NASA Tech Briefs

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National Aeronautics and
Space Administration
July 1992 Vol 16 Number 7

Transferring Engineering
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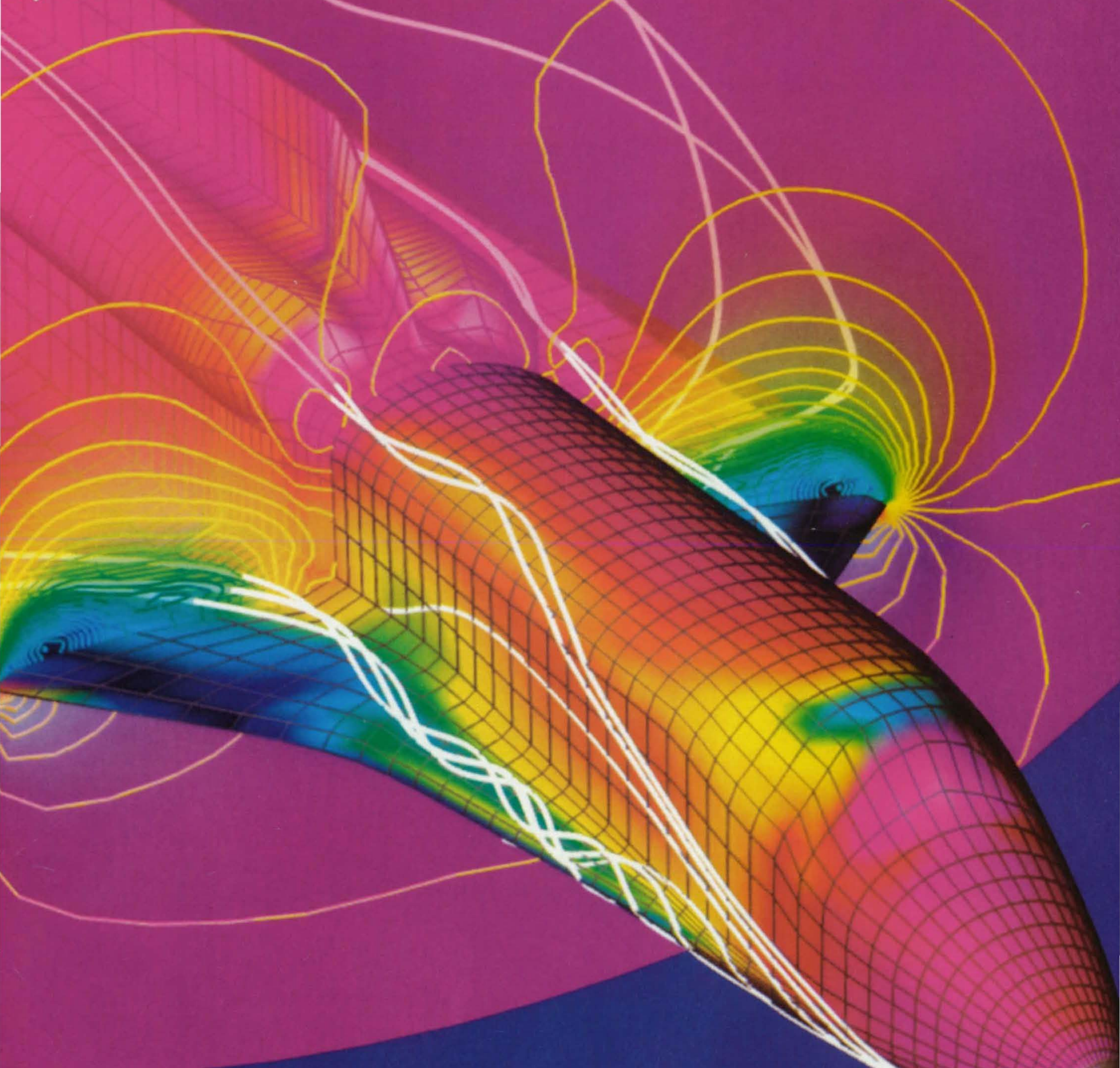

