic counts of errors in the output of the device under test, the overall data are in excellent agreement with the theory. If one extrapolates these data to conditions under which only 1 bit error occurs per cycle, one finds that at an ion-beam flux of less than 5 particles/(cm^2•s) there would be no errors in the output.

In general, the implementation of an error-correction code on a circuit chip should not require any changes in the fabrication processes or design rules. The degree of effectiveness of on-chip error correction is strictly a function of the design and the additional area of silicon that can be allotted for the incorporation of the error-correcting logic circuitry.

This work was done by John A. Zoutendyk, R. Kevin Watson, and Harvey R. Schwartz of Caltech and Leland R. Nevill and Zille Hasnain of Micron Technology, Inc., for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 163 on the TSP Request Card.*
NPO-17406

Ground-Sensing Circuit for Arc Welders

An open-circuit detector prevents arc burns at loose ground connections.

Marshall Space Flight Center, Alabama

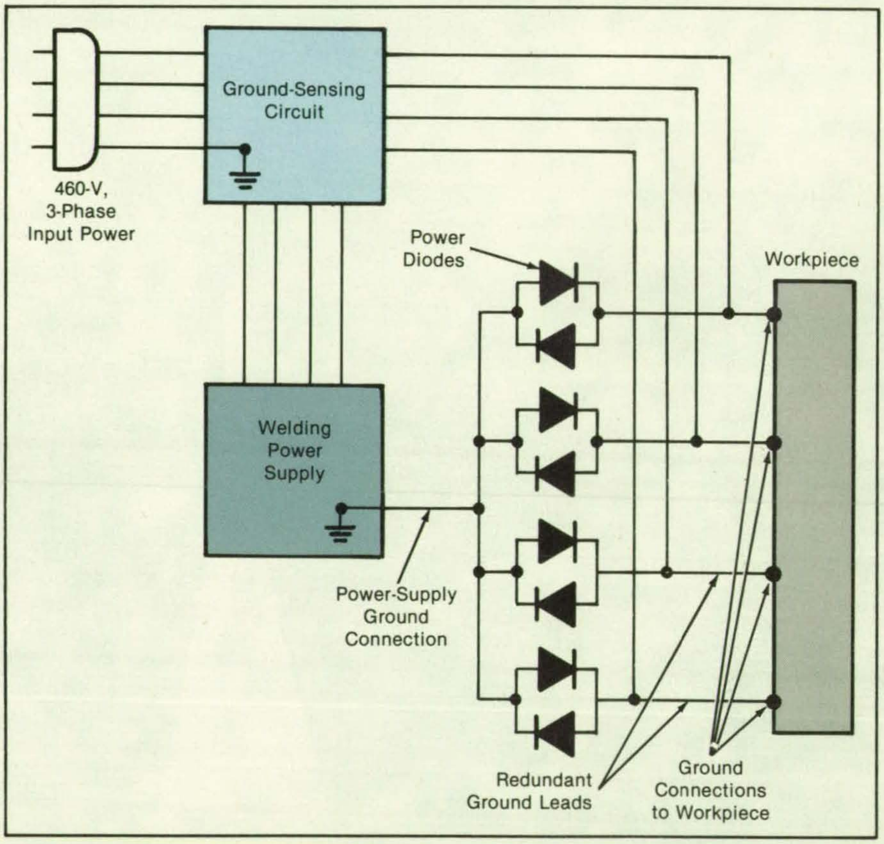
A ground-sensing circuit for an arc-welding power supply prevents arc burns at loose ground connections on the workpiece. This circuit, which is an advanced version of a circuit reported in a prior issue of *NASA Tech Briefs*, can be used with an ac supply or a dc supply of either polarity. For protective redundancy, the welding power supply is connected to the workpiece via four ground leads; if any of these connections is broken, the protective circuit switches off the input power.

The ground-sensing circuit (see figure) is connected to the input power line, the welding power supply, and each of the four ground leads. Each ground lead is connected to the power-supply ground via a pair of oppositely polarized diodes connected in parallel. The diodes are mounted on heat sinks, and each is rated to withstand the full welding current up to 300 A.

The ground-sensing circuit includes four oscillator/detector pairs. The operating frequencies of the pairs are selected in the ratios of 1, 3, 5, and 7 to prevent harmonic interference among the pairs. Each oscillator is transformer-coupled to its detector. These transformer couplings also isolate the oscillators and detectors from the welding ground leads. Each of the two leads between the oscillator transformer and the detector transformer in each oscillator/detector pair is connected to a welding ground lead.

As long as both ground leads in a pair remain attached firmly to the workpiece, the transformer coupling is shorted through the workpiece, and the detector receives little or no signal from the oscillator. However, if either connection to the workpiece is broken, then the short across the transformer coupling is replaced by the resistance of two sets of diodes in series. Although this resistance is small, it is sufficient to allow a detectable signal to reach the detector.

The circuit is equipped with the customary safety-oriented relay logic; that is, the relay for the main power switch is connected in series with several other relay switches, the opening of any of which signals a failure of some kind and causes the main power to be shut off. When a "start" button is pushed, the system tests itself to verify that all power supplies, oscillators, and detectors are operating; then the safety relays are energized, and main power is applied. Thereafter, the power remains on as long as all four oscillator signals are shorted out. However, if any of the oscillator signals becomes detectable during operation, signifying the loss of at least one ground connection, one of the safety relays is tripped.



The **Ground-Sensing Circuit** includes oscillator/detector pairs that are normally shorted out by the ground connections to the workpiece. When one or more of these four connections is broken, one or more oscillator signals is applied across the power diodes and is detected. The detected oscillator signal trips a shutoff relay.

This work was done by Richard K. Burley of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 160 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 24]. Refer to MFS-29455.

Electronic Systems

Weighted Integrate-and-Dump Filter

Cost can be decreased by use of lower sampling and processing rates.

NASA's Jet Propulsion Laboratory, Pasadena, California

A digital weighted integrate-and-dump filter (WIDF) has been proposed for the detection of weak rectangular-pulse signals corrupted by additive white Gaussian noise. In the unweighted IDF described in the preceding article, the signal-to-noise ratio is decreased by approximating the ideal analog implementation with a digital implementation that otherwise has practical advantages. The weighting feature is added to reduce the adverse effect of the approximation.

In the WIDF, the received signal is first low-pass prefiltered, and samples are taken at a multiple of the symbol frequency, as described in the preceding article. In this case, however, each sample y_i is multiplied by a weighting factor W_i before it is added into the sum A_k that approximates the integral of the kth integration period (see Figure 1). The problem is to find the set of W_i that minimizes the mean-square difference between $\hat{A}_k$ and the exact integral A_k that would be obtained from an ideal analog IDF.

It can be shown theoretically that under suitable assumptions, the optimum weights W_i are given by the matrix•vector equation

$$\mathbf{w} = R_{yy}^{-1} \mathbf{R}_{yA}$$

where $\mathbf{w}$ = the column vector of the W_i (i = 1 to N); N is the number of samples in an integration period; R_{yy} is an $N \times N$ autocorrelation matrix, the elements of which are $E[y_i y_j]$ (j = 1 to N); $E[\,]$ is the expectation operator; and $\mathbf{R}_{yA}$ is a cross-correlation column vector, the elements of which are $E[y_i A_k]$.

The case $N = 4$ was chosen as a numerical example, and the W_i were calculated for various sampling offsets ranging from 0 to the sampling period T_s in increments of 0.05 T_s. The signal-to-noise ratios of the WIDF at these offsets were compared with those of an unweighted IDF and an ideal analog IDF in the reception of a random binary signal (see Figure 2). The worst-case losses (of signal-to-noise ratio below that of the ideal analog version) averaged over the data patterns were 1.26 dB in the unweighted version but only 0.68 dB in the weighted version.

Viewing the results of the numerical simulation in another way, the signal-to-noise ratio of an unweighted digital IDF varies 1 dB over the range of offsets, while that of the WIDF varies only 0.3 dB. In comparison with a system in which the samples are locked in phase to the symbol clock, a WIDF with offset sampling suffers a worst-

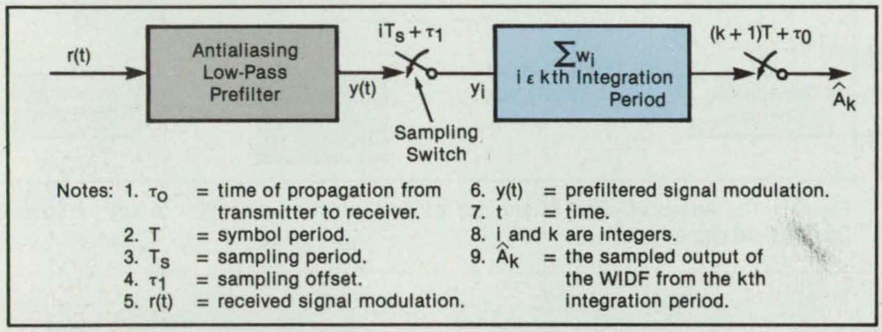


Figure 1. **Samples of the Prefiltered Signal** are multiplied by weighting factors before addition to the integral.

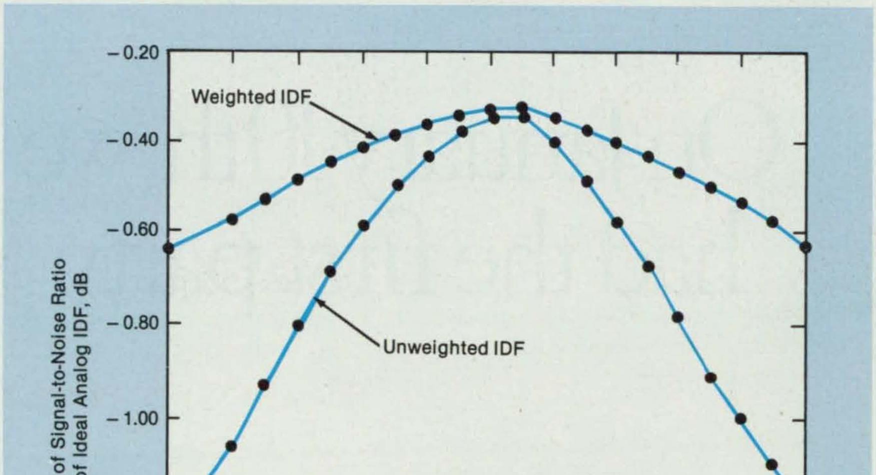


Figure 2. **Weighting Improves the Performance** of an IDF in this example, in which a random binary signal is sampled four times during each symbol period.

case offset loss of less than 0.3 dB and an average loss of less than 0.15 dB.

This improved performance means that lower sampling and processing rates can be used for a given symbol rate, reducing the cost of the system. Alternatively, a higher symbol rate can be used at a given bandwidth and sampling rate. An unweighted IDF would require approximately twice the bandwidth and twice the sampling rate for the same performance.

This work was done by Ramin Sadr of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 79 on the TSP Request Card.* *NPO-17423*

Using Bit Errors To Diagnose Fiber-Optic Links

Bit-error rates are related to degradation of components.

NASA's Jet Propulsion Laboratory, Pasadena, California

A technique for the diagnosis of a fiber-optic digital communication link in a local-area network of computers is based on the measurement of bit-error rates. The technique is similar to that used to detect changes in the performances of telephone modems and transmission media. The objective is to measure the degradation of the transmitter, receiver, optical fiber, connectors, and other equipment so that components can be replaced before they fail.

A variable optical attenuator is inserted in the optical fiber near the receiver (see Figure 1). Using the protocol of the local-area network, pseudorandom sequences of zeros and ones are transmitted as packets of data. The sequences put out by the receiver are compared with the known transmitted sequences to determine the bit-error rates.

For an optimal decision stage (the part

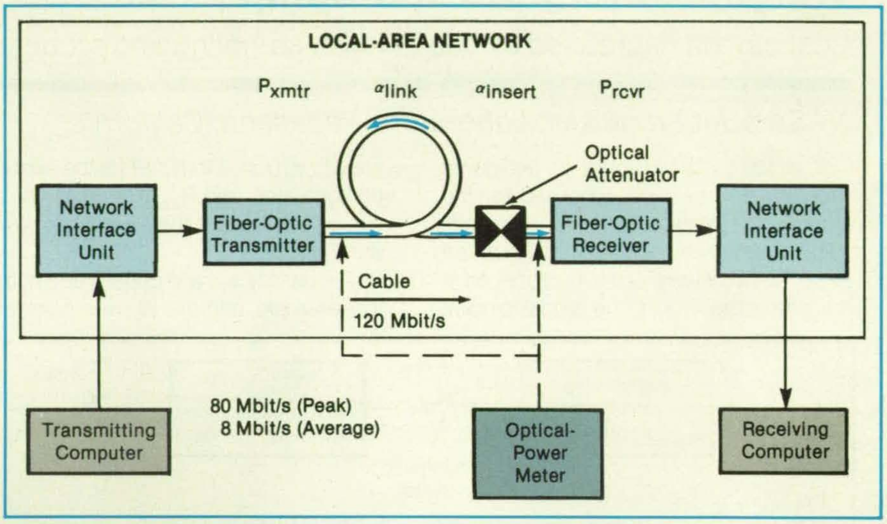


Figure 1. The **Variable Optical Attenuator** is inserted in the optical fiber to vary the power of the received signal.

of the receiver that decides whether a received bit is a zero or a one), the bit-error rate and the signal-to-noise ratio of the output of the receiving photodetector are known functions of each other (see Figure 2). As the total amount of optical attenuation along the transmission path increases, the signal-to-noise ratio in the receiver decreases and the bit-error rate increases. The optical attenuator is adjusted to obtain the desired bit-error rate, which is typically between 10^{-4} and 10^{-8}. From this bit-error rate, the signal-to-noise ratio and, therefore, the effective peak signal power at the receiver are deduced.

The relationship between the transmitted and received powers and the optical attenuation at the desired bit-error rate is given by

$$P_{xmtr} - P_{rcvr} = \alpha_{link} + \alpha_{insert}$$

where P_{xmtr} is the peak signal (in decibels) inserted in the link by the transmitter, P_{rcvr} is that calculated peak signal power (in decibels) in the receiver required to produce the desired bit-error rate, α_{insert} is the known attenuation (in decibels) in the variable attenuator that produces the desired bit-error rate, and α_{link} is the attenuation (in decibels) in the optical fibers, connectors, and any other components of the link. Because α_{insert} is known, this equation can be used to analyze the degradation of performance caused by a decrease in transmitted or received power and/or an in-

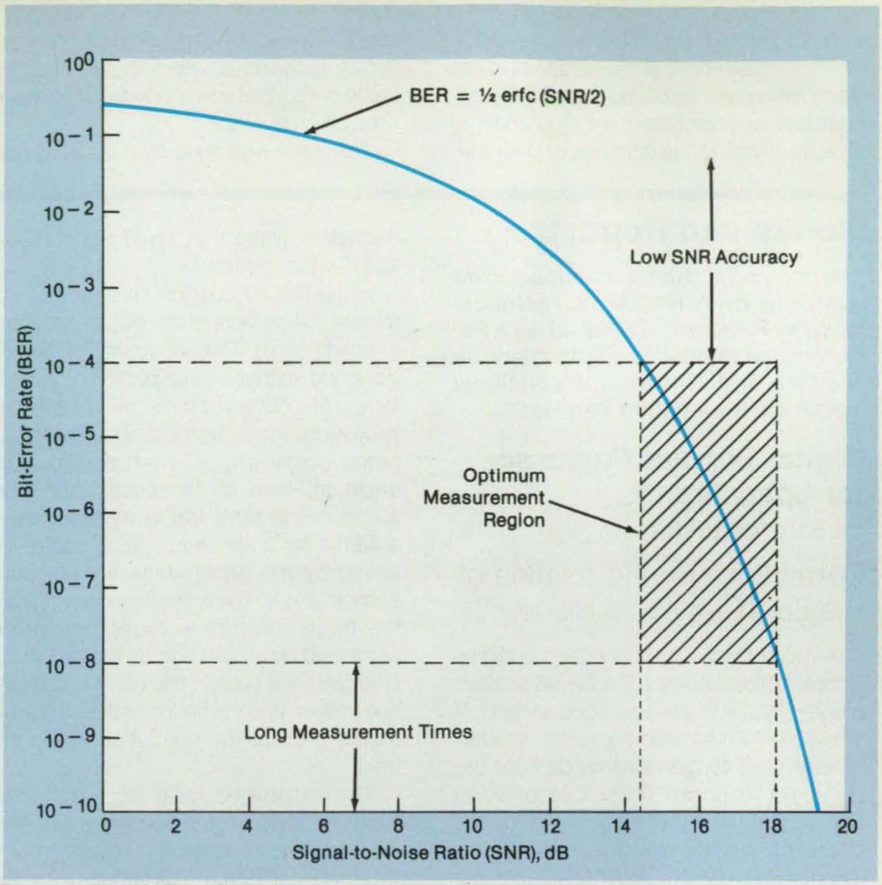


Figure 2. The **Bit-Error Rate** depends on the ratio of peak signal power to root-mean-square noise in the receiver. For optimum measurements, one selects a bit-error rate between 10^{-8} and 10^{-4}. Greater rates result in low accuracy in the determination of signal-to-noise ratios, while lesser rates require impractically long measurement times.

crease in attenuation in the link. If, in addition, one measures the optical power at the transmitting and receiving ends of the optical fiber, one can determine P_{xmtr} and α_{link} directly, enabling the analysis of degradation of the receiver by comparison of the actual received power with the effective value of P_{rcvr} that corresponds to the measured bit-error rate.

This work was done by L. A. Bergman, R. Hartmayer, and S. Marelid of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 99 on the TSP Request Card.*
NPO-17433

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.

Digital Doppler Processor for Spaceborne Scatterometer

Corrections for the rotation of the Earth would be made.

A report describes a conceptual digital Doppler processor for the NASA scatterometer (NSCAT), an advanced version of the SEASAT spaceborne radar scatterometer used to measure winds near the surface of the ocean. The processor would compensate for the component of the Doppler frequency shift caused by the rotation of Earth. The SEASAT scatterometer was vulnerable to degradation of performance and loss of swath because it contained fixed-frequency and fixed-bandwith band-pass filters that could not compensate for the rotation.

In the NSCAT designs, six antennas illuminate the surface of the ocean with fan-shaped beams. The illumination pattern is designed so that a given portion of the surface is first observed by a forward antenna to provide a measurement of the backscattering coefficient (σ_0) from one azimuth angle and then, as the spacecraft moves along the ground track, by the center antenna for a second azimuth angle, followed by the aft antenna for the third azimuth angle. The σ_0 measurements from the three different azimuth angles are combined by processing on the ground to infer the wind vector. The narrow illumination pattern and the timing of the measurements provide the resolution along the track.

The transmitted radar signal reflected from the surface of the ocean is Doppler-shifted due to the relative motion of the surface and spacecraft. The echoes returned from different portions along the illumination pattern have different Doppler shifts and can be separated into crosstrack resolution elements known as "σ_0 cells" by Doppler band-pass filtering.

While crosstrack resolution is obtained by Doppler filtering, along-track resolution is achieved via the times between measurements. As the spacecraft moves along its ground track, the σ_0 cells viewed by each of the antenna beams in sequence are sampled once during the time interval required for the spacecraft to move the along-track sampling distance (25 km for NSCAT).

To maintain each of the σ_0 cells at a fixed crosstrack distance from the spacecraft track as the spacecraft moves along its orbit, the Doppler shifts of the σ_0 cells must be changed to compensate for the effects of the rotation of the Earth. Not only do the cell center frequencies change but the times of flight of echoes also change. To process the scatterometer return signal adequately, the Doppler processor must consider the entire range of time and bandwidth spanned by all σ_0 cells as the center frequencies vary over the orbit. For the NSCAT design, this corresponds to a bandwidth of approximately ±400 kHz with

times of flight between 5.5 and 11 ms (assuming an orbital altitude of 820 km).

The conceptual processor uses fast Fourier transforms (FFT's) to make the required corrections to the times and frequencies. The input signal plus noise and the input noise alone are processed separately, then subtracted to obtain an estimate of the backscattered signal power. First, the input data are sampled, and the FFT's of the segments of data are computed. A "data window" is then applied by convolution. The windowed FFT output is squared to obtain the power. Finally, a sum is taken over the resulting periodograms in the range corresponding to the σ_0-cell bandwidth of interest. The power is related to σ_0 by radar equation.

This work was done by D. G. Long, Chong-Yung Chi, and Fuk K. Li of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "The Design of an Onboard Digital Doppler Processor for a Spaceborne Scatterometer," Circle 114 on the TSP Request Card. NPO-17253*

Progress in Imaging Radar Polarimetry

Recent development efforts are recounted.