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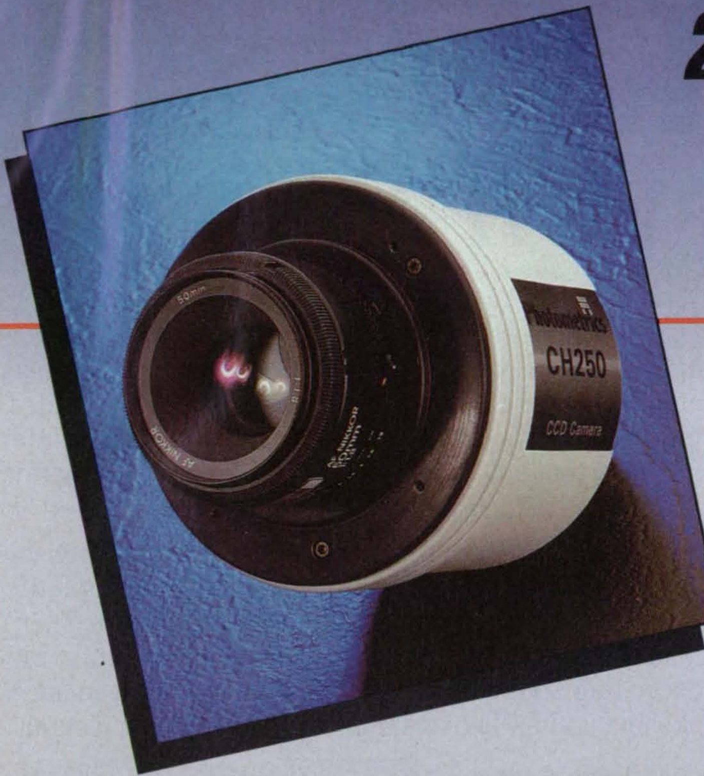
For More Information Circle No. 522

2048 x 2048 Pixel, 12-Bit Digital CCD Camera



Photometrics introduces the world's first **2048 x 2048 pixel CCD camera** with a direct digital output and 12 bits per pixel (4096 gray levels). This ultra-high resolution camera interfaces directly to Macintosh II, 286/386 AT bus computers, or VME-based systems.

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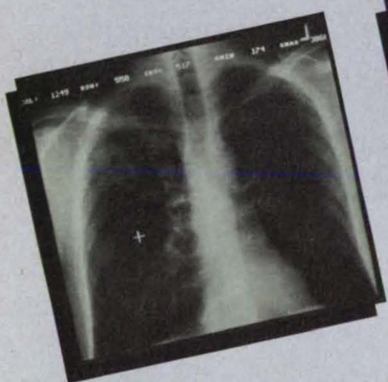
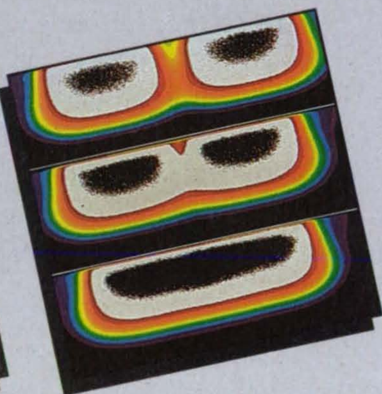
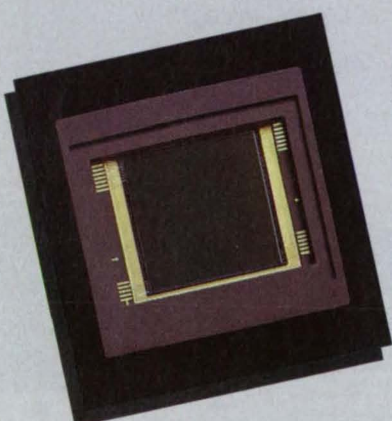
- A scientific-grade CCD image sensor with 2048 x 2048 pixels (Eastman Kodak KAF-4200)
- Thermoelectrically cooled camera head providing 12-bit dynamic range (4096 gray levels per pixel)
- A direct digital interface, plug-in programmable controller for Macintosh II, 286/386 AT bus, or VME computers
- Software for camera control, image acquisition, and calibration





This camera can be used for high-resolution, low light applications including x-ray imaging and densitometry. (Image on right courtesy of the Medical College of Georgia.)



KAF-4200 CCD (2048 x 2048 pixels)

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July 1992
Volume 16 Number 7 ABP BPA

Graphics courtesy Ames Research Center/Sterling Software

NASA is developing an array of software tools to visualize scientific data, making research results easier to understand. One example is the Graphics Animation System (GAS)—detailed on page 68—which animates computational fluid dynamics (CFD) simulations such as the above graphic showing particle traces over a space shuttle orbiter and the cover illustration of shock waves around a shuttle.

SPECIAL FEATURE

TECHNICAL SECTION

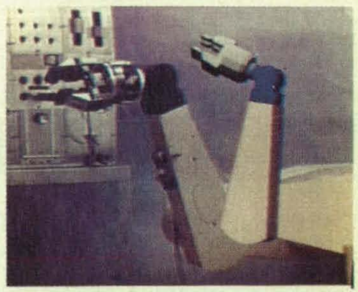
DEPARTMENTS

Graphic courtesy Codonics Inc.

This computer-generated image was output by a state-of-the-art network printer described on page 93.

A simulator created at Jet Propulsion Laboratory would help an operator on Earth to control a robotic worker in low-Earth orbit or on the moon—despite transmission delays—by manipulating a phantom robot that predicts the real robot's movements. See the tech brief on page 32.

Photo courtesy Jet Propulsion Lab



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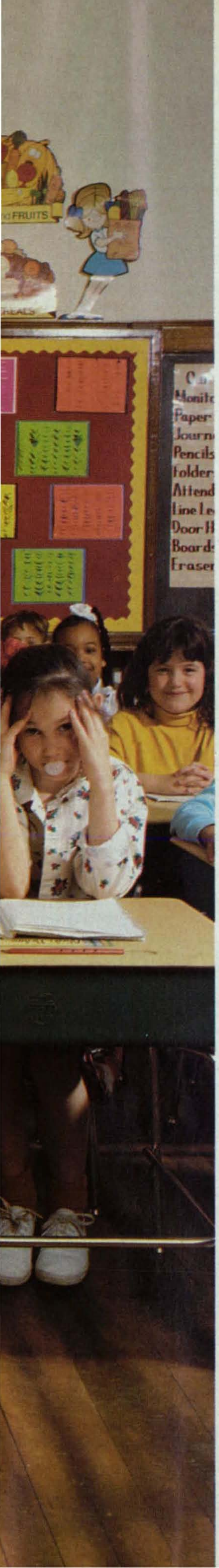