A report traces the development of imaging radar polarimetry at NASA's Jet Propulsion Laboratory during recent years. Imaging radar polarimetry has attracted intense interest in the fields of remote sensing and electromagnetic scattering. When fully developed, multipolarization synthetic-aperture radar (SAR) systems aboard aircraft and spacecraft are expected to yield a wealth of data for the assessment of resources, agricultural forecasting, and the verification of radar-scattering calculations.

In imaging radar polarimetry, the SAR system produces four amplitude-and-phase images of the target area — one for each combination of transmitted and received polarizations (HH, HV, VH, and VV, where H denotes the horizontal and V denotes the vertical). The raw image data are recorded on magnetic tape and processed subsequently on computers. The complete polarization scattering matrix yields more information about a target than does a scalar radar reflectance without regard to polarization.

In July 1985, a CV-990 airplane carrying an L-band and a C-band multipolarization SAR crashed, delaying the acquisition of new data by about 2 years. During the construction of the new radar equipment, work continued on algorithms and equipment for the digital processing of raw multipolarization SAR data.

In September 1986, the synthesis of arbitrarily polarized images from the four L-band images was demonstrated. At that time, it took 20 minutes and 128 Mbytes of memory to synthesize a single image on a VAX 11/785 computer. Since then, a technique has been devised to compress the input data to 10 Mbytes and reduce the computation time to only 2 minutes.

These reductions made it possible to transfer the task of processing to a "polarization workstation" consisting of a smaller computer equipped with an image-display subsystem. The workstation can synthesize a 1,024- by 1,024-point polarization image in 2 to 3 minutes. It can also measure the polarization of any picture element or collection of elements and perform some simple comparisons between polarizations of different parts of the image. For example, it can find the polarization that optimizes the ratio of the radar image of one target to that of another target.

One of the few recent papers on the subject states that polarimetric images of corn contain evidence that this crop differentially refracts horizontally and vertically polarized radiation. This and another paper also recognize a "double-bounce" phenomenon involving scattering from the ground, followed by scattering from vegetation. Other papers discuss the radar polarimetric properties of a quiet body of water and the use of radar polarimetry to measure the roughnesses of geological targets, to classify forest stands, and to characterize the trees within a particular stand.

At the time of the report, work was continuing on the new multipolarization SAR, which is to be flown aboard a DC-8 airplane. The new radar features an increased signal-to-noise ratio and other improvements in design over the earlier version. It will also serve as a "breadboard" prototype radar for the SIR-C program, which is expected to enable the performance of imaging radar polarimetry from outer space in the early 1990's.

This work was done by Daniel N. Held of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Imaging Radar Polarimetry: A Status Report," Circle 82 on the TSP Request Card. NPO-17247*

τ Ranging Revisited

Very-large-scale integration may give new life to an abandoned distance-measuring technique.

A report reviews the history of τ ranging and advocates the use of advanced electronic circuitry to revive this composite-code-uplink spacecraft-ranging technique. τ ranging was abandoned years ago because the necessary analog and digital electronic equipment then available was expensive and inadequate to exploit the full potential of the code. It was replaced by a sequential-code-uplink technique called "μ ranging" that requires less equipment to exploit its full potential and acquires the signal 16 times as fast.

The τ planetary composite transmitter code was generated by combining a clock square wave with a majority-vote logic of five pseudonoise sequences in an exclusive-OR fashion. The components had durations of 2, 7, 11, 15, 19, and 23 symbol periods for a total code period of $N = 1{,}009{,}470$ symbol periods. This, when clocked at a symbol period t_0 of about 1 μs, gave a repetition period of about 1s, yielding a two-way range ambiguity interval of approximately 150,000 km.

A τ receiver consisted of one or two channels that sequentially correlated the transponded signal with combinations of the clock and each separate component, sequentially through each successive symbol delay, to determine the precise delay on each of the components. Because the transmitted power was distributed among the various clock and pseudonoise code components but the receiver was sensitive to only one component at one phase at a time, acquisition time was longer by about a factor of 16 than if the receiver could have processed all the received power during the acquisition time. In contrast, the μ system used all the transponded power for each component during the acquisition time.

The reason for using only a few correlators in each μ-ranging receiver until now has been that each correlator channel consisted of relatively-expensive analog and unit-logic digital equipment. However, with the advent of reasonably-high-speed analog-to-digital devices and very-large-scale integrated digital devices, it is now economically feasible to make a τ receiver that has the number of correlators needed to detect each component of the code at each symbol delay. (It still may be impractical to build a full matched filter for the overall transmitted code.)

To exploit the capabilities of this modern circuitry, the author proposes a new τ code (denoted "ντ") that uses a new combining logic for the transmitter code and a 77-correlator receiver. The performance of the ντ system is analyzed theoretically. The analysis shows that the performance of the ντ method is only about 0.25 dB below that of a matched filter for the optimal transmitter code. As the μ system is now configured, about half of the range-measurement time is spent in correlating with the component of highest frequency (the clock), the other half being spent determining the range cells of the components of the lower frequency. The ντ system thus outperforms the μ code by some 2.5 dB in signal-to-noise ratio.

This work was done by Robert C. Tausworthe of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Tau Ranging Revisited," Circle 114 on the TSP Request Card.*
NPO-17413

Pulse-Position Modulation for Optical Communication

Pulsed Nd:YAG lasers would transmit information over long distances.

A report discusses schemes for the pulse-position modulation of neodymium: yttrium aluminum garnet (Nd:YAG) lasers for the optical transmission of data between distant spacecraft and stations on Earth. Optical communication is an attractive alternative to radio communication because it involves smaller, lighter equipment and because optical beams can be made to diverge less than radio beams do, thereby using the radiated power more efficiently.

In the communication system envisioned, the transmitter would include a Nd:YAG rod pumped longitudinally by laser diodes. The second harmonic of the fundamental (1.06-μm wavelength) output of the laser would be generated in the laser cavity by $KTiPO_4$, a nonlinear optical material. The modulated beam of light would be sent out through a telescope to keep the divergence low.

The receiver would not require a diffraction-limited imaging telescope: a simple large collector (like a solar collector) would suffice. At the receiver, most of the background light would be suppressed by a narrowband interference filter. Further rejection of noise would be provided by the narrow time slots in which information would appear. The optical signals would be detected by cooled avalanche photodiodes.

An important element in the design is the choice between Q-switching and cavity-dumping modulation schemes. In Q-switching, energy is stored in the inversion of the atomic population by keeping the Q (the ratio of the angular frequency of the radiation to the rate of damping of the radiation by the cavity) too low to support oscillation. This is accomplished in the laser cavity with an element, the damping of which can be controlled. Atoms are pumped to the upper state, but, in the absence of stimulated emission, population of the upper state is greater than in the equilibrium condition achieved when lasing occurs. When the Q is increased (by reducing the damping), the energy in the atoms is immediately available, and the rate of stimulated emission becomes large. A high-energy pulse then depletes the upper level, and lasing ceases temporarily. If the Q is reduced at that moment, the pump energy again begins accumulating population in the upper state. The time required to repump the population inversion and the time required to build up the electromagnetic field in the laser cavity impose an upper limit on the rate of Q-switching. A pulse-repetition frequency of the order of 50 kHz is the maximum value that can provide high-peak-power pulses from Nd:YAG.

For pulse repetition frequencies above 50 kHz, cavity dumping is preferred. In this approach, instead of storing the energy in atoms, the energy is stored in the photon field of the cavity. The output coupling strength is varied so that the energy in the cavity is extracted when it is needed. The laser is kept above threshold during the entire process. Although cavity dumping can be extremely efficient at frequencies of many megahertz, at low pulse-repetition frequencies it is less efficient.

This work was done by M. D. Rayman and D. L. Robinson of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Modulation Techniques for Deep-Space Pulse-Position Modulation (PPM) Optical Communication," Circle 134 on the TSP Request Card.*
NPO-17506

Physical Sciences

Hardware, Techniques, and Processes

Two-Frequency Electro-optic Gas-Correlation Spectrometer

An acoustical modulator is not necessary.

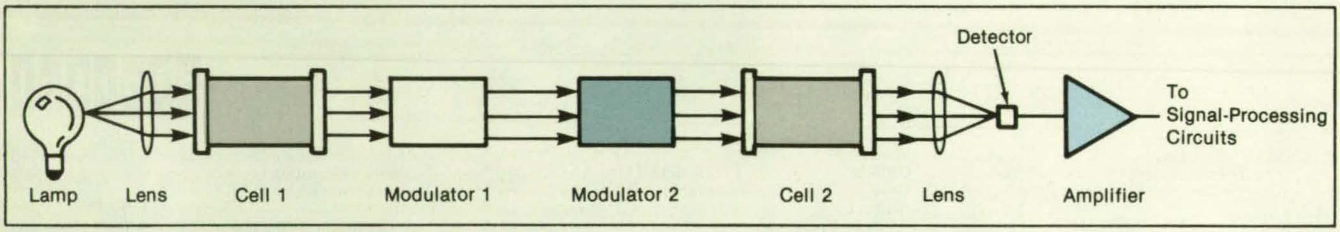
NASA's Jet Propulsion Laboratory, Pasadena, California

A relatively simple gas-correlation spectrometer employs electro-optic phase modulation (EOPM) at two frequencies rather than at one [*Applied Optics*, 25, 2860, 1986] to detect selectively gaseous absorption of radiation. Detection is performed at the difference of the two modulation frequencies.

In the EOPM correlation spectrometer (see figure), collimated light from a source is passed through a cell that contains a sample for analysis. Light emerging from the cell is passed sequentially through two EOPM modulators operating at frequencies f_1 and f_2 and then through a reference gas cell. Equivalently, the two frequencies can be applied to a single EOPM. A photodetector measures the intensity of the light transmitted through the system. The effect of the EOPM's is to redistribute the molecular absorption lines of the gas in the sample cell into upper and lower sidebands that are displaced from the original positions by the phase-modulation frequencies. If the absorption spectrum of the gas in the sample cell correlates with that of the gas in the reference cell, a signal appears at the detector at the difference frequency, $|f_1 - f_2|$. In this case, the amplitude of this signal is proportional to the amount of gas in the sample cells. If there is no correlation between the spectra of the gases in the sample and reference cells, there is no signal.

This technique offers the advantage that the difference frequency, $|f_1 - f_2|$, may be chosen to avoid the 1/f noise region inherent in light sources, detectors and amplifiers. The two frequencies, f_1 and f_2, must be comparable to or greater than the width of an absorption line to achieve high responsivity; however, the difference may be small so that a large bandwidth detector is not required. The signal at $|f_1 - f_2|$ is proportional to the absorption in the gas so that there is no need to resort to error-prone subtraction of one large signal from another to estimate the absorption. The correlation spectrometer must be empirically calibrated to obtain a quantitative measure of the gas in the sample cell.

This work was done by Jack S. Margolis, David M. Rider, Daniel J. McCleese, and John T. Schofield of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 9 on the TSP Request Card.*
NPO-17638



The **Two-Frequency Electro-optic Gas-Correlation Spectrometer** is relatively simple. Illumination is provided by an ordinary lamp, there are no moving parts (e.g., piston or acoustic-driver pressure modulators), and the filtered output of the detector is a beat-frequency signal directly proportional to the correlation between the spectra of the gases in cells 1 and 2.

Subliming Layers Would Reveal Aerodynamic Effects

Multicolored coatings are proposed to study aerodynamic effects on surfaces.

Langley Research Center, Hampton, Virginia

In a proposed technique, the flow of fluid across a surface would be studied in detail by use of a multilayered, multicolored coating. The technique would be particularly useful in the study of the flow of air over a small area of an aerodynamic surface. By use of this method, incremental determinations could be made as to friction, the transfer of heat, the positions of shock waves, and the position and extent of turbulence on a given surface.

A multilayered, uniform coating of the type contemplated could consist mostly of a chemical, such as naphthalene, that evaporates or sublimes from the surface as air flows over it. The chemical would be applied to the surface in a sequence of thin layers, each of which has a different color. After a flow time, various colors would appear on the surface, and the researcher could relate the colors to specific aerodynamic effects related to such characteristics as friction, the transfer of heat, or laminar-to-turbulent boundary-layer transitions.

An important advantage of this technique is that it could show effects of flow over a small area of the aerodynamic surface inexpensively. The technique could be applied to the surface of a model in a wind tunnel or to an aerodynamic surface on an aircraft.

This work was done by Ronald N. Jensen of **Langley Research Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 24]. Refer to LAR-13742.

Correcting Distortions in Optical Correlators

A coordinate transformation maps object space to correlation space.

NASA's Jet Propulsion Laboratory, Pasadena, California

Theory has been developed to predict and correct typical anamorphic coordinate-transformation errors in off-axis Vander Lugt optical correlators (see figure). These errors cause nonlinear anamorphic mapping between the coordinates in object space and those of the correlation spot in correlation space. With the help of the new theory, they could be corrected by nonlinear optical preprocessing or digital postprocessing.

The tracking-and-recognition aspect of an optical correlator is evident when the input function $f(x, y)$ in object space is the same as the initial filter-making function, $s(x, y)$, shifted by some amount Δx, Δy in object space:

$$f(x, y) = s(x - \Delta x, y - \Delta y)$$

Paraxial theory predicts that this input function will produce a bright spot at a point in the correlation plane that maps linearly to a location in object space. However, paraxial theory is insufficient in practical cases where high spatial carrier frequencies are required.

The nonparaxial complex amplitude of the shifted Fourier transform of the shifted function in the transform space is given by

$$F\{s(x - \Delta x, y - \Delta y)\} = S(p,q)\exp[2\pi i(p \cos \beta_x + q \cos \beta_y)]$$

where β_x and β_y are the $x-$ and $y-$axis direction cosines, respectively, of a line between the shifted point (Δx, Δy) on the object plane and the center of lens L_1. This transform function is multiplied by a term proportional to

$$S^* (p, q) \exp [2\pi ip \sin \theta]$$

which is part of the transmittance function of the matched filter made with $s(x, y)$ and a reference beam incident at angle θ to the z axis in the (p, z) plane of correlation space. The product is the portion $C(p, q)$ of the outgoing wave front in correlation space that carries the correlation signal:

$$C(p, q) = A\, S^*(p, q)\, S(p, q) \exp\{2\pi i[p(\sin \theta + \cos \beta_x) + q \cos \beta_y]\}$$

The coefficients of p and q in the exponent can be factored out to create a set of direction cosines Γ_p, Γ_q, and Γ_z for the coordinates in correlation space.

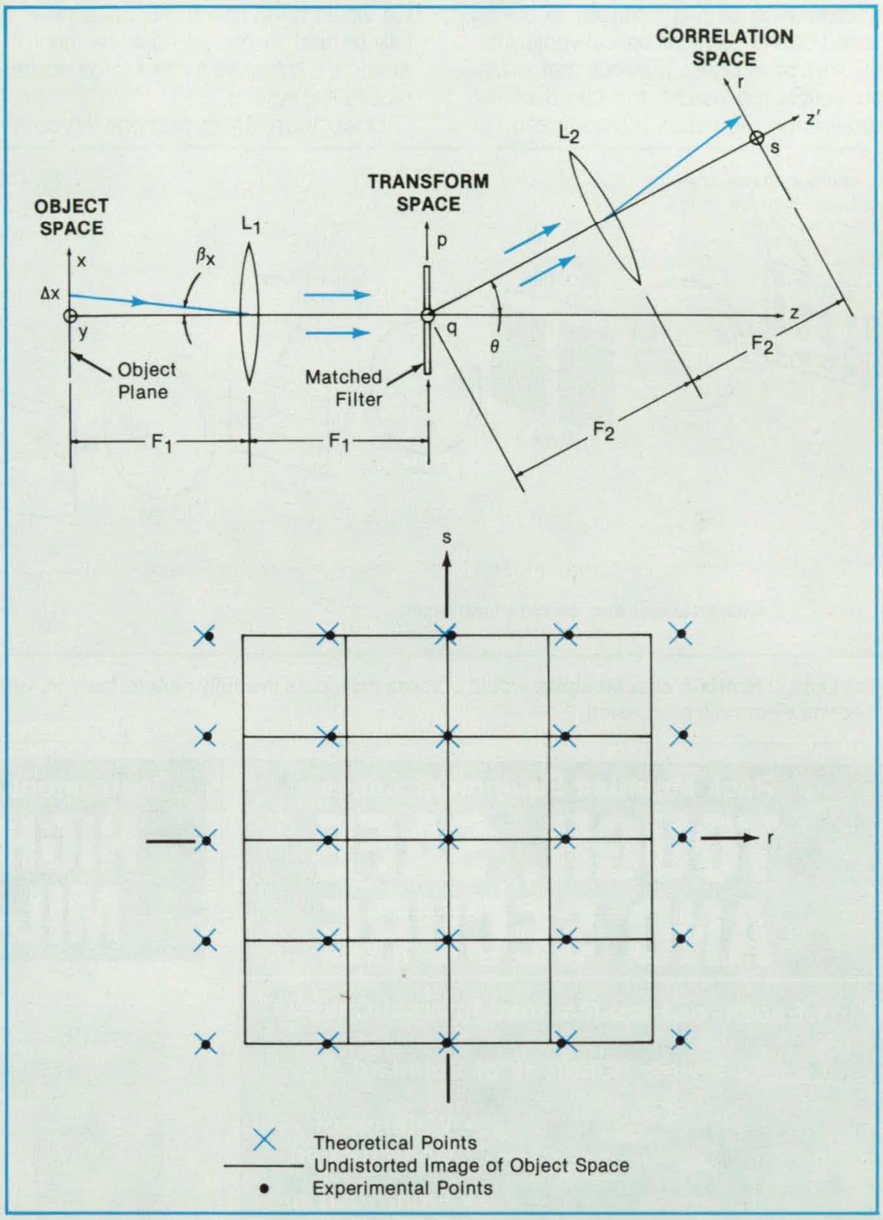
Lens L_2 Fourier-transforms $C(p,q)$ to produce the correlation spot in the (r, s) plane. The placement of this lens along the z' axis (which lies along the direction θ of the reference beam) brings the correlation spot of an unshifted function $s(x, y)$ to the origin of the r, s plane. This is convenient for tracking.

The transformed direction cosines are transformed further by a rotation of coordinates to produce yet another set of direction cosines Φ_r, Φ_s, Φ_z, in the r, s, z' coordinate system. The coordinates in the (r, s) plane of the correlation spot of a shifted function $s(x - \Delta x, y - \Delta y)$ are then given by

$$\Delta r = F_2(\cos \Phi_r / \cos \Phi_z) \text{ and}$$

$$\Delta s = F_2(\cos \Phi_s / \cos \Phi_z)$$

where F_2 = the focal length of lens L_2. Thus, a sequence of transformations has been obtained to map the point (Δx, Δy) on the object plane to the point (Δr, Δs) on the correlation plane.



A **Typical Optical Correlator** and its coordinate systems are shown schematically to illustrate the mathematical model. The correlation-spot map shown below shows how the theory worked in a test: The theoretical predictions and experimental results agreed closely.

This work was done by Thomas G. Chrien and Yeou-Yen Cheng of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 131 on the TSP Request Card.*
NPO-17176

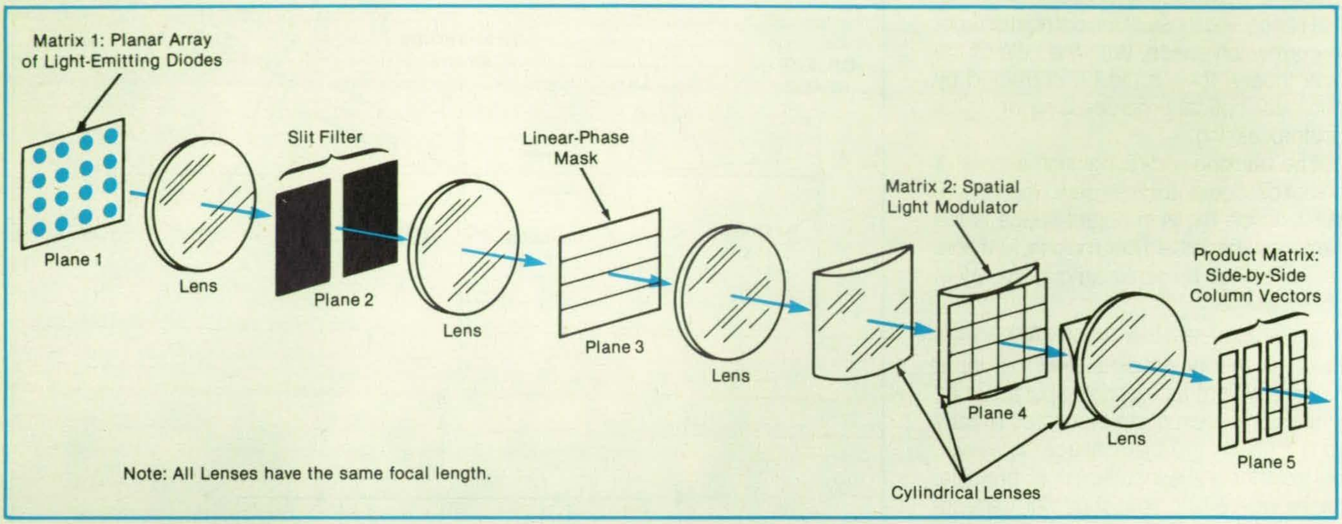
Optical Matrix•Matrix Multiplier

A concept offers the speed of fully-parallel optical processing.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed apparatus for the optical multiplication of two matrices would be based on the Stanford optical vector•matrix multiplier. Unlike previous matrix•matrix optical processors, this one does not require the redundant representation of one of the matrices. Because the apparatus would perform the multiplication in a fully parallel manner, it could be incorporated as a subsystem into a large optical-processing system.