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BV-2000U: S-VHS VCR

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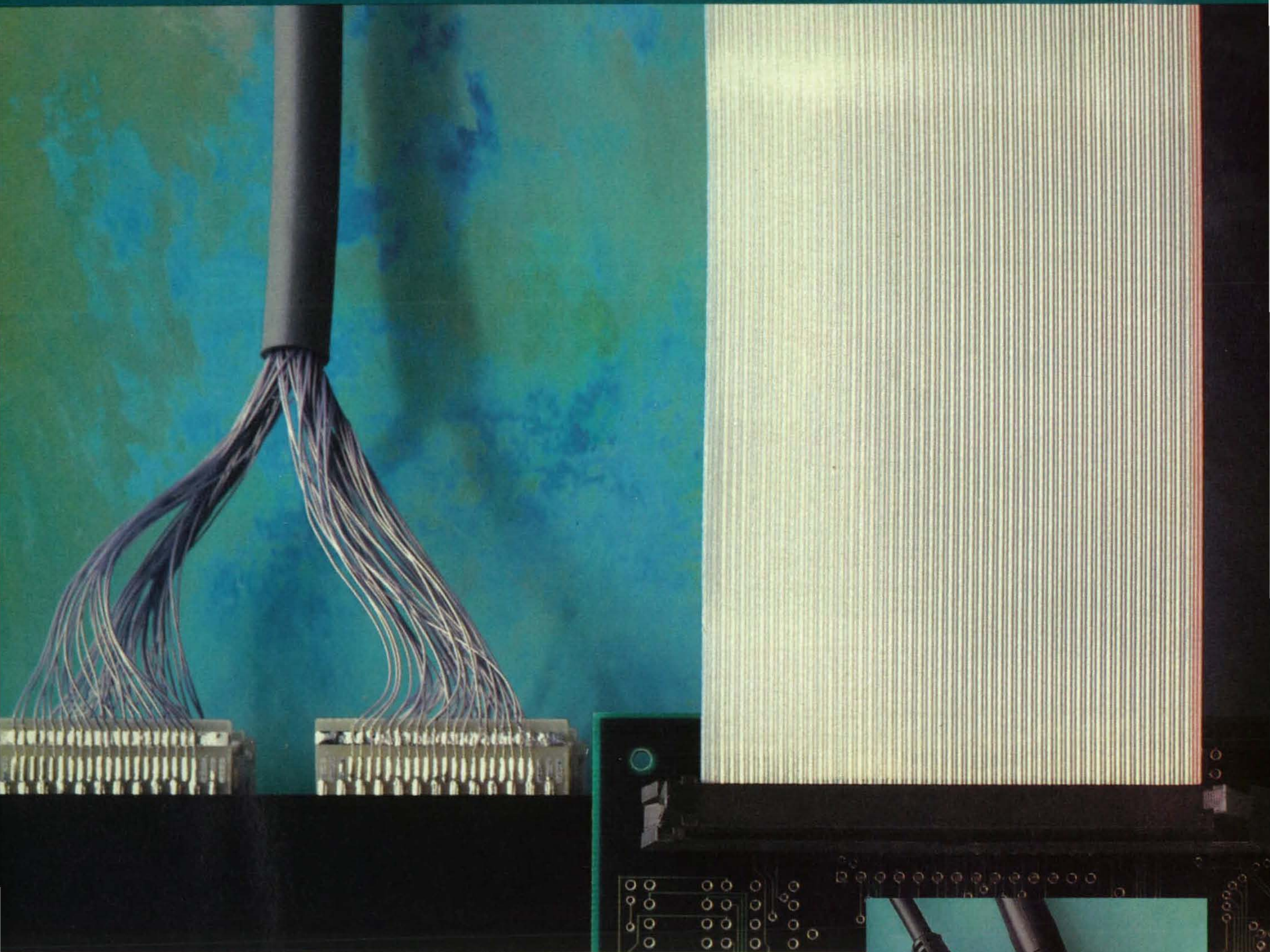

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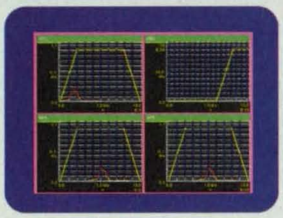

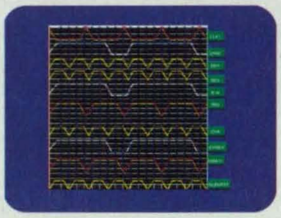

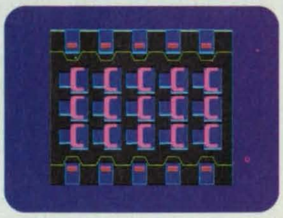

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Through the technology transfer process, many of the systems, methods, and products pioneered by NASA are reapplied in the private sector, obviating duplicate research and making a broad range of new products and services available to the public.

Photo courtesy Eastman Kodak Co.

Kodak's new electronic camera system captures color or black and white images which can be viewed instantly on an LCD screen, then transmitted by modem over ordinary phone lines and/or downloaded to a Macintosh computer for editing.

An innovative "filmless" camera designed and built by the Eastman Kodak Company, Rochester, NY, has provided space shuttle astronauts with a valuable imaging tool and holds promise for a wide range of Earth applications. Kodak's digital camera system (DCS) more than doubles the resolution of still video systems; for an astronaut in orbit, the difference between 500,000 pixel and 1.3 million pixel resolution can mean the difference between sighting an indeterminate shape near the Earth and swiftly identifying a 747.