One of the matrices would be represented by a planar *N*-by-*N* array of light-emitting diodes, while the other would be represented by a spatial light modulator of *N*-by-*N* picture elements (see figure). The portion of the apparatus between planes 3 and 5 would be almost identical to that of the



The Optical **Matrix•Matrix Multiplier** would process the inputs in a fully parallel fashion, without redundant matrix images or ancillary intermediate electronic processing.

Stanford multiplier, in which an input row vector is multiplied by the spatial light modulator to generate an output column vector on plane 5.

If two row vectors were present at the input of the Stanford multiplier, the output column vectors would be superimposed. However, if a linear-phase mask (which makes the phase vary along the length of a row vector) were placed over one of the input vectors, its output column vector would be displaced to the side of the other column vector. The width of the output column vectors would be controlled by spatially filtering the input row vectors through the slit at plane 2 before the light passes through the linear-phase mask. This would enable a large number of row vectors to pass through the vector•matrix multiplier simultaneously and produce the set of spatially-distinguishable output column vectors that would constitute the product matrix.

This work was done by Gregory Gheen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 24 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 301-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-17316, volume and number of this NASA Tech Briefs *issue, and the page number.*

Infrared Pyrometry From Room Temperature to 700 °C

Consistent readings are obtained when specimens are prepared appropriately.

Lewis Research Center, Cleveland, Ohio

Experiments have shown that with appropriate preparation, infrared pyrometry can be used to measure temperatures of the surfaces of specimens in the range from ambient to 700 °C. The objective is to make such measurements on specimens in surface-analytic vacuum systems. Heretofore, optical pyrometry has seldom been used for this purpose because of the usually unknown and possibly variable emissivities of specimens, the poor infrared transmission of viewing ports in vacuum chambers, and the large viewing areas required by most infrared pyrometers.

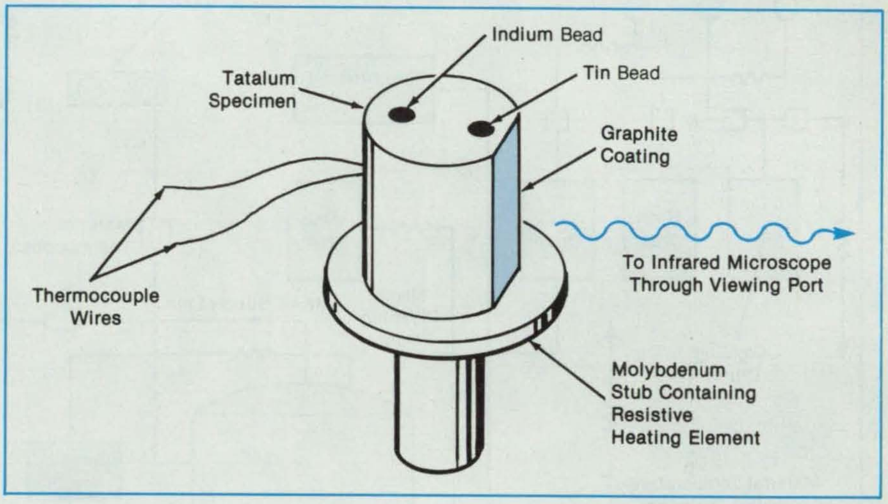


Figure 1. The **Graphite Coat** on the specimen has a known emissivity. The thermocouple is used to calibrate the reading of the infrared microscope. The melting of the beads provides reference temperatures, including corrections for thermocouple errors caused by thermal conduction in the wires.

The new method largely overcomes these limitations. The transmission of infrared is increased by replacing the customary metal-coated glass viewing port with a quartz viewing port covered with tantalum mesh. A commercially available infrared microscope with a focal distance of 53 cm focuses on a spot only 1 mm wide on the specimen. The microscope has an InSb detector, cooled by liquid nitrogen, that detects wavelengths from 1.8 to 5.5 μm and can detect temperatures near ambient. The microscope is operated as a radiometer. Because the output of the detector varies by several orders of magnitude, it is processed by a logarithmic amplifier before reading.

The problem posed by unknown emissivity is solved by focusing the microscope on a flat spot on the specimen painted with colloidal graphite (see Figure 1). The graphite has a high emissivity that is independent of the specimen, insensitive to the ion bombardment to which the specimen is to be exposed, and unchanged by exposure to most gases. In the experiments, a tantalum specimen so coated was mounted on a molybdenum heating stub. A type-K thermocouple was welded to the specimen. Fixed reference temperatures were provided by attaching beads of indium and tin, which melt at 157 and 232 °C, respectively. (These metals were chosen because they have low vapor pressures in the temperature range of interest.)

Figure 2 shows the calibration curve obtained from the infrared and thermocouple readings. After initial calibration, the thermocouple was removed, and the beads alone were used. The calibration did not change during 6 weeks of intermittent use, nor was it changed by removal and repainting of the graphite. The calibration also did not depend critically on the angle between the optical axis of the microscope and the coated flat on the specimen or on the angle between the axis and the quartz window. Both angles could be within ±15° of perpendicular and were easily set by eye.

This work was done by Donald R. Wheeler, William R. Jones, Jr., and Stephen V. Pepper of **Lewis Research Center**. *For further information, Circle 20 on the TSP Request Card.*
LEW-14872

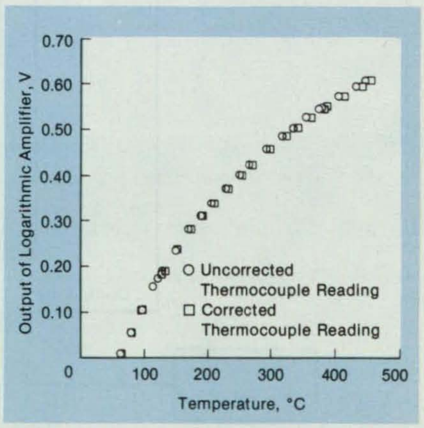


Figure 2. The **Reading of the Infrared Microscope** varies consistently with the temperature of the specimen shown in Figure 1.

Materials

Hardware, Techniques, and Processes

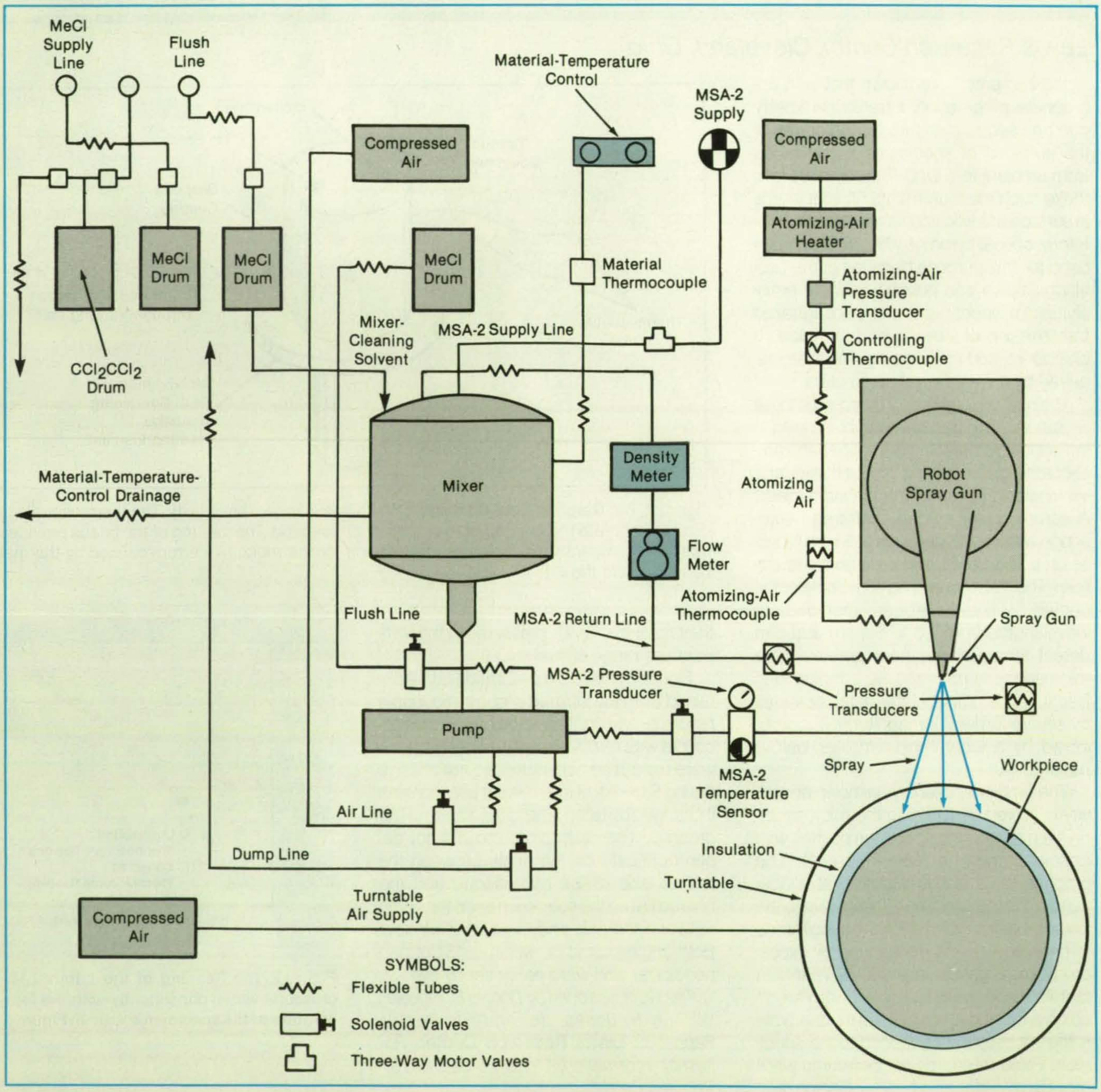
Books and Reports

Low-Density, Sprayable, Thermal Insulation

An improved formulation prevents cracks.

Marshall Space Flight Center, Alabama

A low-density, thermally insulating material is applied by spraying it onto the surface to be protected. The material, called "MSA-2" is an improved version of a similar material called "MSA-1." In turn, MSA-1 was designed for use in place of manually bonded cork as an ablative insulating material on the Solid Rocket Booster of the Space Shuttle. MSA-2 may also be useful



This **Robotic System** Sprays MSA-2 insulation onto a workpiece as it rotates on the turntable. The mixture is recirculated between the spray gun and the mixer.

as sprayed, lightweight insulation to cover large areas in terrestrial applications in which manual attachment would be too slow or otherwise impractical.

In the situation for which MSA-2 was formulated, it was desired to apply MSA-1 to a thickness of ½ in. (13 mm). However, MSA-1 cracks at coating thicknesses greater than ¼ in. (6 mm). The MSA-2 is formulated to be more flexible than MSA-1 is, to prevent coats as thick as ½ in. from developing stress cracks as they cure. The table shows the ingredients of MSA-1 and MSA-2. The MSA-2 is made more flexible by two major changes: First, 15 percent of the phenolic microballoons are replaced by an equal volume fraction of ground cork. Second, the epoxy-modified polyurethane-resin binder is replaced by a flexibilized epoxy-resin binder.

The methylene chloride and perchloroethylene solvents serve as a carrier for the sprayable mixture. The high volatility of the methylene chloride causes most of it to evaporate from the spray and thereby causes the mixture to begin to thicken before the spray hits the surface. The lower volatility of the perchloroethylene protects against excessive dryness during application. A small amount of ethyl alcohol activates the clay for control of viscosity.

The figure illustrates a robotic system that mixes and sprays the ingredients. Typically, insulation ½ in. (13 mm) thick would be sprayed onto a substrate in ¼-in. (6-mm) layers with a delay of as much as 1 h between applications. The cured MSA-2 has a flatwise tensile strength of 60 to 80 psi (0.41 to 0.55 MPa) at a temperature of 75 °F (24 °C), a density of 16 to 18 lbm./ft^3 (256 to 288 kg/m^3), and a thermal conductivity of 0.4 to 0.5 Btu•in./(ft^2•h• °F) [58 to 72 mW/m• °C]. The cured MSA-2 also has low flammability.

MSA-1 Major Component	Weight Percent
Phenolic Microballoons	37.7
Hollow Glass Spheres	12.6
Chopped Glass Fibers	1.3
Milled Glass Fibers	3.1
Epoxy-Modified Polyurethane Resin and Catalyst (Crest 7343 and 7199 or Equivalent)	41.9
Clay (Bentone 27 or Equivalent)	3.5
MSA-2 Major Components	**Weight Percent**
Phenolic Microballoons	32.88
Hollow Glass Spheres	12.89
Chopped Glass Fibers	1.29
Milled Glass Fibers	3.33
Ground Cork	3.12
Epoxy Resin and Catalyst (EC2216A and EC2216B, or Equivalent)	43.04
Clay (Bentone 27 or Equivalent)	3.55
Solvents for MSA-1 and MSA-2	**WeightPercent**
Ethanol	≲1
Methylene Chloride	~55
Perchloroethylene	~44

The **Ingredients of MSA-2 Insulation** make it more flexible than MSA-1 is, so that MSA-2 can be applied in thicker layers without cracking.

This work was done by James P. McLemore, William E. Norton, Joe D. Lambert, William G. Simpson, Sherman Echols, Max H. Sharpe, and William E. Hill of **Marshall Space Flight Center**. *For further information, Circle 90 on the TSP Request Card.*
MFS-28372

Simple Test for Organic Material in Gas

Dried enzymes and color indicators test sensitively and selectively.

NASA's Jet Propulsion Laboratory, Pasadena, California

Dehydrated enzymes can be used in a convenient method for analyzing gases for specific organic substances, outside the laboratory. For example, the method can be used to detect alcohol in breath or formaldehyde in gas streams.

Enzymes dehydrated under controlled conditions on selected organic or inorganic supports can rapidly catalyze reactions of organic compounds diluted in gases. A redox dye can be included with dehydrated enzymes in a powder or on a porous polymer strip. The dye changes color sharply when the mixture of dye and enzymes is exposed to a gas or vapor containing the organic material of interest. The enzymes are selected for their sensitivity to a particular organic material. The method can be used for simple semiquantitative detection or for precise quantitative measurement.

In one demonstration, the method was used to conduct simulated "breathalyzer" tests, to detect ethanol in gases that represented the breaths of human subjects after they had ingested alcoholic beverages. The enzymes alcohol oxidase and peroxidase and the color indicator 2,6-dichloroindophenol were dissolved in water. The solution was dispersed on microcrystalline cellulose powder and dried at room temperature until the water content amounted to only 30 to 40 percent of the total weight. The powder was packed in small glass tubes to a depth of about 1 cm.

Ethanol vapor at the various concentrations was passed through the tubes for 5 s. The final color and the time for a complete change in the color of the indicator from dark blue to pale violet could be adjusted by changing the amount of indicator. For example, the time for a complete change in color at a concentration of alcohol equivalent to that in breath corresponding to a legally defined maximum for driving (0.1 percent ethanol in blood) could be preset to occur after an exposure lasting 1 min.

An unknown concentration can be determined by comparing the time required to change color or the final color or optical density with calibrated values. For quantitative measurements, sheets of microcrystalline cellulose containing the enzyme-and-dye mixture are cut to size and placed in glass tubes. After 10-s exposures to ethanol vapor, changes in optical density of the sheets at a wavelength of 605 nm are monitored by a densitometer connected to a recorder. The slope of the plot and the final optical density are a function of the concentration of ethanol.

The enzyme/dye test is extremely sensitive: it can detect concentrations of ethanol as small as 1 micromolar in gas. It is also highly specific, giving a positive reaction, in addition to ethanol, only to methanol, formaldehyde, and hydrogen peroxide, all of which are absent in human breath. Moreover, the test is easy to perform and takes only 1 to 3 min.

In contrast, other methods currently used to detect ethanol in breath tend to be nonspecific. They involve the use of oxidizing agents that change color by reaction with virtually any organic substance in the breath. More specific methods, such as analyzing the ethanol content in saliva, require careful manipulations and take up to 10 min.

This work was done by Eduardo Barzana, Alexander Klibanov, and Marcus Karel of Massachusetts Institute of Technology for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 104 on the TSP Request Card.*
NPO-17540

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.

Photochemistry of 2,5-Diacyl-1, 4-Dimethylbenzenes

These compounds can be used in the synthesis of substituted anthracenes.

Experiments described in a report have revealed some potentially useful aspects of the photochemistry of 2,5-dibenzoyl-1,4-dimethylbenzene (DBX) and 2,5-diacetyl-1, 4-dimethylbenzene (DAX). In some respects, the behavior of these compounds is reminiscent of that of the orthoalkylphenyl ketones, which have been studied from a similar perspective for more than two decades.

Both DAX and DBX were found to undergo photoenolizations similar to those of the orthoalkylphenyl ketones. However, unlike the orthoalkylphenyl ketones, each of the two compounds can undergo two tandem photoenolizations. Furthermore, just as photoenols derived from orthoalkylphenyl ketones have been trapped with Diels-Alder dienophiles before they decayed within microseconds to provide a convenient synthesis of substituted tetralins, Diels-Alder trapping of photoenols from DBX provided a route to the synthesis of tetrahydroanthracenes and octahydroanthracenes.

The photoenolization is a stepwise process involving the formation of a monoadduct, which then reacts further to form the bisadduct. The formation of the photoadducts is regiospecific. Because the reaction is stepwise, the overall stereochemistry is complicated by the presence of two independent reaction sites.

All of the photoadducts of DBX were smoothly dehydrated to the corresponding tetrahydroanthracenes by the use of hydrochloric acid in refluxing acetic anhydride or benzene. By the use of sulfur in refluxing diphenyl ether, the tetrahydroanthracenes were dehydrogenated and aromatized to the substituted anthracenes with yields of about 80 percent.

The photoenols of DAX could not be trapped with the dienophiles used successfully with DBX in these experiments. However, the results of a previous experiment suggest that it may nevertheless be possible to do so at low yields.

This work was done by Michael A. Meador of **Lewis Research Center**. *Further information may be found in NASA TM-89836 [N87-22005], "2-5-Diacyl-1,4-Dimethylbenzenes — Examples of Bisphotoenol Equivalents."*

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-14708

Computer Programs

COSMIC: Transferring NASA Software

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

COSMIC's inventory is updated regularly; new programs are reported in *Tech Briefs*. For additional information on any of the programs described here, circle the appropriate TSP number.

If you don't find a program in this issue that meets your needs, call COSMIC directly for a free review of programs in your area of interest. You can also purchase the annual *COSMIC Software Catalog*, containing descriptions and ordering information for available software.

COSMIC is part of NASA's Technology Utilization Network

COSMIC® — *John A. Gibson, Director,*
(404) 542-3265
The University of Georgia, 362 East Broad Street,
Athens, Georgia 30602

Computer Programs

These programs may be obtained at a very reasonable cost from COSMIC, a facility sponsored by NASA to make computer programs available to the public. For information on program price, size, and availability, circle the reference number on the TSP and COSMIC Request Card in this issue.

Mathematics and Information Sciences

XPQ/GCOS-8 SYSOUT Interface Software

A slave user program can obtain SYSOUT records and transfer them to a remote device.

The XPQ/GCOS-8 SYSOUT interface software consists of modifications of the GCOS-8 operating system. It includes an application subroutine that enables the XPQ remote-print software package as modified by LSOC to gain access to, read, and release data from the GCOS-8 system output (SYSOUT) files. Specifically, it contains a slave subroutine RSYOT, a site-unique Master Mode Entry (MME) processor, and alterations to the GEOT, INIT, and System Macro modules for GCOS-8 SR3002/3003.

The RSYOT subroutine enables a slave user program to obtain and transfer SYSOUT records to a remote device. There is no limit to the number of SYSOUT jobs that can be in the process of transferring data simultaneously, but it is the responsibility of the slave program to keep track of the jobs.