Last November, astronauts aboard the shuttle Atlantis tested the camera as part of the Military Man In Space (MMIS) program, designed to evaluate the ability of men in orbit to support military operations. From an altitude of 195 nautical miles, the astronauts were able to identify ships, parked aircraft, and other objects at sites around the globe.

The DCS answers the need for real-time image assessment, according to Air Force Captain Rick Shimon, director of Department of Defense space experiments. "The increase in experimental data has been dramatic — on the order of twenty-fold," he said, adding, "The astronauts can look at the images on a high-resolution monitor immediately after a 30-second fly-by, which enables them to recall more than if they had to store the information in their heads."

Kodak's DCS marries the Nikon F3, a 35 mm camera used by many government and media professionals, with state-of-the-art digital imaging technology. The Nikon body accepts standard telescopic and telephoto lenses and, despite its enhanced capabilities, operates in essentially the same way as if the camera held film — aperture settings, metering, shutter speeds, and focusing are controlled in the familiar way.

Weighing just 5-1/2 pounds with the lens, the DCS comprises three principal components: a color or monochrome camera back, which contains the system's electronic "heart," a 1280 x 1024 pixel sensor that transforms optical images into electronic signals; a winder that operates at up to 2.5 captures per second; and the digital storage unit (DSU), which can store up to 158 uncompressed or 400 to 600 compressed images. Tethered to the camera and carried in a shoulder case, the DSU is powered by a 12-volt, 2.3-amp-hour rechargeable battery that can fill its 22 MB drive with uncompressed images. The DSU's 8 MB DRAM buffer stores up to six images in one continuous burst; an optional 32 MB buffer can store up to 24 images per burst for recording fast-moving events.

Images captured by the DCS can be viewed immediately on the DSU's four-inch LCD monitor, then captioned for quick recall or deleted. They can be transmitted via modem over ordinary phone lines directly to any computer capable of receiving ANPA/IPTC files. Once downloaded, the images are easily retrieved for enhancement and color balancing using image processing software such as Adobe Photoshop.One practical application: a photojournalist working in a region remote from any film processing facilities can, in matter of seconds, provide a high-resolution image captured with the DSC to his newspaper thousands of miles away.

A Space-Based Technology

NASA, which pioneered the art of digital image processing and enhancement in the 1960s, was instrumental in the development of the DCS, according to John Richardson, manager of Kodak's commercial electronic imaging systems. "Suggestions from reviewers at NASA's

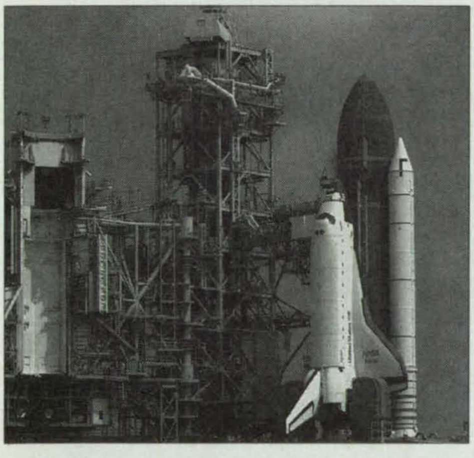
Johnson Space Center helped us to select parts and materials that would survive the rigors of space launch while not emitting gases or producing electromagnetic interference that might endanger other systems," he recalled.

A new facility at NASA's Kennedy Space Center will assess the system's performance in ground-based image acquisition and process documentation for shuttle flight preparation. Nancy Pope, project control specialist for photo and video services at Kennedy, believes the DCS will be useful in quickly disseminating information from spacecraft. "If the particulars of a shuttle problem were made available on a local area network," she said, "ground-based experts could review them simultaneously to facilitate a solution."

The same technique could be employed for industrial design verification, allowing numerous engineers to examine a design at once. Similarly, photographers in aircraft could relay images of natural disasters such as floods and, while still in the air, receive instructions from ground-station reviewers to take additional shots from different angles.