The modifications of the operating system enable the RSYOT subroutine to gain access to the system SYSOUT (BLINK) files. This implements all of the privilege logic needed to gain access to SYSOUT jobs. System privileges are not needed for either the user's program or this subroutine.

RSYOT was written in GCOS-8 Assembler for execution on a Honeywell DPS-8/70 computer. The subroutine requires 1106 36-bit words of memory. This program was developed in 1987.

This program was written by Franklin A. Flohr of Honeywell Federal Systems, Inc. for **Kennedy Space Center**. *For further information, Circle 25 on the TSP Request Card. KSC-11446*

Program for Local-Area-Network Electronic Mail

Computer workstations are used as electronic mail boxes.

MailRoom is a computer program for local-area network (LAN) electronic mail. It enables users of a LAN to exchange electronically notes, letters, reminders, or any sort of communication via their computers. MailRoom links all users of the LAN into a communication circle in which messages can be created, sent, copied, printed, downloaded, uploaded, and deleted through a series of menu-driven screens. MailRoom includes a feature that enables users to determine whether messages they have sent have been read by the receivers.

Each user must be installed separately in and removed from MailRoom as he or she joins or leaves the network. MailRoom comes with a program that enables this to be done with minimum effort on the part of the administrator or manager of the network. The program also includes a portion that enables the administrator or manager to install MailRoom on each user's workstation so that, on execution of MailRoom, the user's station can be identified and the configuration settings activated. The program creates its own configuration and data/supporting files during the setup and installation process.

The MailRoom program is written in Microsoft QuickBasic. It was developed to run on networked IBM XT/AT or compatible computers and requires that all participating workstations share a common drive. It has been implemented under DOS 3.2 and has a memory requirement of 71K. MailRoom was developed in 1988.

This program was written by Michael J. Weiner of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 150 on the TSP Request Card. NPO-17745*

NASA Software Update

Each month NASA Tech Briefs features new computer programs available through COSMIC, NASA's Computer Software Management and Information Center in Athens, GA. In addition to this new technology, the COSMIC inventory contains a large selection of "classic" computer programs that are widely used and maintained within NASA. Classic codes updated in the last year include:

Properties and Coefficient Program for the Calculation of Thermodynamic Data (PAC2) The program calculates ideal gas thermodynamic properties for any species for which molecular constant data is available, and offers the user a choice of methodologies for performing the thermodynamic calculations. This year PAC2 was updated to PAC4. Improvements include increased user friendliness and the ability to extrapolate thermodynamic properties for gases to higher temperatures using Wilhoit's formulas. *Circle 66 on the TSP Request Card. LEW-10254*

Interactive Controls Analysis (INCA) Version 3.12 of INCA provides a user-friendly environment for the design and analysis of linear control systems. The system configuration and parameters are easily adjusted, enabling the INCA user to create compensation networks and perform sensitivity analysis in a very convenient manner. A full complement of graphical routines makes the output easy to understand. The program is written in Pascal and FORTRAN for interactive or batch execution and runs on a DEC VAX computer under VMS. *Circle 67 on the TSP Request Card. GSC-12998*

Systems Improved Numerical Differencing Analyzer (SINDA) Considered the standard in heat transfer, SINDA '85/FLUINT can handle complex problems involving pumps, valves, heat exchangers, and resistor-capacitor networks. When combining SINDA with another classic program, TRASYS II, users can tackle thermal radiation problems, including shadowing by opaque or semitransparent surfaces. Utility programs can automatically convert SINDA/TRASYS output to a form compatible with NASTRAN-developed structures. The 1989 versions of both programs were recently ported to the CONVEX computer. *Circle 62 on the TSP Request Card. MSC-13805, MSC-20448*

Global Reference Atmosphere Model (GRAM) The GRAM series of four-dimensional atmospheric models has been validated by years of data. The basic GRAM program, written for a UNIVAC computer, is still available. More current are GRAM 86, which includes atmospheric data from 1986 and runs on a DEC VAX, and GRAM 88, which runs on an IBM 3084. The program generates altitude profiles of atmospheric parameters along any simulated trajectory through the atmosphere, and is also useful for global circulation and diffusion studies. *Circle 63 on the TSP Request Card. MFS-23336*

NASA Structural Analysis System (NASTRAN) The grandaddy of structural analysis programs, NASTRAN has been used since the mid-1960s to design products ranging from aircraft to automobiles to printers. In addition to DEC VAX, IBM, CDC, and UNIVAC machine versions, NASTRAN is available for the MicroVAX under VMS and UNIX. COSMIC generates a new release of NASTRAN each year. *Circle 61 on the TSP Request Card. HQN-10952*

Earth Resources Laboratory Applications Software (ELAS) Originally developed to process Landsat satellite data, ELAS has been modified over the years to handle a broad range of digital images, and is now finding widespread application in the medical imaging field. This year, in an effort to increase portability, the many versions of ELAS were condensed into v. 8.0, which is available for the DEC VAX, the CONCURRENT, and for the UNIX environment. *Circle 64 on the TSP Request Card. ERL-10013*

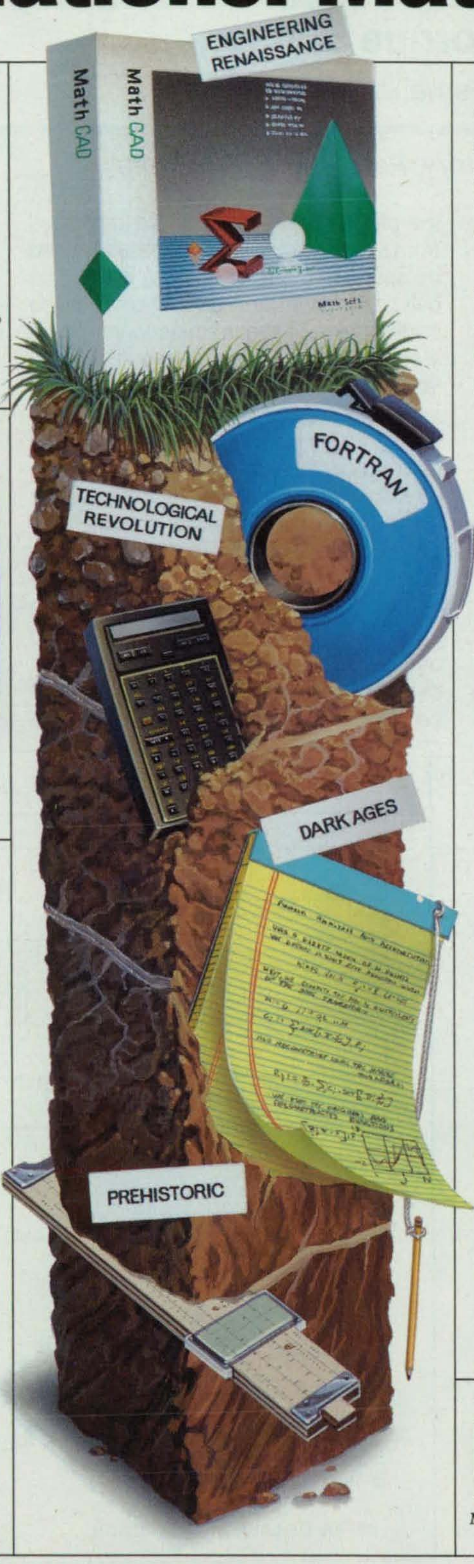
Land Analysis System (LAS) Version 4.1 of LAS provides a flexible framework for algorithm development and the processing and analysis of image data. Over 500,000 lines of code enable image repair, clustering, classification, film processing, geometric registration, radiometric correction, and manipulation of image statistics. *Circle 65 on the TSP Request Card. GSC-13075*

NASA-Enhanced Version of Automatically Programmed Tool Software (APT) The APT code is one of the most widely used software tools for complex numerically-controlled machining. APT is both a programming language and the software that processes the language. Recent upgrades include super pocket for concave polygon pockets and an editor to reprocess cutter location coordinates according to user-supplied commands. *Circle 68 on the TSP Request Card. GSC-12758*

Network Queueing System (NQS) This program provides batch and device queueing facilities for various computers networked in a UNIX environment. It allows the network manager to allocate and track resources across the network without requiring a user to specifically log in on remote target machines. *Circle 69 on the TSP Request Card. ARC-11750*

Semi-Markov Unreliability Range Evaluator (SURE) An analysis tool for reconfigurable, fault-tolerant systems, SURE provides an efficient way to calculate accurate upper and lower bounds for the death state probabilities for a large class of semi-Markov models. The calculated bounds are close enough (usually within five percent of each other) for use in reliability studies of ultrareliable computer systems. SURE v. 6.3 is written in PASCAL for interactive execution and runs on a DEC VAX computer under VMS. *Circle 70 on the TSP Request Card. LAR-13789*

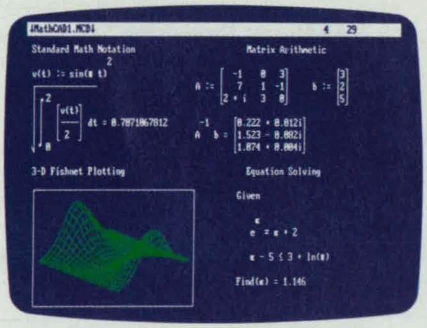
After centuries of practice, mankind perfects engineering calculations: MathCAD.



Announcing MathCAD 2.5: The Dawn of a New Age.

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

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



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

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

And now we've made the best even better. MathCAD 2.5 is a dramatically improved version that includes three-dimensional plotting, enhanced numerical analysis, and the ability to import HPGL files from most popular CAD programs, including AutoCAD.® And now you can print on PostScript® compatible printers.

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

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

No matter what kind of math you do, MathCAD 2.5 has a solution for you. In fact, it's used by over 60,000 engineers and scientists, including electrical, industrial, and mechanical engineers, physicists, biologists, and economists.

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

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

And for Macintosh® users, we present MathCAD 2.0, rewritten to take full advantage of the Macintosh interface. Entering operators and Greek letters into equations is pure simplicity!

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

Available for IBM® compatibles and Macintosh computers.

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

MathCAD®

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

22

U.K.: Adept Scientific 0462-480055; **France:** ISE CEGOS 1-46092768; **Germany:** Softline 07802-4036; **Japan:** CRC 03-665-9768. *PE*

Circle Reader Action No. 628

Mechanics

Hardware, Techniques, and Processes

Multiple-Cantilever Torque Sensor

Sensitivity to spurious loads is small.

NASA's Jet Propulsion Laboratory, Pasadena, California

High stiffness, high resolution, and ease of fabrication are among the features of a specially designed torque sensor. The device is flexible and sensitive to torque about its cylindrical axis (which one seeks to measure) and stiff enough to be insensitive to bending about any perpendicular axis.

In effect, the torque sensor is a quasi-flexible inner coupling plate between outer coupling plates that are connected to the driving and driven shafts. The inner plate — the main body of the torque sensor — has cantilever cutouts around its edge. Cantilevers are connected alternately to the driving and the driven plate, so that when there is torque between the driving and driven shafts, pairs of adjacent cantilevers deflect circumferentially toward or away from each other (see figure).

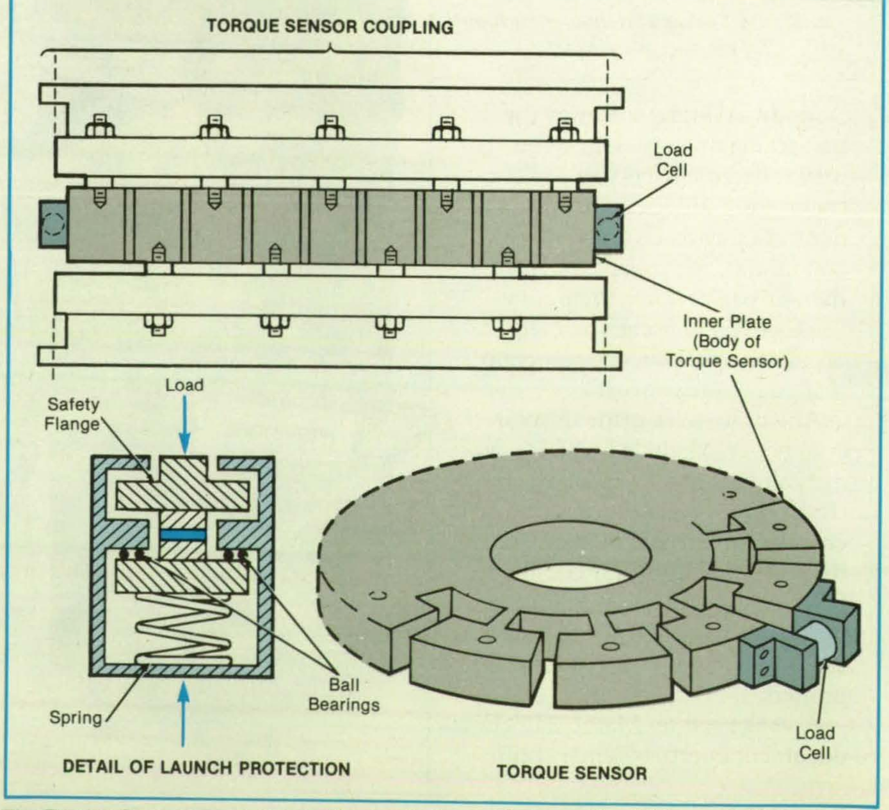
A load cell is positioned to measure the circumferential deflection between adjacent cantilevers in two or more pairs. The load cell could be a strain gauge, piezoelectric transducer, or linear variable-differential transformer. In the prototype, a piezoelectric ceramic transducer is used because its sensitivity is the greatest.

Although the ratio of flexibility about the cylindrical axis to flexibility about any perpendicular axis is orders of magnitude greater than that of other torque sensors, the piezoelement must still be protected from small residual shear stresses caused by spurious (non-axial-torque) loads. The ball bearings in the load cell prevent the transmission of shear stress to the piezoelement by accommodating the small lateral movements induced by spurious loads. The ball bearings are preloaded by a spring, which yields when the load on the cell approaches the maximum safe value for the piezoelement. Any further increase in load then bypasses the piezoelement and is borne by the safety flange.

The dimensions of the cantilevers are chosen to provide the required stiffness and flexibility in the undesired and desired bending modes, respectively. The design should be such that if the smallest torque to be measured were borne entirely by the cantilevers, they would deflect much more than the piezoelements would if the same torque were applied to them. When this condition is satisfied, the piezoelements bear most of the torque and provide most of the stiffness for the transmission of the torque.

This work was done by Boris J. Lurie, J. Alan Schier, and Michael Socha of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 21 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA's Resident Office-JPL [see page 24]. Refer to NPO-17461



The **Torque Sensor** measures and transmits torque between the driving and driven plates.

Compliant Prosthetic or Robotic Joint

Rotation is partly free and partly restrained by resilience and damping.

Goddard Space Flight Center, Greenbelt, Maryland

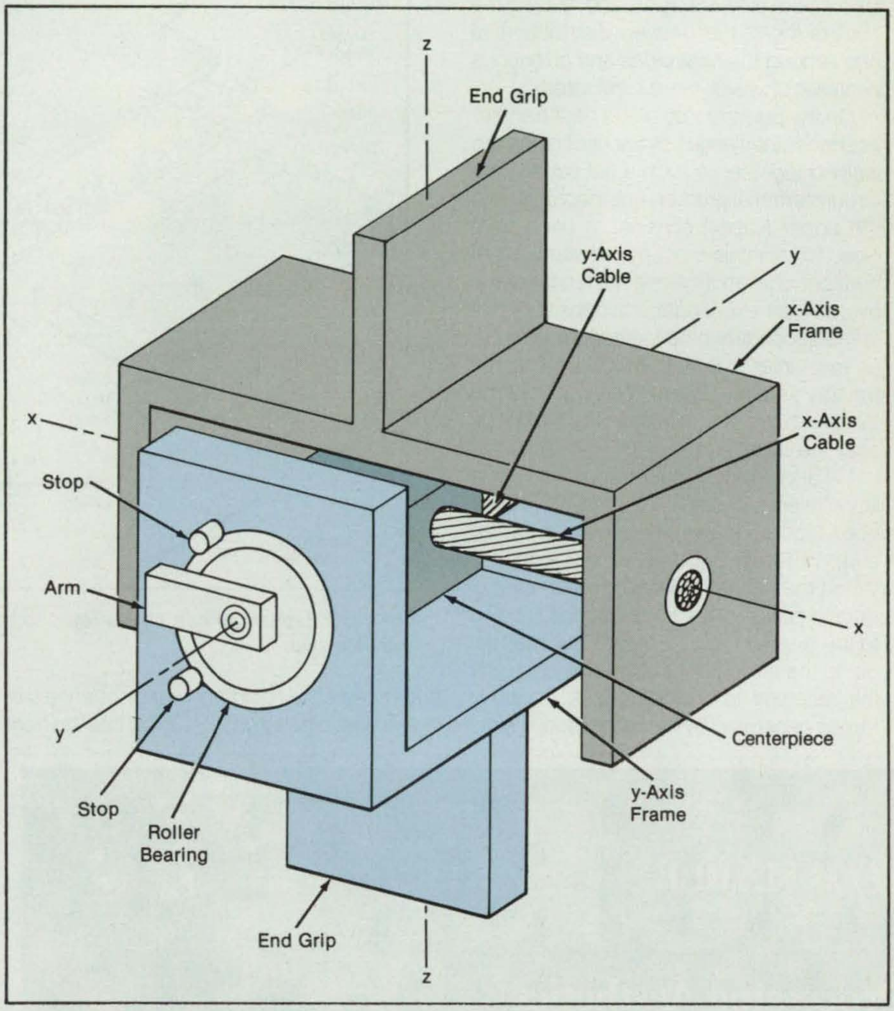
A rotating joint behaves much like a knee, knuckle, or hip-to-leg joint: it can rotate freely through a limited angle in one plane and is resilient at the limits of the range, and is resilient in an orthogonal plane so that it can absorb the impact loads that occur in everyday use. The joint can be used in a prosthetic device to replace a diseased or damaged human joint, or in a robot linkage to limit movement and cushion overloads.

The joint includes U-shaped x- and y-axis frames joined by cables that cross in at a center piece (see figure). The y-axis frame can rotate about the y-axis on a roller bearing within a predetermined angular range; an arm on the bearing strikes a stop at either end of the range. The y-axis frame can rotate slightly farther when the arm strikes a stop, because the cables can twist. This mimics the compliant resistance of knee joint reaching the limit of its forward or backward motion.

End grips on the x- and y-axis frames are connected to skeletal or robotic members. The upper end grip and the x-axis frame can rotate through a small angle about the x-axis because the x-axis cable can also twist. This is not free rotation, but damped, compliant rotation like that of the y-axis frame beyond the stops. This compliant rotation is like the sideways movement of a knee.

The cables are made of independent-wire-rope cable, possibly stainless steel. They are joined to the frames and center block by swaging. The degree of compliance is determined by the lengths, diameters, materials, and strandings of the cables. For a robot joint, shear stress is likely to be large, requiring thick, strong cables. For a prosthetic human joint, however, loads are small, and thinner cables can be used.

For a human prothesis, the geometry of the joint can be adapted to the local anatomy. In a knee, for example, the center piece could could be spherical, and the end grips could be rods rather than plates. The rods could be fastened by threading to fittings in the leg bones or by slide-fitting them into the bones.



A **Kneelike Joint** rotates freely through a limited angular range around the y axis. At the limits of the range, it rotates compliantly through an additional small angle. Similarly, it rotates compliantly through a small angle around the x axis.

This work was done by James J. Kerley of **Goddard Space Flight Center** *and Wayne D. Eklund of NSI Technology Services Corp. 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 24]. Refer to GSC-13153

Heat Exchanger With Reservoir and Controls

A heat-pipe assembly operates as an evaporator or as a condenser.

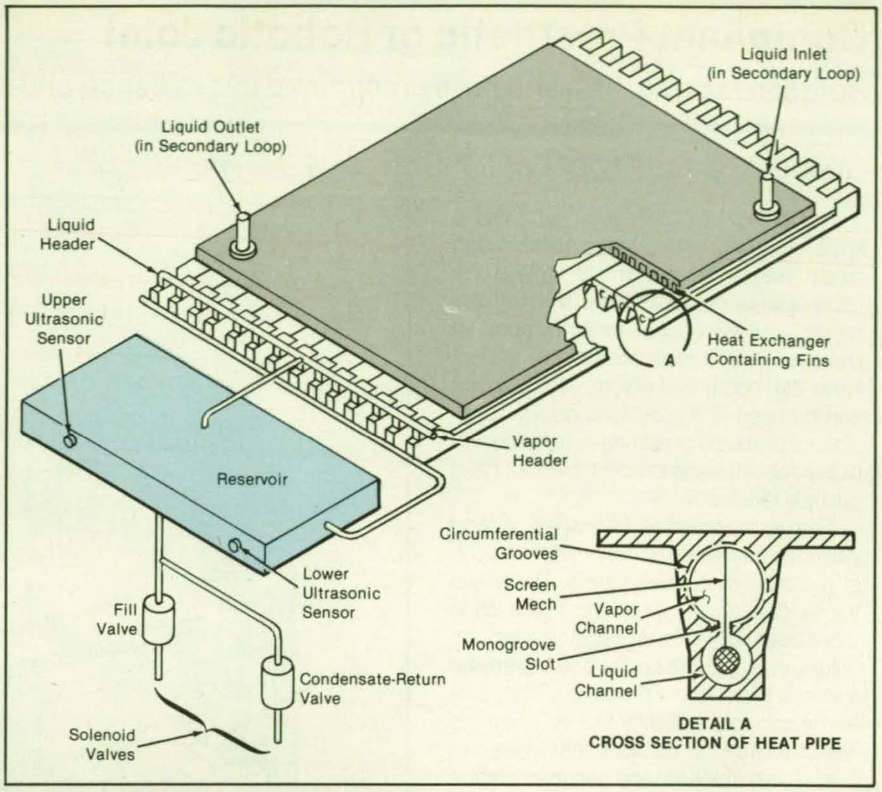
Lyndon B. Johnson Space Center, Houston, Texas

The figure shows a heat exchanger that can transfer heat in both directions. The heat exchanger includes an assembly of heat pipes connected to a reservoir in the primary fluid loop. Heat is transferred through the flanges of the heat pipes and a finned heat exchanger in contact with the joined flanges, to or from the fluid in the secondary loop, which fluid flows through the finned heat exchanger. When operated as an evaporator (to transfer heat from the secondary to the primary loop), the array of heat pipes demonstrated good load-sharing performance and a heat-flux capability of over 2 W/cm^2 with ammonia as the working fluid.

The new heat exchanger incorporates important improvements over previous designs. By adding the reservoir to the primary loop, locating ultrasonic liquid-level sensors on the reservoir rather than directly on one of the heat pipes, and revising the control logic, the uneven distribution of flow among the heat pipes and erroneous behavior of valves were eliminated.

On the primary side of the heat-transfer interface, the flanges of the heat pipes are welded together to form a flat panel. Fine circumferential grooves are machined into the upper (vapor) channel of each heat pipe. To maintain a nearly constant flux of heat per unit length along the length of the overall heat exchanger, the density of fins in the secondary heat exchanger increases from inlet to outlet. This compensates for the smaller difference between the temperatures of the fluids in the two loops near the outlet end.

Fill and condensate-return valves allow liquid to enter or leave the reservoir during operation of the heat-pipe panel as an evaporator or condenser, respectively. When the panel is operating as an evaporator, a pressurized source supplies liquid to the reservoir, which, in turn, supplies liquid to the panel. A liquid header connects the reservoir to the heat pipes. Capillary forces generated by the monogroove slots between the liquid and vapor channels in the heat pipes transport liquid into the heat pipes for evaporation, as needed. The vapor produced in the heat pipes flows through a vapor header to a condenser elsewhere in the system. The vapor header is also connected to the vapor space in the reservoir.



The **Heat Exchanger** can be operated to transfer heat to or from a secondary liquid heat-transfer loop.

The fill valve opens and closes in response to the signals from the ultrasonic liquid-level sensors and from thermocouples on the flange of one of the heat pipes and on the vapor header. Evaporation is allowed to deplete the reservoir until both ultrasonic sensors indicate "dry" and the thermocouples indicate that the flange temperature exceeds the vapor header temperature. The fill valve then opens until both ultrasonic sensors detect liquid, regardless of the thermocouple signals.

During operation of the heat-pipe panel as a condenser, vapor flows from an evaporator elsewhere in the system, into and through the vapor header. The temperature of the vapor header exceeds the temperature of the flange. When the difference between these two temperatures exceeds a threshold value of, say, 5 to 10 °F (2.8 to 5.6 °C) and both ultrasonic sensors detect liquid, the condensate-return valve opens, allowing a pump to remove fluid from the reservoir. When the reservoir becomes empty or the difference between the temperatures falls below the threshold value, the condensate-return valve closes.

This work was done by Richard F. Brown and Fred Edelstein of Grumman Aerospace Corp. for **Johnson Space Center**.

For further information, Circle 135 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 24]. Refer to MSC-21295/MSC-21296

Computation of Flow About a Helicopter Rotor

Vortical wakes are captured without ad hoc mathematical modeling.

Ames Research Center, Moffett Field, California

An improved method has been developed to simulate numerically the flow about a helicopter rotor with multiple blades. In contrast with previous methods of numerical simulation, this one computes the vortical wake beneath the rotor without using simplified ad hoc mathematical models of the effects in the wake.

In this method, the Euler equations of flow are solved in an integral formulation in which the conservation law is applied to each cell of the computational grids. A cylindrical system of rotating patched grids (see figure) accommodates multiple blades. The cylindrical rotating outer grid for one blade is generated by solving Poisson equations with periodic boundary conditions at blade cuts. This grid can be rotated and connected with copies of itself to form a multiblade grid. There are no discontinuities of slope between the grids of adjacent blades.

The Euler equations are solved by a computer code that uses Steger-Warming flux-vector splitting in the circumferential (primary-flow) direction and Jameson's dissipative terms in the other two directions. The use of flux splitting enables one to avoid the necessity for the "tuning" of explicit dissipation coefficients. Furthermore, the linear stability analysis shows that the use of flux-vector splitting combined with upwind differencing in the main flow direction and central differencing in the other two directions can result in an unconditionally stable two-factored algorithm.

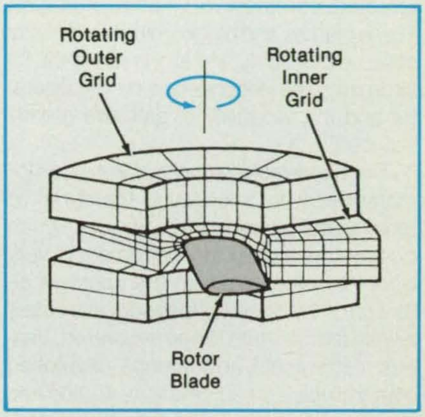
The conservation law is applied to cells defined by the primary grid. The van Leer MUSCL(monotone upstream-centered scheme for the conservation laws) approach is used to evaluate the conservative variables at the surface of each cell in the circumferential direction.

All of the boundary conditions are implemented explicitly. The only unknown boundary condition is the one regarding pressure, and it can be determined by solving the equation for the component of momentum perpendicular to the surface of the blade at the surface. Azimuthally periodic boundary conditions are used in the case of hover. In the far field, nonreflecting boundary conditions are used. At the roots of the blades, no flux is allowed across the cylindrical inner surface of the grid. This means that the simulation includes a fictitious solid cylinder at the hub of the rotor.

The method has been applied to one case of nonlifting forward flight and several cases of lifting while hovering. In the forward-flight case, the unsteady growth and decay of the shocks at the tips of the rotor blades agree well with experimental results. In the hovering case, at low and moderate transonic tip speed, the results show good agreement with experimental data in the tip region.

This work was done by C. L. Chen and W. J. McCroskey of **Ames Research Center**. *Further information may be found in AIAA paper 88A-22031, "Numerical Simulation of Helicopter Multi-Bladed Rotor Flow."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500.
ARC-12227



Patched Grids are used in the numerical simulation of flow about the rotor blades. The cylindrical configuration simplifies the interpolation at the interface between the rotating and stationary grids.

Tensile Film Clamps and Mounting Block for Viscoelastometers

Samples are gripped uniformly and reproducibly.

Langley Research Center, Hampton, Virginia

A set of clamps and a mounting block have been developed for use in determining the tensile moduli and damping properties of films in a manually operated or automated commercial viscoelastometer. These clamps and block provide uniformity of sample gripping and alignment in the instrument. The dependence on the operator and the variability of data are greatly reduced.

The viscoelastometer has been used for many years for measuring the dynamic mechanical properties of polymers. When operated manually, the instrument is very labor-intensive, requiring the constant attention of the operator for hours at a time if a wide temperature range is covered. Various instruments and clamps developed over the years for automatic operation and improved clamping still have not satisfactorily solved the problem of reproducible and uniform gripping of samples.

This new design allows for mounting of the sample in T-clamps on a film-mounting fixture that is removed from the instrument (see upper part of figure). The mounting fixture securely holds the T-clamps and ensures alignment and reproducible positioning of the film in the clamps. The specimen of film is placed on the mounting fixture and is aligned by positioning the edge of the film along a ledge that is spaced so that a film of specified width will be centered on the T-clamps.

The bottom of the T-clamp fits into cutouts in the mounting block and is securely locked into place, ensuring reproducible positioning. The top portion of the T-clamps fits over two alignment pins and is secured to the bottom of the clamps by an Allen screw. To prevent slipping, twisting, or uneven clamping of the film as the top of the T-clamp is tightened, a rectangular film holder is placed over the film. This is held in position by screwing a top plate, which extends over the film holder, to the mounting block.

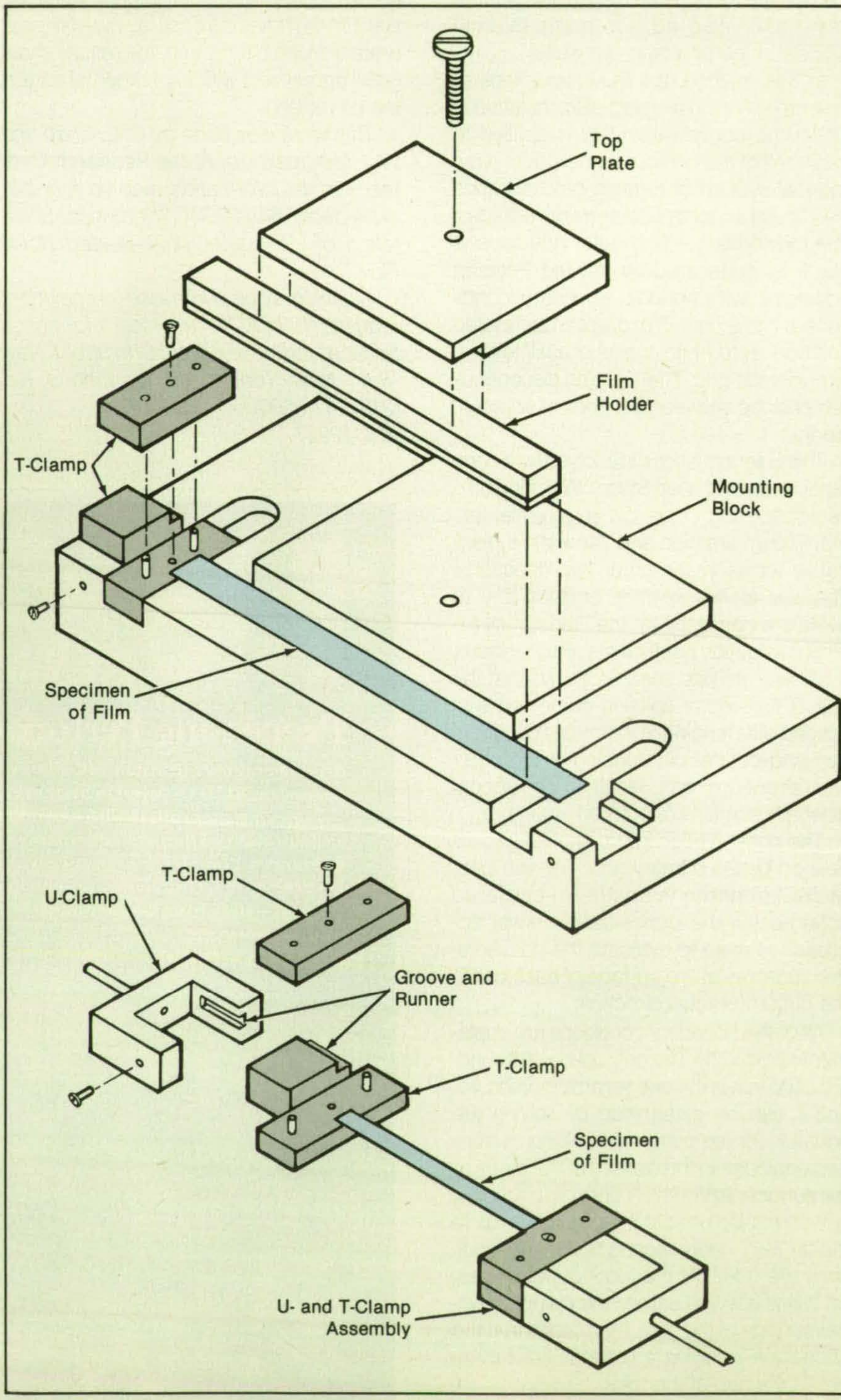
After both ends of the film are secured in the T-clamps, the top plate and film holder are removed. The film can then be viewed from the side to assure the operator that the clamping is uniform.

The setscrews on the side of the mounting fixture are then loosened, and the clamped film and T-clamps removed from the block. The T-clamps are then mounted in the viscoelastometer in U-clamps (see lower part of figure). The U-clamps are on rods that are connected to the stress and strain gauges. This portion of the clamping assembly is left in place at all times.

The T-clamps are slipped into the U-clamps so that the T-clamp runners fit into the U-clamp grooves, ensuring reproducible alignment of the film on the axis. An Allen-head setscrew on the top side of the clamps eliminates slippage of the T-clamps during tensioning of the film and the acquisition of data. This gripping assembly results in a vertical film mounting, allowing an edge-on view of the film as a final check on the mounting of the sample.

This work was done by Diane M. Stoakley, Anne K. St. Clair, and Bruce D. Little of **Langley Research Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 24]. Refer to LAR-13696



T-Clamps Are Removed From the Mounting Fixture and remounted in U-clamps on the instrument.

DEVELOPING CHANGE

Capture Dynamic Design, Material And Processing Creativity With GE

Solutions in total from a single source. Diverse material technologies. Copolymers, alloys, composites. Leading-edge process development. In-depth, worldwide market expertise. The exclusive Engineering Design Database—unique design and analysis tools in a total system for plastics engineering.

The innovative KODAK Minilab System 20. Blow-molded developer tanks, injection-molded racks, foam-molded panels and tank supports of NORYL® resin. Rollers of extruded LEXAN® resin.

Unmatched customer commitment, unlimited creative resources—only from GE.

For more information, call:
(800) 845-0600

GE Plastics

Circle Reader Action No. 615

Dynamic Torque Calibration Unit

Unit offers precision torque measurement for rotary components.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed dynamic torque calibration unit (DTCU) would measure the torque in rotary actuator components such as motors, bearings, gear trains, and flex couplings. The DTCU would be unique because it is designed specifically for testing components under the low rates typically found in precision pointing applications. The DTCU would drive mechanisms at constant rates or in oscillation at rates up to 8 rad/s, with 0.5-percent rate stability. Torques up to 100 lb-in (11 N-m) would be measured to within 0.002 lb-in. (2.2×0^{-4} N-m), at frequencies up to 5 kHz.

The DTCU (see Figure 1) would include a rate table and the device under test, which would be driven by the rate table through a custom-fitted fixture. The rate table would include two subsystems: (1) a brushless dc motor and its controller and (2) a torque sensor and associated data-acquisition equipment, as shown in Figure 2. The rate table would drive the device under test at constant speed or in oscillation, depending upon which parameters are to be measured. For example, the cogging, back electromotive force, ripple, and drag of a motor would be measured at constant speed, while certain frictional parameters of bearings would be measured in ramp or sinusoidal oscillation about a particular angle.

The brushless dc motor in the rate table would be commutated in response to the angular-position signal of an angle resolver, the phase of the output of which is proportional to the shaft angle. The motor controller would be an analog proportional/integral/derivative circuit for high-bandwidth performance without the complexity of digital control. The rate or position mode would be selectable. Within these modes, rate and position commands would be selected digitally and converted to analog to assure repeatability of tests.

The torque sensor would be a piezoelectric dynamometer. The output of the sensor would be recorded and analyzed either by a computer with data-acquisition hardware and software or by a spectrum analyzer.

This work was done by Michael L. Agronin and Carl A. Marchetto of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 40 on the TSP Request Card.*
NPO-17509

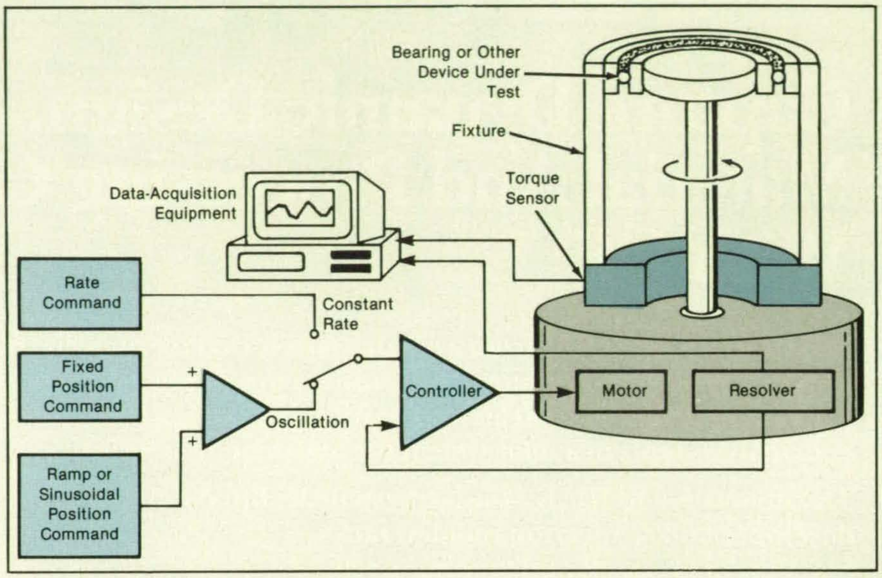


Figure 1. The **Dynamic Torque-Calibration Unit** would measure the torque in the device under test during controlled steady rotation or oscillation.

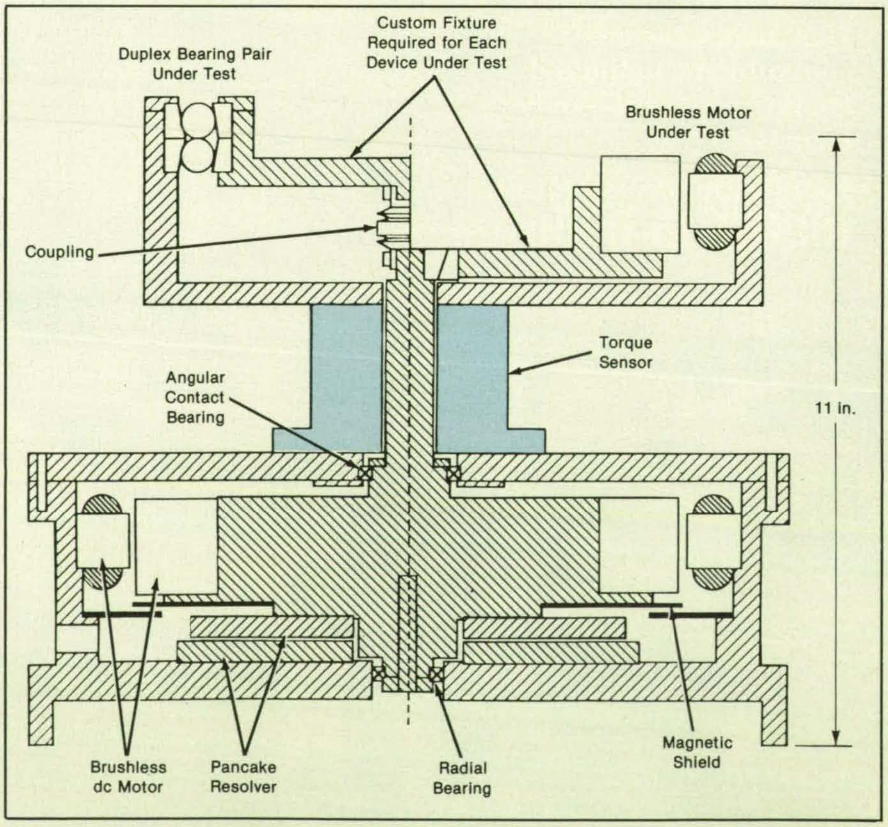
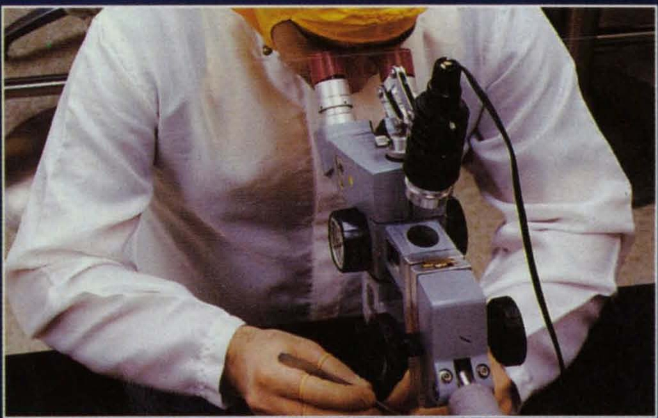


Figure 2. The **Mechanical Components of the Rate Table** are shown in more detail. The rotor would be oriented vertically, supported by an upper angular-contact bearing and a lower radial-contact bearing that would float axially to prevent thermal expansion from loading the bearings. A high-load capacity air bearing would be available to replace the ball bearings when higher load capacity or a reduction in rate noise is required.