Designed to work in concert with other instruments, the DCS readily snaps onto the Nikon mounts of microscopes used in VA hospitals, providing high-resolution images to aid doctors in diagnosing illnesses. The system also could help assess the health of forests and wildlife. Fitted with a special filter, the camera can show areas where trees are in decline. And it allows wildlife managers to monitor flocks of birds and animal herds at a safe, nonintrusive distance.

High-speed digital imaging could bring a new dimension to crime fighting. "Imagine a team of investigators maintaining surveillance as a suspect departs on an airline flight," explained Dr. Gary Conners, vice president and general manager of Kodak's Government Systems Division. "Our digital system would allow a high-resolution, full-color image of the suspect to be in the hands of law enforcement officials when the suspect arrives at his destination."



The DCS captured this shot of the space shuttle Atlantis on the launch pad.

Photo courtesy Eastman Kodak Co.

As the list of potential applications for portable, high-quality digital imagery broadens, Kodak continues to refine its system. According to John Richardson, the company is currently working on a tetherless model with improved image clarity and color balance.

Will digital camera systems make film obsolete? Answered Richardson: "Film will continue to be the medium of choice for many, many years. But in cases where you need high-resolution images instantaneously, digital offers an exciting new capability." ❑

For more information about the technology described in this article, contact: John Richardson, Eastman Kodak Company, 1447 St. Paul Street, Rochester, NY 14650; (716) 253-1853.

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 18). NASA's patent-licensing program to encourage commercial development is described on page 18.

Self-Collimating Unstable-Resonator Diode Lasers

These diode lasers would produce collimated output beams without the help of external collimating optics. Potentially, there is a large market for these lasers. Operating at powers of ½ to 10 W, they could be used as pumps for optical-fiber amplifiers and for other solid-state lasers and as sources of light for free-space communications.
(See page 54)

Durable, Low-Surface-Energy Treatments

A chemical treatment for glass, ceramics, and other protonated surfaces creates a very thin semipermanent film with extremely low surface tension. Such a film can form water- and oil-repellent surfaces, antimigration or corrosion barriers, mold-release agents, and self-cleaning surfaces.
(See page 64)

Orbital Welding Head Held by Robot

An orbital welding head is positioned by a robot that also controls the motion and the voltage of an arc-welding torch mounted in the head. The unit is intended for welding pipes or similar round parts.
(See page 87)

Shape-Memory Wires Switch Rotary Actuator

A rotary actuator uses two thermally activated shape-memory wires. The wires are heated alternately to rotate a shaft back and forth.
(See page 72)

Compact Visible and Infrared Spectrometer

A portable prototype spectrometer measures spectral intensity from 3,700 to 11,700 Å, with a resolution of 12 Å. The instrument weighs 15 kg and fits into an envelope of 37 by 37 by 48 cm.
(See page 58)

Phosphor Scanner for Imaging X-Ray Diffraction

An optoelectronic scanning apparatus is used in conjunction with a phosphor to generate an image of an x-ray diffraction pattern or other image recorded on the phosphor. The apparatus can be used in x-ray crystallography, medical radiography, and molecular biology.
(See page 32)

Hidden Fastening-and-Unfastening Mechanism

A proposed mechanism to be placed behind a panel can fasten or unfasten the panel from the underlying structure. The panel can be joined or separated without cutting.
(See page 71)

HOW YOU CAN BENEFIT FROM NASA's TECHNOLOGY UTILIZATION SERVICES

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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.

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Mail Code 200-11
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Mail Code LE-LAW
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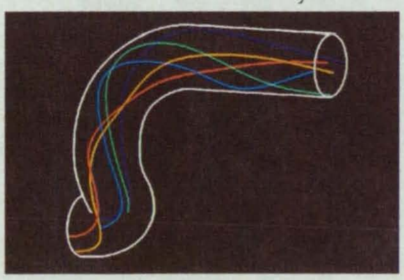

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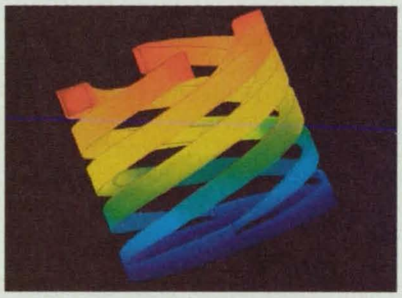

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Preventing Blooming in CCD Images

A simple clocking scheme prevents smearing of images and eliminates residual images.