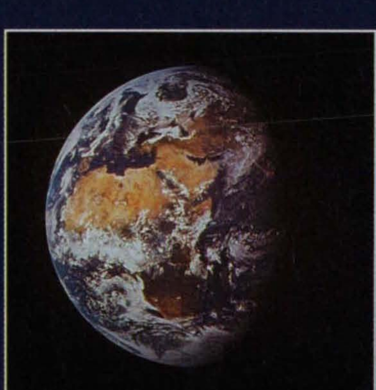
MADE IN ONTARIO



FLOWN AROUND THE WORLD

Ontario, Canada, is a tariff-free source of military products, thanks to the US/Canada Defense Production Sharing Agreement. This agreement simplifies access to a versatile, successful and highly competitive aerospace/defense industry.

The Canadian industry is among the world's five largest; the bulk of Canadian manufacturing resources are located in Ontario. Here, we have the technology and the expertise to



manufacture virtually any product o component for aerospace/defense. We are well-known around the world three-quarters of our output is sold outside Canada.

Think of Ontario as a domestic supplier, but a supplier capable of giving you a competitive advantage. For up-to-date information on Ontari aerospace/defense industry capabilities, call any of these Government of Ontario offices and ask for a director

Atlanta (404) 956-1981
Boston (617) 266-7172
Chicago (312) 782-8688
Dallas (214) 386-8071
Los Angeles (213) 622-4302
New York (212) 308-1616
Toronto (416) 963-2500

ONTARIO'S BUSINESS
More than Competitive!

Ministry of Industry Trade and Technology

Americas Branch
Fifth floor, Hearst Block 900 Bay Street
Toronto, Ontario, Canada M7A 2E1

Ontario, Canada

Fabrication Technology

Hardware, Techniques, and Processes

Enclosed Cutting-and-Polishing Apparatus

Solid, liquid, and gaseous materials would be withdrawn from or held within a removable liner.

Marshall Space Flight Center, Alabama

A proposed apparatus would cut and polish specimens while preventing contamination of the outside environment or of subsequent specimens processed in it. The apparatus is designed for use in zero gravity but also includes features that would be useful in the cutting and polishing of toxic or otherwise hazardous materials on Earth.

The apparatus would include a remote manipulator for handling specimens, a cutting and polishing wire, inlets for gas (air, nitrogen, or inert gas) and liquid (e.g., water), and outlets for waste liquid and gas. A replaceable plastic liner would surround the working space (see figure).

The liner would contain an access port for introduction and removal of specimens, a hydrophobic particle filter, a cutting-and-polishing head, and the inlet and outlet connectors for the liquids and gases. Pressure in the liner would keep it inflated and force the gas through the filter.

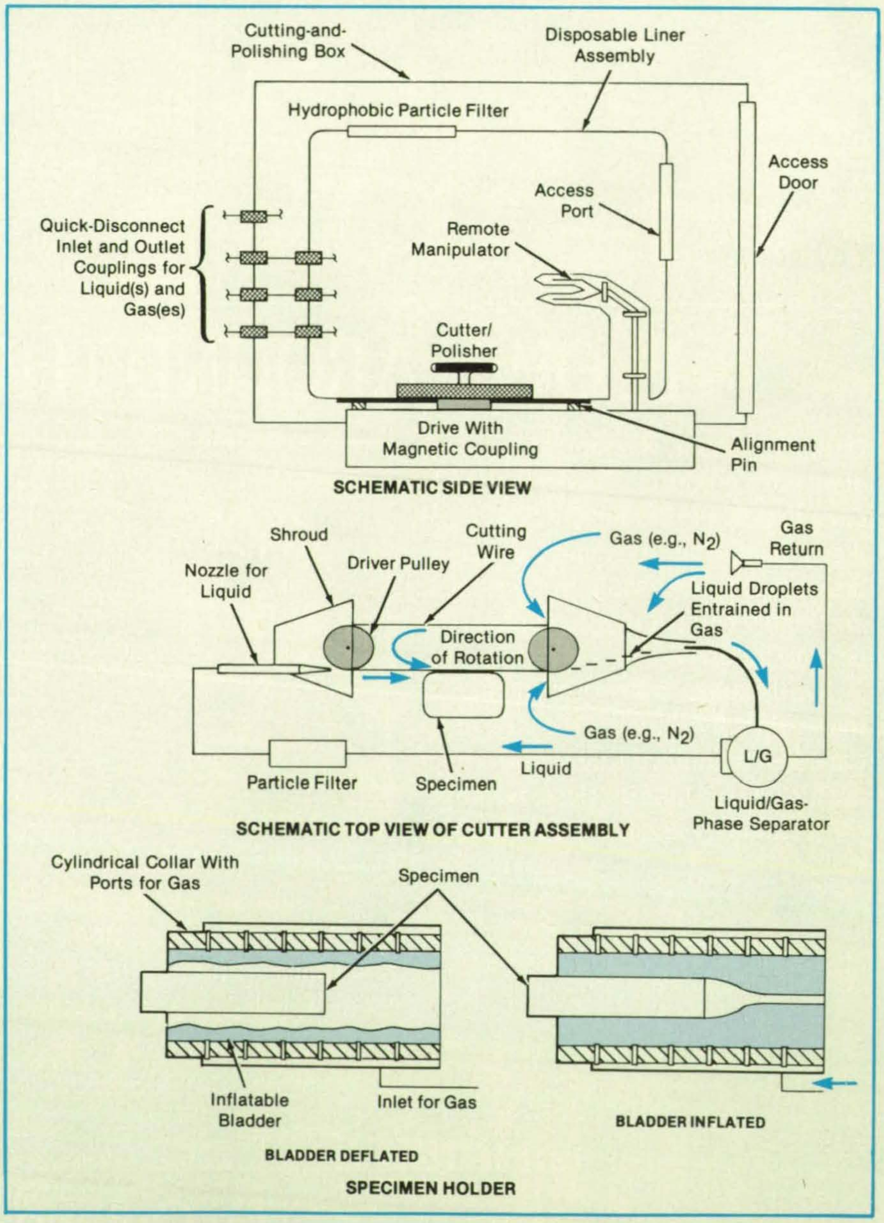
Liquid would be sprayed onto the cutting wire to provide lubrication and cooling and to remove particles. The flowing gas would entrain droplets of water and particles, carrying them to a centrifugal phase separator. The liquid thus recovered would be filtered and reused.

From outside the liner, a magnetic coupling would drive both the cutting-and-polishing head and a pulley that would drive the cutting wire. During cutting and polishing, a cylindrical collar would hold the specimen. A bladder inside the collar would inflate to secure the specimen for processing without damaging it. Thus held, the specimen could be positioned by the remote manipulator without being harmed.

After the specimen is processed, it could be removed from the machine through a bag assembly that would be attached to the access port. The bag would prevent the contents of the liner from entering the outside atmosphere. The liner and its contents — including the cutting-and-polishing head — would then be removed and replaced by a fresh liner.

This work was done by R. N. Rossier and B. Bicknell of Martin Marietta Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-28393



A **Removable Liner Would Surround** the workspace. The liner would include a glovelike portion that would provide access for a remote manipulator.

TEAC.
BECAUSE IT TAKES ALL KINDS.

If you need to measure the bumps, the shakes, the beats, the pressure, or the heat, TEAC makes a data recorder in the right size and format to meet your needs. In fact, we make so many different kinds of data recorders you almost need a data recorder to keep track of them all.

We made the first, and we offer the most extensive line of VHS data recorders. For ease of operation, economy, and convenience of media, the VHS format is the best.

We make the world's smallest 9-channel portable Philips cassette data recorder.

And we make a comprehensive line of reel-to-reel data recorders with extended recording times and up to 28 channels available.

We offer the widest selection of cassette data recorders from 1- to 9-channel models, from pocket-sized to sturdy laboratory and field systems.

Our new portable data recorders incorporating DAT technology are the leading edge in instrumentation recorders.

If you can't find the data recorder in the format you need from TEAC, then it doesn't exist.

And if it doesn't exist it's because TEAC hasn't built it yet.

TEAC®

Instrumentation Data Recorder Division.

Circle Reader Action No. 344

Partitioning and Packing Equations for Parallel Processing

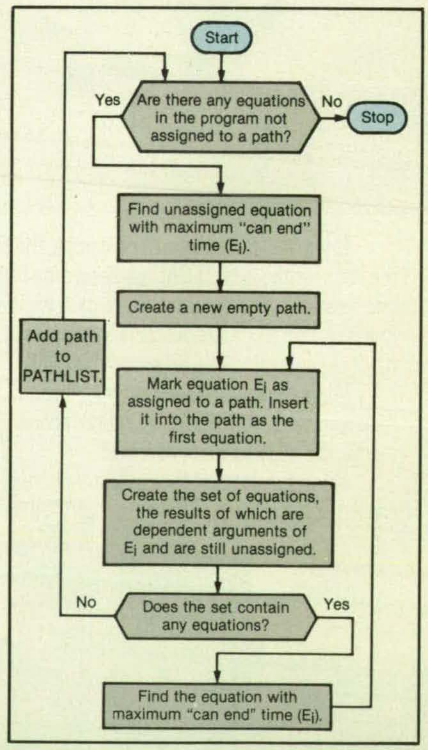
The parallelism in equations is exploited to speed calculations.

Lewis Research Center, Cleveland, Ohio

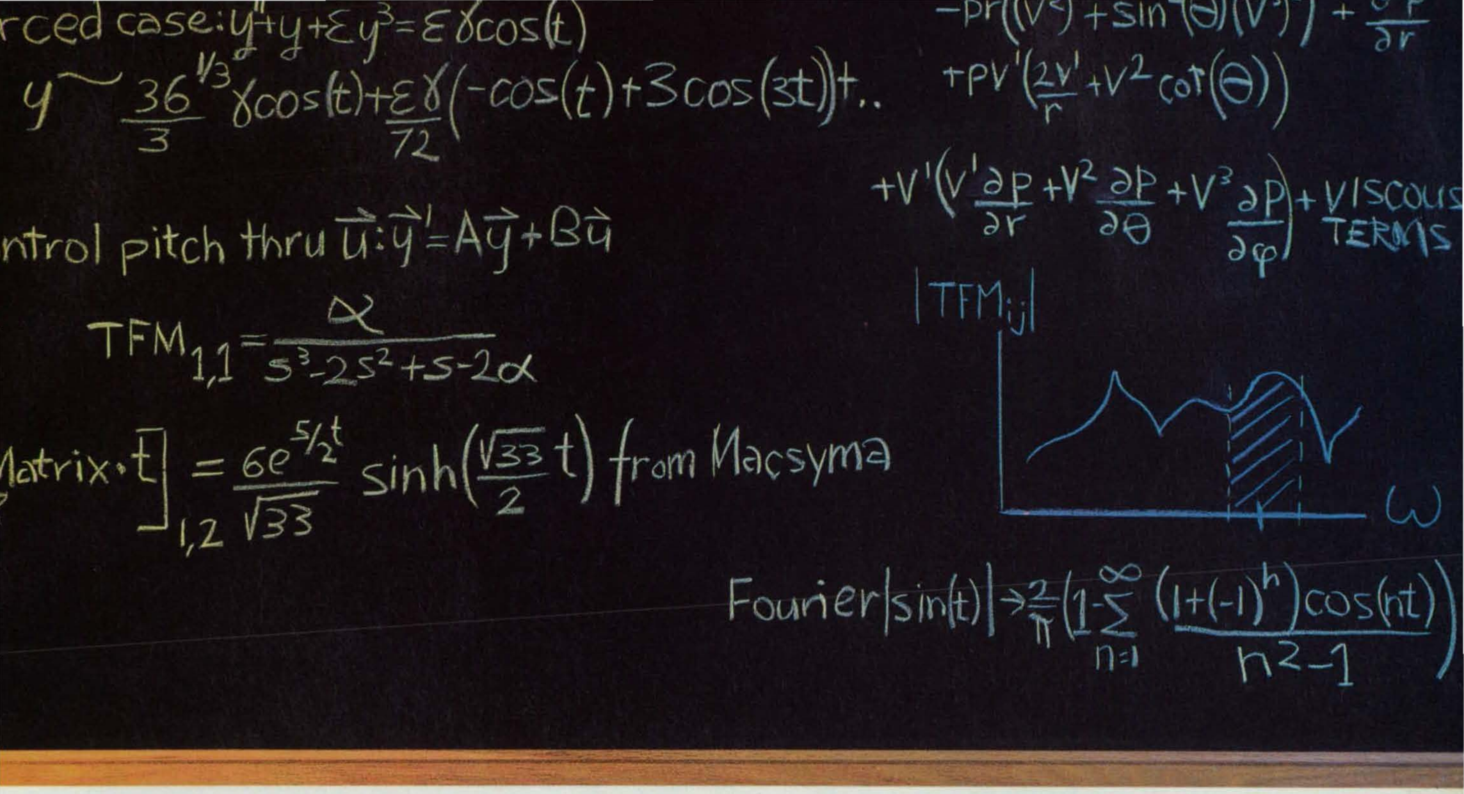
An algorithm has been developed to identify the parallelism in a set of coupled ordinary differential equations that describe a physical system and to divide the set into parallel computational paths, along which parts of the solution can proceed independently of the others during at least part of the time. A related algorithm packs the equations into a minimum number of processors. Together, the algorithms help to exploit the potential for speedup in parallel processing while using the available computing resources effectively.

The partitioning or path-identifying algorithm operates on a computer program that incorporates the mathematical model of the system in question and solves the equations by conventional serial processing. To develop the computational paths, this algorithm processes the program to extract the result/argument relationships from the serial set of equations. Because the calculation time of each equation is crucial to partitioning, it is also extracted during this initial processing.

The time at which an equation can start



The **Path-Identifying Algorithm** creates a number of paths consisting of equations that must be computed serially and a table that gives the dependent and independent arguments and the "can start," "can end," and "must end" times of each equation. The "must end" time is used subsequently by the packing algorithm.


from Macsyma
Fourier

is determined by the time needed to compute previously any arguments that appear in the equation. The time at which an equation can end is the starting time plus the calculation time, and this in turn sets an earliest starting time for another equation of which the result of the present equation is an argument.

Once these attributes have been established for each equation in the program, the identification of computational paths (see figure) can begin. The algorithm identifies all paths that contain no parallelism and the equations of each of which must be computed serially. The paths are organized into a linked list and ordered in terms of decreasing path calculation time. The first path in the list is the critical (longest) path, which determines the overall calculation time.

To begin the formation of a path, the algorithm selects the equation that has the maximum "can end" time and that has not already been assigned to another path: this is the last (result) equation of this path. The next equation chosen for this path is the next-to-last equation of this path and is the equation with the maximum "can end" time that produces a dependent argument needed in the result equation. The process repeats in this manner until the insertion of an equation that has only independent arguments and has not already been assigned to another path. This last-chosen equation becomes the first equation of the path. Paths are formed in this manner until all the equations have been chosen.

The partitioning algorithm is concerned not only with when equations can end but also with when they must end to keep within the specified update time and simulation time step. The minimum number of processors needed for a given numerical simulation depends on the maximum allowable update time, which must be specified prior to packing. The simulation time step is usually based on the requirements of stability and dynamic accuracy.

The packing algorithm calls for processors as needed and inserts paths generated by the partitioning algorithm. When a processor is selected, the path with the longest calculation time is inserted. Next, the unpacked paths related to paths already in the processor are tested and inserted if they fit according to a hierarchy of relationships between the equations in the packed and unpacked sets. When no other paths can be inserted into a processor, another processor is called for.

This work was done by Dale J. Arpasi and Edward J. Milner of **Lewis Research Center**. *Further information may be found in NASA TM-87170 [N86-19008/NSP], "Partitioning and Packing Mathematical Simulation Models for Calculation on Parallel Computers."*

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-14634

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.

Frequency Estimation Techniques for High Dynamic Trajectories

Four frequency-estimation techniques are compared by means of analysis and numerical simulations.

This report presents a comparative study of four techniques for estimating the frequency of a sinusoidal signal received in the presence of noise when the transmitter and/or receiver are experiencing very high dynamics. The study bears directly on the processing of signals encountered by Global Positioning System receivers. The four techniques involve an approximate-maximum-likelihood estimator, an extended Kalman filter, a cross-product automatic-frequency-control loop, and a digital phase-locked loop, respectively. In numerical simulations, each technique is applied to the signal from a transmitter maneuvering along a common trajectory; the performance of each is examined to determine its useful operating range, and the performances are compared.

The trajectory is characterized by positive- and negative-going pulses in jerk lasting 0.5 s and having a magnitude of 100 g/s (where g = normal Earth gravitational acceleration, ~9.8 m/s), separated by a constant acceleration lasting 2 s. A mathematical model is developed for the received signal, which is frequency modulated by the Doppler effect of this trajectory. The trajectory-modulated signal is assumed to be accompanied by zero-mean, stationary Gaussian noise, the bandwidth of which greatly exceeds that of the signal but is otherwise regarded as narrow. The in-phase and quadrature signals are assumed to be sampled and sent to digital accumulators, the outputs of which are modeled. An equation for the statistics of the samples is also derived.

Next, the frequency-estimating algorithms are described. The maximum-likelihood estimates of the parameters of the signal (amplitude, frequency, and phase) are those values that simultaneously maximize the conditional joint probability density of the observation vector, conditioned on the parameters of the signal. For each estimate, the observation vector consists of consecutive samples obtained during an interval that is short compared to the characteristic time scale of the variations in the trajectory.

The maximum-likelihood estimator provides the average values of the parameters after processing a large number of samples. In contrast, the extended Kalman filter yields an instantaneous estimate after each new sample based on the latest sample and previous estimates. In the cross-product automatic-frequency-control loop, a frequency discriminator tracks the received frequency, and its output is a cross product of two consecutive pairs of in-phase and quadrature samples. The phase-locked loop is a fifth-order digital loop, which was chosen because it can track linear variations in frequency with zero steady-state error.

A mathematical model was developed for each case and used in the simulation with the trajectory-modulated signal. The maximum-likelihood approach was found to attain the lowest loss-of-lock threshold (23 dB-Hz), as well as the lowest root-mean-square estimation errors above threshold. Although the performance of the extended Kalman filter was somewhat worse in both respects, it was able to operate with lower frequency-estimation errors near threshold. The digital phase-locked loop performed well above threshold but could not maintain lock reliably below about 26 dB-Hz. The threshold for the cross-product automatic-frequency-control loop was somewhat lower than for the phase-locked loop, but its estimation errors above threshold were the greatest of the four algorithms. In general, the performance of an algorithm in terms of the probability of loss of lock and the estimation error depends on the severity of the dynamics and on the extent to which the parameters of the signal-processing system can be matched to the temporal characteristics of the trajectory.

This work was done by V. A. Vilnrotter, S. M. Hinedi, and R. Kumar of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "A Comparison of Frequency Estimation Techniques for High Dynamic Trajectories," Circle 101 on the TSP Request Card. NPO-17695*

Write 50,000 Lines Of Program Code Or Call One Toll-Free Number*

For Signal Processing Software, your best call is ILS.®

You can write DSP software until you're blue in the face, or try using competing software products. But it boils down to this: today, there's only one software package with the designed-in capability to integrate data acquisition with your signal processing requirements. That package is ILS, the world standard.

Additionally, ILS is supported on five popular workstations: VAX, Masscomp, Apollo, Sun and the PC/PS-2 series (and compatibles).

Network Consistency

If you have a networked mix of systems, ILS presents a consistent file and user interface . . . no relearning is required as users switch from one workstation to another, and they have a choice of a menu interface or a command-line interface.

Unmatched DSP Functionality

No other software package gives you so many signal processing options . . . without you having to write a single line of code! These include waveform display and editing, digital filtering, spectral analysis, pattern classification, data manipulation and speech processing. ILS Fortran source code is available for custom applications.

For these reasons, ILS is in use at more than 2,000 sites in 40 countries, working in such areas as speech processing, noise and vibration, biomedical research, radar and sonar, communications and more.

Remember too, that no software developer is more committed to customer support and satisfaction than Signal Technology. For details, or for a free, no-obligation ILS demonstration tape, call toll-free: **800-235-5787.**

ILS®

STi Signal Technology Inc

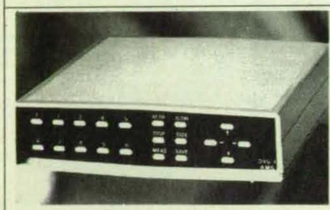
5951 Encina Road, Goleta, CA 93117
(805) 683-3771 (800) 235-5787
Telex 650-280-1641
FAX (805) 967-0871

*Outside the USA, call 805-683-3771 or your closest ILS representative shown below.

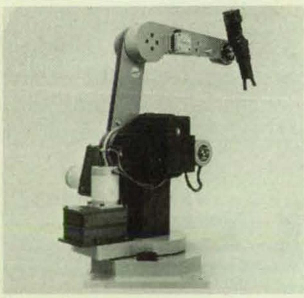
• **Australia** Measurement Technology Pty. Ltd. Tel. (03) 580-8333 FAX (03) 580-9654 • **France** SACASA Tel. 011-33-1-69.07.78.02 FAX 011-33-1-69.28.71.71 Telex 603649 • **Germany (FRG) & Austria** Stemmer Elektronik GMBH Tel. 011-49-89-809020 FAX 011-49-89-8090216 Telex 5216425 • **Hong Kong** Rikei Corporation H.K., Ltd. Tel. 5-865-5393 FAX 5-865-5376 Telex 86256 • **India** Sapphire Systems and Services Pvt., Ltd. Tel. (022) 231040 FAX (022) 2040017 Telex 11-5291 • **Israel** McKit CAD/CAM Systems, Ltd. Tel. (03) 540-3729 FAX (03) 540-3707 • **Italy** Morra Ingegneri E Consulenti Tel. 011-39-1-72422577 FAX 011-39-1-72431243 Telex 215415 • **Japan** Rikei Corporation Tel. (03) 345-1411 FAX (03) 344-3949 Telex 24208 • **Netherlands, Belgium, Luxembourg** Multihouse T.S.I. b.v. Tel. 011-31-20-104949 FAX 011-31-20-106940 Telex 57768 • **People's Republic of China** Imag Industries, Inc. Tel. 868721 ext. 4017 Telex 20028 • **Republic of China (Taiwan)** Hermes Epitek Corporation Tel. (02) 709-7606 FAX (02) 700-6484 Telex 26794 • **Republic of Korea (South Korea)** Sam Hong Commerce Corporation Tel. (02) 774-1397 FAX (02) 756-9954 Telex 23231 • **Spain** Instrumatic Espanola, S.A. Tel. 011-34-1-4558112 FAX 011-34-1-5971077 Telex 46277 • **Sweden, Finland, Norway** Acoutronic AB Tel. 011-46-8-6644080 FAX 011-46-8-152843 Telex 12442 3K Systems AB Tel. 011-46-8-7647240 FAX 011-46-8-982588 Telex 15559 • **Switzerland** Instrumatic AG Tel. 011-41-1-7231410 FAX 011-41-1-7211268 Telex 826801 • **United Kingdom, Ireland** Logica Space & Defence Systems, Ltd. Tel. 011-44-1-637-9111 ext. 4073 FAX 011-44-932-66184 Telex 267413

New on the Market

Lano Lube, a 100% pure anhydrous **lanolin** developed by Flexbar Machine Corp., Central Islip, NY, coats gauges and gauging accessories, protects parts from rusting, and shields instruments from coolant contact. The lubricant acts as an anti-seize agent for screws, gears, and micromanipulators, and as a release agent for molds and die cavities. A two-ounce tube sells for $4.25.
Circle Reader Action Number 800.

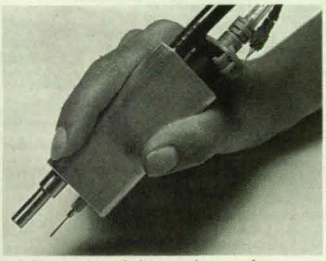


The OVG-1 high-resolution **graphics display generator** from Advanced Micro Systems Inc., Hudson, NH, can superimpose text, lines, circles, crosses, and icons on standard composite video signals, such as those generated by closed-circuit TV cameras. The compact unit features four selectable image displays (frames), a nonvolatile memory that retains all display information, and signal outputs for image processing. Applications include robotics, pattern recognition, and targeting systems.
Circle Reader Action Number 794.



ST Monforte Robotics, Trenton, NJ, has developed an anthropomorphic **robot system** suitable for light industrial work and educational training. It features a 24" arm extension, 0.0003" position resolution, 2.4 pounds of payload, and wrist roll and pitch. The system is comprised of a five-axis "R12" robot, pneumatic operated gripper, K11R robot motion controller, IBM-compatible host PC computer/controller, software, cables, and operation manuals. Industrial applications include gluing, pick and place, loading, inspection, material handling, and assembly.
Circle Reader Action Number 780.

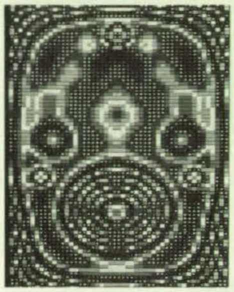
Advanced Graphics Software, Sunnyvale, CA, is offering a **free demonstration disk of SlideWrite Presenter™**, a graphics package for IBM PCs and compatibles that enables users to create slide show presentations on the computer screen. The software combines PCX file images from graphics programs (such as SlideWrite Plus™ and Lotus Freelance™), paint programs (including PC Paintbrush™), and color and black and white scanners. In addition, a full-featured screen capture program, Shoot from Inner Media Inc., is included to capture text and graphics screens from other programs such as Lotus 1-2-3™ and WordPerfect™. SlideWrite Presenter will display any standard PCX file it receives, adjusting the image size if necessary.
Circle Reader Action Number 792.



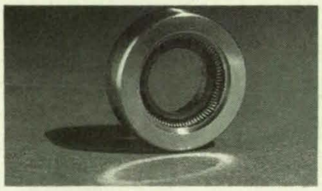
A dispensing/ultraviolet **curing system** for labor-intensive applications is now available from Efos Inc., Mississauga, Ontario. The compact handheld unit houses standard 10cc syringes and 5mm diameter liquid light guides. To ensure maximum safety, the ultraviolet light activation is controlled by a switch on the hand piece.
Circle Reader Action Number 798.

Eclectic Products Inc., Carson, CA, has introduced the E-6000™ **adhesive/sealant** for plant, marine, automotive, and fleet maintenance applications. E-6000 bonds to highly porous surfaces such as cinder blocks, and to nonporous surfaces such as glass and metals. Because it is abrasion-resistant, E-6000 can be used on surfaces subject to excessive wear and it retains its adhesive and sealant properties even when submerged under water. E-6000 can stretch to 600% of its length, making it ideal for use between surfaces that have different coefficients of expansion. The product is available in tubes, cartridges, one and five gallon pails, and 55 gallon drums.
Circle Reader Action Number 786.

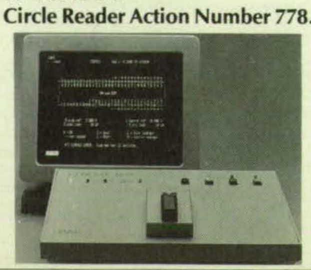
Cellular Automata Laboratory (CA Lab™) software from Autodesk Inc., Sausalito, CA, **produces real-time, animated graphics** that simulate physical and biological phenomena. The software, which repeatedly updates an initial pattern according to a preselected rule, can simulate complex processes such as turbulence, heat flow, erosion, and the mixing of gases. Priced at $59.95, CA Lab runs on IBM PC/XT/AT, PS/2, or compatible computers.
Circle Reader Action Number 790.



American Variseal, Broomfield, CO, has developed a new metal-encased **rotary shaft seal** capable of handling pressures up to 1000 psi. Called the Varilip HP, the seal contains a spring-energized sealing element made of self-lubricating Turcite® PTFE compounds for low friction, wide temperature service, high surface speed, wear resistance, and fluid compatibility. Industrial applications include rotary joints and hydraulic pumps and motors.
Circle Reader Action Number 782.



A portable **ATE system** from Oliver Advanced Engineering Inc., Glendale, CA, screens a variety of semiconductor components for light, moderate, or severe electrostatic discharge (ESD) damage. The system can test PMOS, NMOS, CMOS bipolar, and ECL devices using an internal database of DC test parameters. It can store up to 25,000 device tables in non-volatile memory, or the operator can use the Learn command to build an ESD parameter table from a known good device in less than ten seconds. An optional parametric editor enables the user to modify the DC test parameters once they have been loaded into RAM.
Circle Reader Action Number 778.



Burr-Brown's new ZPP1001 and ZPP2001 **analog-to-digital and digital-to-analog converters** are the first high-performance I/O devices designed specifically to connect with a general-purpose DSP microprocessor. The "Zero-Chip" interface reduces design time and circuit complexity, allowing the user to concentrate on DSP solutions, not DSP implementation details. Current models will interface directly with the AT&T WE DSP16 and DSP32 microprocessors; others will be available for the Motorola 56000 and Texas Instruments TMS320C25. Applications include speech processing, SONAR, ultrasonics, machine health monitoring, medical instrumentation, and professional audio.
Circle Reader Action Number 788.

The Modgraph GX-2241 is a **color graphics/alphanumeric PC terminal** for users who require complete compatibility when operating in multiple environments. Designed for DEC, TEK, ANSI, ASCII and PC-Term environments, the GX-2241 meets the needs of scientific and engineering users in CAD/CAM/CAE applications where multiple hosts are in use and high-resolution color is needed. Features include 800 × 500 resolution and a 14" color display.
Circle Reader Action Number 784.

Mechanical Technology Inc., Latham, NY, has introduced the MTI-2000 **Fotonic™ Sensor** for high-precision, noncontact measurement of displacement and vibration as well as nonintrusive modal analysis. Its interchangeable fiber optic probes are immune to electromagnetic interference and operate on most any type of surface, including metallic, composite, plastic, and glass. The MTI-2000 provides submicroinch resolution and frequency response up to 200 kHz; dual channel capability for simultaneous measurements at two locations; and display readout in engineering units, eliminating the need to convert volts to displacement units or to double integrate acceleration signals.
Circle Reader Action Number 796.

New on the Market

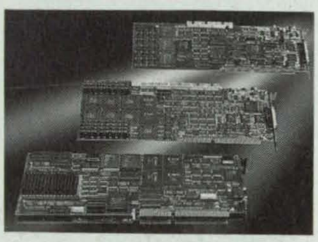
Dimension Technologies Inc., Rochester, NY, has developed a **flat-panel computer monitor** that enables users to view in 3D without wearing special glasses. The monitor, which delivers black-and-white displays generated by any IBM PC, produces its 3D effect by means of a special illumination panel placed behind a standard transparent liquid crystal display. The illuminator allows the user's left eye to see one image while the right eye is viewing a different angle of the same scene. The brain instantly combines the two into a single image with vivid perceived depth.
Circle Reader Action Number 770.

CHAM of North America Inc., Huntsville, AL, has introduced a new **turnkey system for computational fluid dynamics**. The company's Flowstation 88000 features a workstation based on the Motorola 88000 microprocessor and is packaged with PHOENICS, CHAM's general-purpose software for the simulation of fluid flow, heat transfer, combustion, and chemical reactions. Flowstation is also offered as an 80386-based workstation which can be field-upgraded to the more powerful 88000-based system.
Circle Reader Action Number 772.

A new **A/D converter** from Prema Precision Electronics Inc., Montclair, CA, offers 25-bit resolution, linearity deviations of less than 0.0001 percent, typical temperature coefficients of 0.5 ppm/C, and serial data output. Its unipolar and bipolar applications include weighing systems, precise data collection, and measuring instruments in the research field. Prema's A/D converter is priced at $360.
Circle Reader Action Number 776.

A noncontact **thickness measurement system** that uses optical technology to achieve up to 0.001" accuracy, with virtual immunity to color and reflectivity changes, is offered by Spectronics Inc., Beaverton, OR. The system's optical sensors are 100% solid-state, resulting in a compact design capable of up to 500 Hz sampling rates.
Circle Reader Action Number 774.

The Parallel Inference Machine™ (PIM) from Flavors Technology Inc., Amherst, NH, is billed as the first **supercomputer** designed for real-time applications in control and simulation. The computer combines the software productivity and natural parallelism of expert systems with a new multiprocessor that delivers the power demanded in applications such as factory automation, process control, command and control, and signal and image understanding. The largest PIM can examine and fire one million rules per second, 2000 times the performance of an expert system workstation.
Circle Reader Action Number 768.

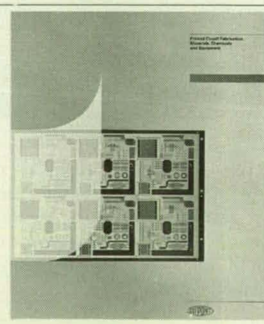


Imaging Technology Inc., Woburn, MA, has introduced a new line of **AT-based frame grabbers** with processing and memory expansion. Targeted at OEMs and system integrators, the VISION-plus-AT family provides a range of image processors with mid-level capabilities for applications in image analysis, machine vision, and scientific research. Initially, the product line consists of (top to bottom) the Overlay Frame Grabber, a single-board product featuring 8-bit digitization and pseudocolor display; the AT Color Frame Grabber, a single-slot frame grabber for 24-bit true color image processing; and the Advanced Frame Grabber, a two-slot image processor with high-level functions such as variable scan and onboard real-time pipeline processing.
Circle Reader Action Number 766.

New Literature

The RF/Microwave Fiber Optic Link Design Guide from Ortel Corp., Alhambra, CA, discusses link performance characteristics, applications, and advantages. Written for microwave engineers and designers, the guide uses formulas and diagrams to illustrate how to design an analog system. It contains a glossary and an appendix that describes typical features of photodiode receivers.
Circle Reader Action Number 708.

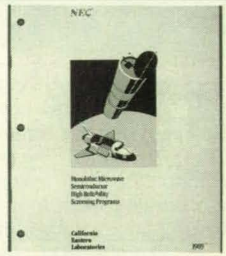
A free technical guide from IOtech Inc., Cleveland, OH, spotlights new **IEEE 488 interface products,** including the first Sun and DEC SCSI to IEEE controllers, an advanced IEEE bus analyzer, and WorkBench — a Macintosh test and measurement software program. The guide contains sections on IBM PC and Macintosh IEEE products, Sun and DEC workstation IEEE products, serial to IEEE converters and controllers, analog and digital I/O to IEEE converters, and IEEE bus analyzers/extenders/buffers/ converters. Each section includes specifications, software command summaries, programming examples, and block diagrams.
Circle Reader Action Number 702.



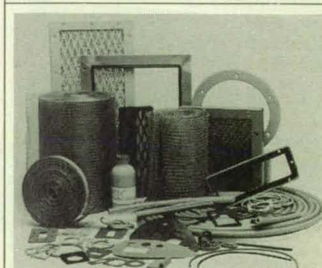
Du Pont Electronics has introduced the VALU System, an **automated lamination unit** that allows printed circuit board fabricators to apply a uniform, defect-free solder mask coating to printed wiring boards. Described in a new brochure from Du Pont, the VALU System combines the advantages of dry film solder mask and liquid technology. The brochure illustrates the system's ability to encapsulate high-density circuitry and tent via holes with a uniform coating.
Circle Reader Action Number 712.

"Diffraction Notes," a newsletter from Lambda Research Inc., Cincinnati, OH, describes the use of **x-ray diffraction techniques** for the simultaneous determination of residual stress and hardness in steels. The newsletter also reports an order of magnitude improvement in the rate at which electropolishing can be performed in a variety of materials, enabling stress-free removal of material to far greater depths than previously practical.
Circle Reader Action Number 714.

The CAD Utility Company, Chatsworth, CA, has published a catalog of third-party **CAD/CAE software,** including database and netlist translators, partlist generators, file format converters, thermal analysis library management software, and design rule checkers.
Circle Reader Action Number 706.



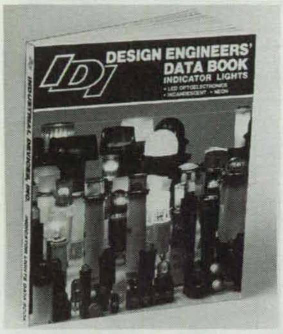
A new brochure from California Eastern Laboratories Inc., Santa Clara, CA, describes screening and qualification procedures for NEC **silicon and GaAs monolithic microwave integrated circuits (MMICs)**. The brochure provides reliability data for both chips and packages in military and industrial grades. Qualification of the NEC devices is in accordance with MIL-STD-883, Method 5005, including radiation hardness testing and a 5000-hour life test.
Circle Reader Action Number 704.



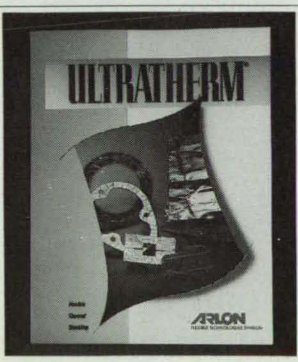
Electro-Kinetic Systems Inc., Trainer, PA, is offering a 52-page catalog of **EMI/RFI shielding and suppression products** for architectural, commercial, financial, industrial, and military applications. Products featured include conductive adhesives, coatings, and elastomers, wire-in-silicone, and knitted wire mesh. The catalog provides specifications, properties, and performance data.
Circle Reader Action Number 710.

New Literature

"Magnetic Cores for Hall Effect Devices," a new brochure from Magnetics, a division of Sprang and Company (Butler, PA), discusses core selection and the effects of an air gap on different magnetic materials in **Hall Effect sensors.** The brochure explains the Hall Effect phenomenon and considers applications such as detector elements in tranducers (converting mechanical motion into electrical signals), magnetometers, and wattmeters.
Circle Reader Action Number 724.

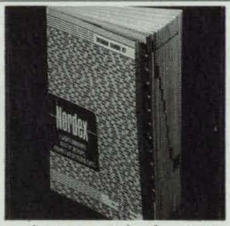


More than 100 high-efficiency **PC board and panel-mount LED indicators, lamps, and modular assemblies** are detailed in a catalog from Industrial Devices Inc. (IDI), Hackensack, NJ. Product categories include 5- and 12-volt LEDs; high-brightness, low-current devices; LED modular assemblies in assorted shapes and sizes; and neon glow lamps. The 224-page publication features engineering data, illustrations, charts, an applications section, and information on IDI's design and custom manufacturing facilities.
Circle Reader Action Number 718.

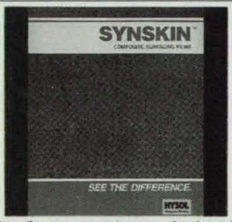


Arlon's Flexible Technologies Division, East Providence, RI, is offering a free brochure on Ultratherm®, a **flexible shielding material** that provides high thermal resistance at a fraction of the weight of traditional stamped metal heat shielding. Ultratherm weighs less than two-tenths of a pound per square foot and is available in thicknesses ranging from .010" to .125" in rolls, sheets, diecut pieces, and thermoformed shapes.
Circle Reader Action Number 720.

A new line of **OEM cooling fans** for computers, printers, and medical equipment is described in a brochure from Canon USA Inc., Lake Success, NY. Designed for quiet operation, the fans feature DC brushless motors with ball bearings, safety finger-guards, and full protection against faulty power supply connections and mechanical locking. They vary in size from 1.57" × 1.57" to 4.72" × 4.72" with a 23 to 44 db noise level range.
Circle Reader Action Number 722.



A free design guide from Nordex Inc., Danbury, CT, features over 400 pages of standard **precision instrument components and assemblies.** The guide provides a blueprint of each component detailing its material, finish, and hardness, as well as technical specifications such as angular misalignment, planar misalignment, and stall torque capacity.
Circle Reader Action Number 716.

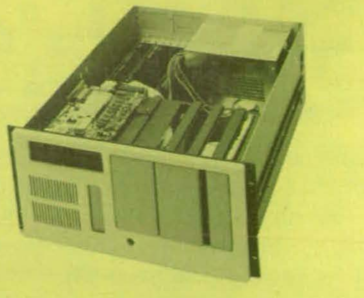


Synskin® **composite surfacing films** are described in a new brochure from the Dexter Corp., Pittsburg, CA. Conventional surfacing films are lightweight epoxy film adhesives designed for structural bonding and adapted secondarily for a surfacing application. In contrast, Synskin is specifically formulated to solve honeycomb core mark-through, porosity, and core crush problems, and provides a smooth, paintable surface with little or no secondary preparation. Synskin is compatible with a wide variety of composite matrix resins and surfaces, and protects composites during machining, routing, and drilling.
Circle Reader Action Number 726.

Subject index of all 1989 Briefs

The following pages contain a cross-referenced index of all technical briefs published in NASA Tech Briefs during 1989 (Volume 13). The blue listings refer to briefs appearing in this issue. You can receive more information on these briefs by requesting the Technical Support Package (TSP) referenced at the end of the full-length article. For information on briefs featured in previous issues of volume 13, contact NASA's Scientific and Technical Information Facility (see page 24).

A



RACKMOUNT COMPUTERS

286/386 computers configured with motherboard or passive backplane. Models accept up to six drives and others offer built-in 14" color or 9" mono monitor. We customize to meet your system requirements for adapter cards, floppy and/or hard drives, etc.

RECORTEC, INC.
1290 Lawrence Station Road
Sunnyvale, CA 94089 800/729-7654

Circle Reader Action No. 676

Pressure, Flow & Temp. Switch

RELIABILITY

Specify Hydra-Electric

If you have special requirements, we can probably save you time and money by satisfying them with one of our standard models. They maintain their accuracy over many thousands of cycles. The "snap-action" disk spring eliminates most problems of aerospace pressure switches. Ask for your copy of the H-E catalog.

Hydra-Electric Co.
3151 Kenwood St., Burbank, CA 91505
(213) 843-6211 89-1

Circle Reader Action No. 427

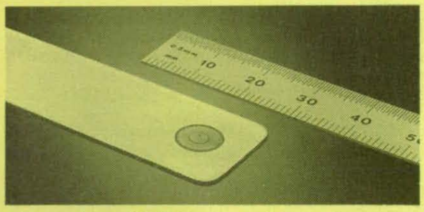
FREE! 130 Page Catalog

"Optics for Industry"

Free 130 page product catalog from Rolyn, world's largest supplier of "Off-the-Shelf" optics. 24-hour delivery of simple or compound lenses, filters, prisms, mirrors, beamsplitters, reticles, objectives, eyepieces plus thousands of other stock items. Rolyn also supplies custom products and coatings in prototype or production quantities. **ROLYN OPTICS Co.,** 706 Arrowgrand Circle, Covina, CA 91722-2199, (818)915-5707, FAX (818)915-1379

Circle Reader Action No. 551

ARE YOU STILL TRYING TO MEASURE VERY THIN GAPS THE HARD WAY?



Capacitec HPS Series of thin (back to back) sensors can measure gaps as small as 0.025" (.635mm) inboard 84" (2133.6mm) with accuracies of 0.0003" (7.6μm), without scratching delicate surfaces.

Capacitec
P.O. Box 819, 87 Fitchburg Rd., Ayer, MA 01432 U.S.A.
Tel. (508) 772-6033 • Fax (508) 772-6036

Circle Reader Action No. 593

3-Volume Set 1990

IC MASTER

Vol 1 - Functional guide to 80,000 standard ICs including 14,000 NEW devices.
Vol 2 - 1,000+ manufacturers tech data pages.
Vol 3 - Systems level guide to Custom / Semi-custom ICs and Design Automation tools.

Available February 1990. Pre-paid orders received by 1/31/90 - $120, after 1/31/90 - $145. (Taxable in NY, MA, IL, CA)

10 Day Money Back Guarantee

Send Check with P.O. To:
ICM / Hearst Business Communications, 645 Stewart Ave., Garden City, NY 11530, Att: Marie Botta
(516) 227-1300 • FAX (516) 227-1901

VISA and MC welcome

Circle Reader Action No. 596

Acquiring data on a Mac?

Now you can examine and compare lengthy data files — and find out what your data really means!

WavEdit™

Waveform editing software for reviewing, overviewing and editing data recorded with acquisition programs and equipment running on Macintosh® computers.

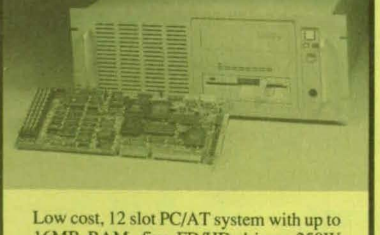
Full-function demo: $5

World Precision Instruments
375 Quinnipiac, New Haven CT 06513
203-469-8281

Circle Reader Action No. 585

---

25 MHz 80386 Computer
For 19" Rack Mount Use



Low cost, 12 slot PC/AT system with up to 16MB RAM, five FD/HD drives, 250W power supply, and 0° to 50°C operation.

SMT 619-744-3590

1080 Linda Vista Dr., San Marcos, CA 92069

Circle Reader Action No. 547

Climb aboard the world's best fighter aircraft - the F-16 Falcon, F-15 Eagle, and F-111 - for high flying adventure! This action-packed VHS videotape features real combat footage. $19.95 each plus $3.00 postage. NY residents add sales tax.

Name ______________
Address ______________
City ______________
State ______________ Zip ______
Total enclosed: ______________
for ________ Jet videos.

Send check or money order to:
NASA Tech Briefs, Dept. F
41 East 42nd St.,
New York, NY 10017

DATA ACQUISITION

LOW COST, 100% U.S.A MADE COMPATIBLE WITH

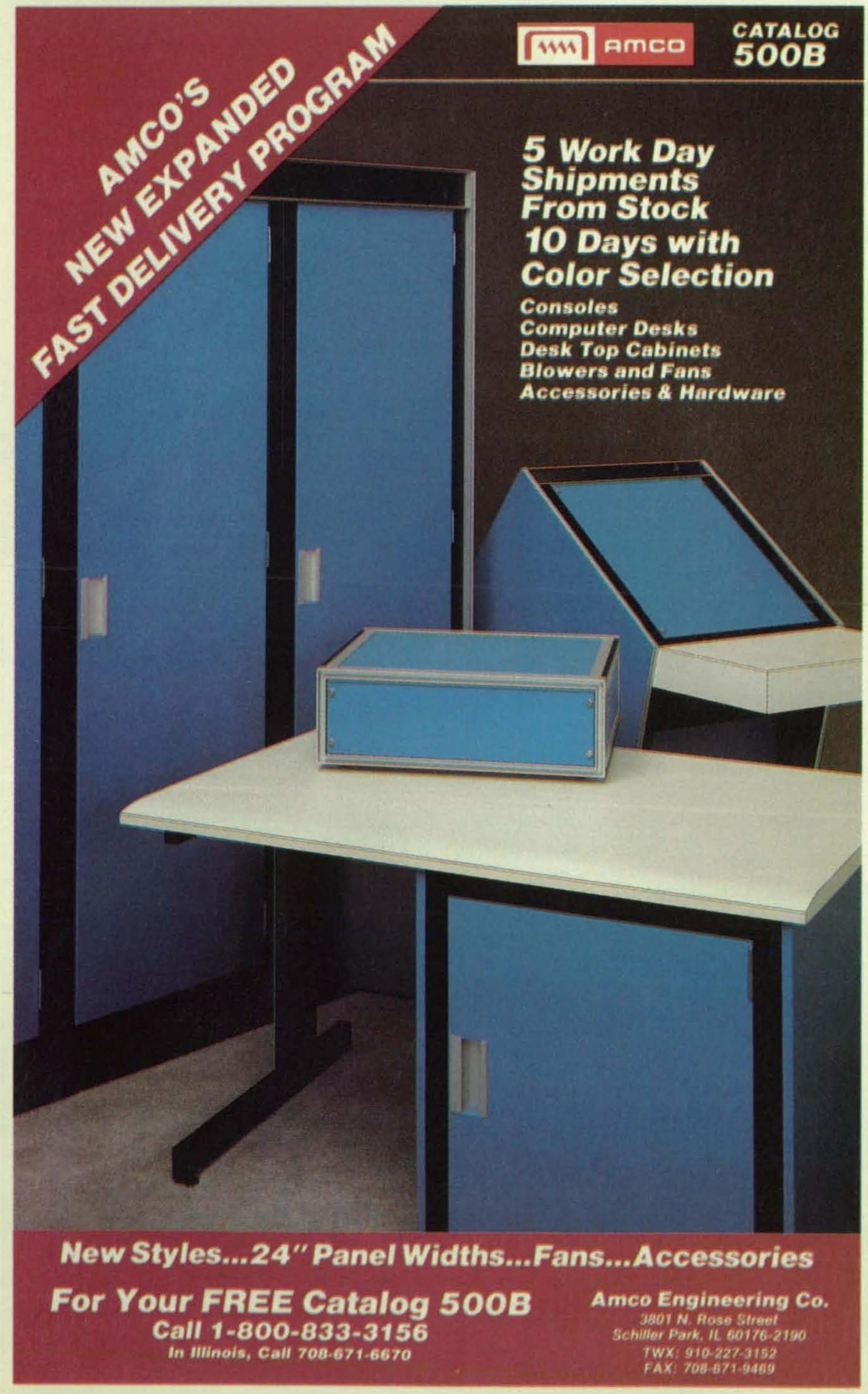
MetraByte, Data Translation, National

NEW!

Computer Boards, Inc.
44 Wood Avenue, Mansfield, MA 02048
(508) 261-1123 FAX (508) 261-1094

Circle Reader Action No. 682

1989 Annual Subject Index


AMCO'S NEW EXPANDED FAST DELIVERY PROGRAM
AMCO
CATALOG 500B
5 Work Day Shipments From Stock
10 Days with Color Selection
Consoles
Computer Desks
Desk Top Cabinets
Blowers and Fans
Accessories & Hardware
New Styles...24" Panel Widths...Fans...Accessories
For Your FREE Catalog 500B
Call 1-800-833-3156
In Illinois, Call 708-671-6670
Amco Engineering Co.
3801 N. Rose Street
Schiller Park, IL 60176-2190
TWX: 910-227-3152
FAX: 708-671-9469

1989 Annual Subject Index

Sometimes overnight is absolutely, positively too late.

We're not knocking the other guys, but sometimes you need to get it there right away. The very same day. Today, not tomorrow.

With TWA's Next Flight Out® delivery service, you're in business.

Even as you read this, TWA planes are about to take off. We can make sure your small package is on the next flight out to any one of over 100 U.S. cities. And we'll deliver it door-to-door or airport-to-airport. Same day. Seven days a week.

We'll give you our money-back guarantee and Frequent Flight Bonus miles, too (exciting details when you call).

We also deliver next day to Europe and second day to the Middle East.

So for anything up to 70 pounds domestic and 50 pounds international, just call the 800 number. It's that easy. It's *not* that expensive. And most of all, it's fast —very, very fast.

1-800-638-7380

For information or immediate pick-up, ask for Agent 901.

Circle Reader Action No. 438

1989 Annual Subject Index

H

I

1989 Annual Subject Index

1989 Annual Subject Index

Advertiser's Index

(continued on page 98)

NASA 1990

(continued from page 22)

Enhancement Complex, these investigators work together in almost 40 research cells performing studies in coatings, insulations, composites, robotics, welding, tooling, metal cutting, forming, and other fields. The results of these studies are available to private industry through the NASA technology transfer program. ☐

Stennis: Testing Advanced Technologies

Roy Estess, Director
Stennis Space Center
Mississippi

During 1990, the Stennis Space Center will maintain its role as NASA's prime installation for static firing of large rocket propulsion systems. The center will continue to operate and maintain dedicated test support facilities including a high-pressure industrial water facility, an emergency power generating system, high-pressure gas facilities, propellant and cryogenic facilities, meteorological and acoustic facilities, an engine plume diagnostic test facility, and support laboratories such as the Non-Destructive Test and Evaluation Laboratory and the Gas Materials and Analysis Laboratory.

The Advanced Propulsion Instrumentation Technology and Propulsion Test Technology initiative, conceived during 1988, focuses on applications involving ground test operations, engine plume diagnostics and health monitoring, leak detection, and propulsion data systems. One invaluable spinoff of this initiative has been the design and construction of an engine Diagnostics Test Bed Facility (DTF) providing a plume source and analysis capability for rocket plume diagnostics research. Initial observations of the space shuttle main engine (SSME) plume during testing at Stennis showed occasional flarings of different colors, some of which coincided with catastrophic failure. These observations led to the hypothesis that the plume of a healthy engine could provide a characteristic spectral signature, while an anomalous signature would be seen due to the presence of abnormal wear. The development of advanced techniques to monitor performance of the SSME and future

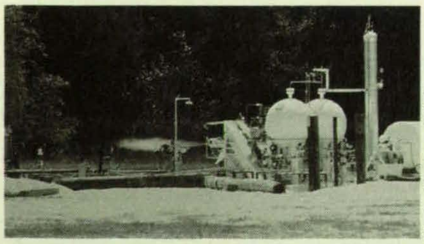


Photo Courtesy NASA

The Stennis Diagnostic test Bed Facility accomplishes one of the hundreds of exhaust plume spectroscopy experiments conducted thus far.

systems during testing, certification, and flight is of primary importance.

The DTF houses a 1200 pound thrust rocket utilizing liquid oxygen as an oxidizer and gaseous hydrogen or methane as a fuel. The thruster is fitted with a plume seeding device which allows metallic salt solutions to be precisely injected directly into the combustion chamber and provides seeding accuracies to the order of parts per million. Another DTF innovation is that many firing operations are controlled remotely by state-of-the-art computer hardware and software. Graphics control software allows for interactive valve actuation through "soft switches" displayed on the monitor. Microcomputer data acquisition provides operational data turnaround within five minutes of actual firing.

For many years, the use of hydrogen has posed a significant problem for NASA. The only means to insure safety in operations involving hydrogen storage, transfer, and use has been to operate under the assumption that explosive concentrations were present. As a solution, NASA required a fast, reliable hydrogen detection system capable of functioning in a harsh and dynamic environment. Commercially available systems were examined and found to suffer from inadequacies in speed, accuracy, reliability, or compensation for changes in the gaseous background. In response to this need, Stennis has designed and developed an advanced hydrogen detection system. This was accomplished through the development of a compact signal processing computer integrated with the best known commercially available transducer. The final product, dubbed the Smart Hydrogen sensor (SHS), has undergone rigorous hydrogen detection testing at the DTF and early indications are that the system will meet or exceed design specifications. The SHS is presently in a patent-pending status.

In addition to engine test activities, Stennis will continue to play a key role in the nation's space and environmental research efforts. Technology development and remote sensing activities will proceed through initiatives undertaken by a staff of senior research scientists and engineers involved in fields such as forestry, geology, botany, oceanography, zoology, anthropology, computer science, mathematics, and physics. These professionals are developing the tools and techniques required for humans to more effectively manage the environment. This includes scientific investigation, remote sensor development, and data-processing and image analysis technique development.

In support of remote sensing activities, the center will continue to operate an Advanced Sensor Development Laboratory (ASDL) for the purpose of creating low-noise, high resolution remote sensing instrumentation. Among the ASDL activities scheduled for 1990 are upgrades to the Thermal Infrared Multispectral and Calibrated Airborne Multispectral Scanners, completion of the Airborne Multispectral Pushbroom Scanners, and development of an ice detection system. ☐

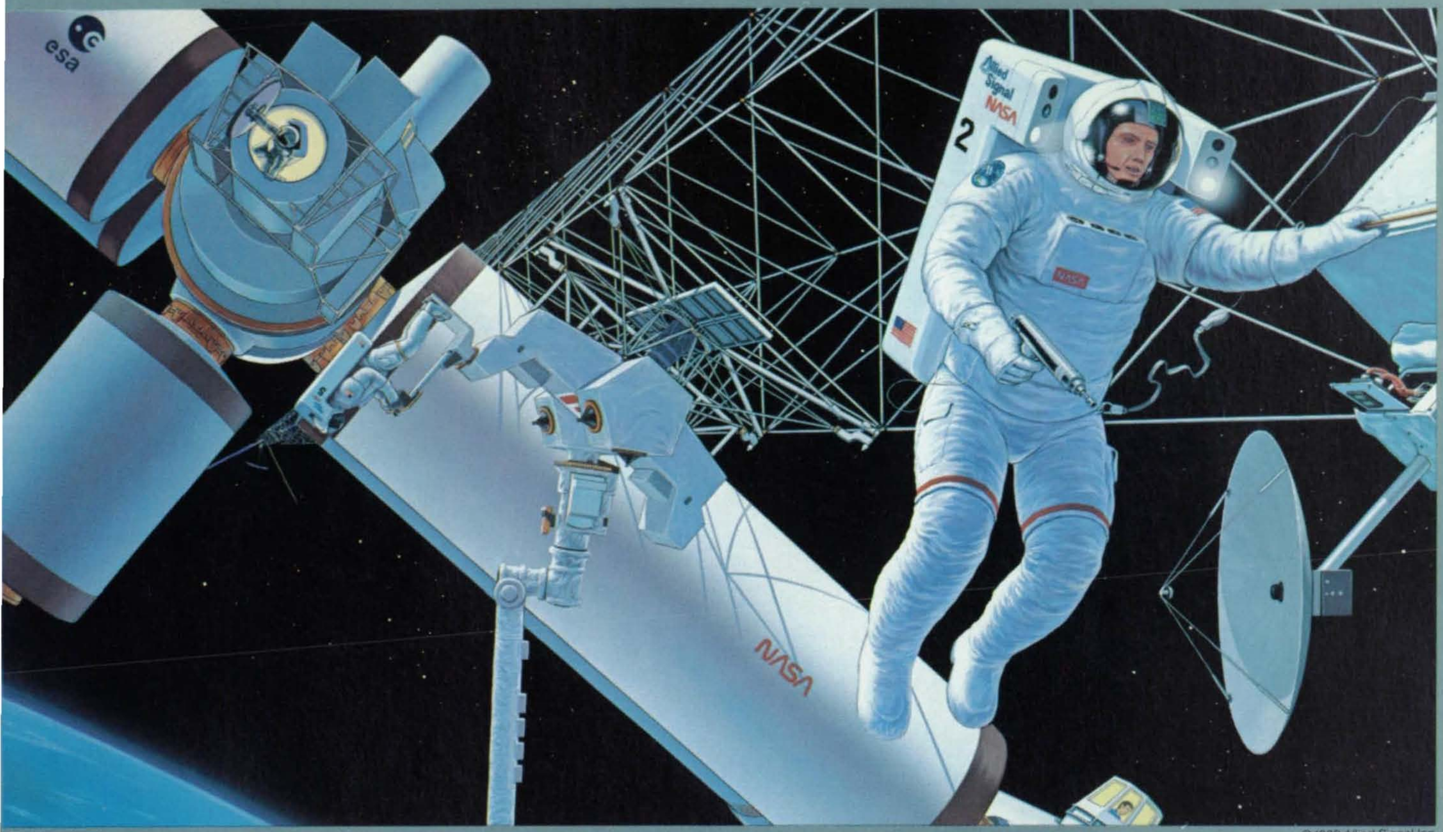
Advertiser's Index

(continued from page 97)

***RAC** stands for **Reader Action Card.** For further information on these advertisers, please circle the RAC number on the Reader Action Card elsewhere in this issue. This index has been compiled as a service to our readers and advertisers. Every precaution is taken to ensure its accuracy, but the publisher assumes no liability for errors or omissions.

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright © 1989 in U.S., is published monthly by Associated Business Publications Co., Ltd. 41 E. 42nd St., New York, NY 10017-5391. The copyrighted information does not include the individual Tech Briefs which are supplied by NASA. Editorial, sales, production and circulation offices at 41 E. 42nd Street, New York, NY 10017-5391. Subscriptions for non-qualified subscribers in the U.S., Panama Canal Zone, and Puerto Rico, $75.00 for 1 year; $125.00 for 2 years; $200 for 3 years. Single copies $10.00. Remit by check, draft, postal or express orders. Other remittances at sender's risk. Address all communications for subscriptions or circulation to NASA Tech Briefs, 41 E. 42nd Street, New York, NY 10017-5391. Second-class postage paid at New York, NY and additional mailing offices.

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



© 1989 Allied-Signal Inc.

EXTRAVEHICULAR ACTIVE WEAR.

WE'RE THE FIRST AND LAST WORD IN EXTRAVEHICULAR ACTIVITY. WITH A PIONEERING PAST AS NASA'S ORIGINAL PORTABLE LIFE SUPPORT SYSTEM SUPPLIER. AND CONTINUING LEADERSHIP IN ENVIRONMENTAL CONTROL/LIFE SUPPORT SYSTEM TECHNOLOGY.

WE'VE WON THREE SPACE STATION FREEDOM PORTABLE LIFE SUPPORT SYSTEM TECHNOLOGY CONTRACTS. DEVELOPING EFFICIENT NEW SUBSYSTEMS FOR VENTILATION, THERMAL CONTROL AND CO_2 REMOVAL.

NOT ONLY HAVE WE LIVED WITH THIS UNPRECEDENTED NEW TECHNOLOGY FOR SEVERAL YEARS, WE ARE THE PERFECT PARTNER TO TURN IT INTO HARDWARE.

AIRESEARCH LOS ANGELES DIVISION 2525 WEST 190TH STREET TORRANCE CA 90509 (213) 512-5488. WHERE THE ULTIMATE EFFICIENCY IS RELIABILITY.

Allied-Signal Aerospace Company

Circle Reader Action No. 415

Allied Signal