NASA's Jet Propulsion Laboratory, Pasadena, California

A clocking scheme for a charge-coupled-device (CCD) imaging photodetector prevents smearing of bright spots in the scene and eliminates the residual images of bright spots that can remain when the optical stimulus is removed. The scheme works under almost any lighting conditions (except, of course, those that cause permanent damage to the CCD).

The smearing of bright spots in television images is well known and is called "blooming" in the industry. In a CCD, it occurs because excessive brightness causes the local excessive accumulation of image charge, which then spreads to neighboring, less illuminated (and, therefore, initially less charged) picture elements. Although antiblooming structures have been incorporated into some CCD's, they are complicated, and they degrade quantum efficiency. The antiblooming clocking scheme not only prevents blooming (see Figure 1) but also imposes a charge-collecting electric field of optimum-full-well configuration, minimizes nonuniformities among picture elements, keeps dark current low, and eliminates residual images.

Figure 2 helps to illustrate the antiblooming clocking scheme applied to a three-phase CCD. During the integration of charge in phase 1, phases 2 and 3 are inverted and phase 1 is biased into surface full well (slightly above optimum full well). If the illumination is too bright, the electrons collected in phase 1 eventually fill the surface full well up to the surface (the "surface" being the interface between the Si and SiO_2), and electrons become trapped in quantum electron-energy states of the Si/SiO_2 interface. Such trapped electrons can give rise to residual images.

To obliterate the trapped electrons, a barrier phase (in this case, phase 2) is biased high (+4 V) while phase 1 is biased into inversion (−8 V). Electrons trapped under phase 1 then recombine with the inversion layer of holes supplied by the channel-stop regions. The bias voltages and clock signals are then returned to their initial states. This process is repeated as many times as necessary during integration of charge

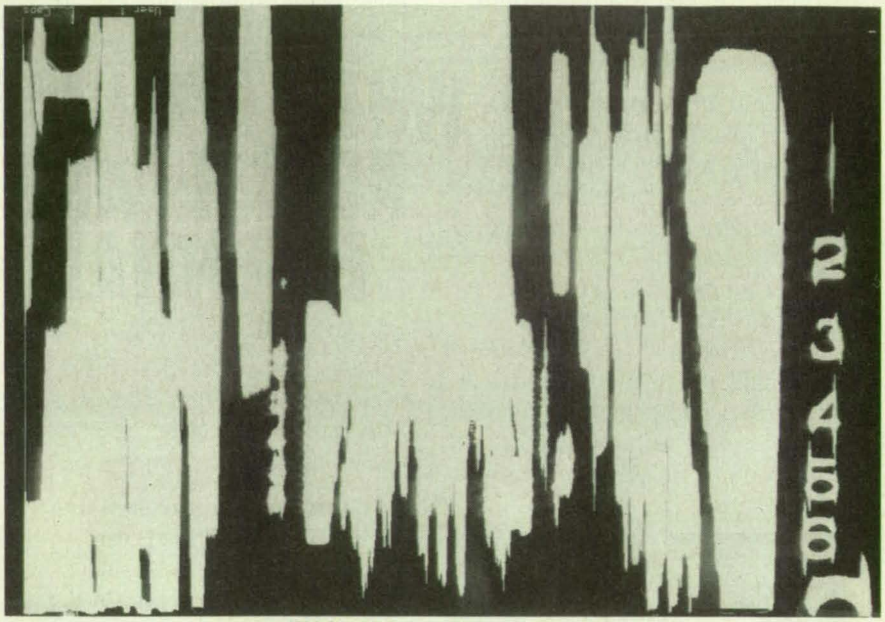

IMAGE FROM OVEREXPOSED CCD

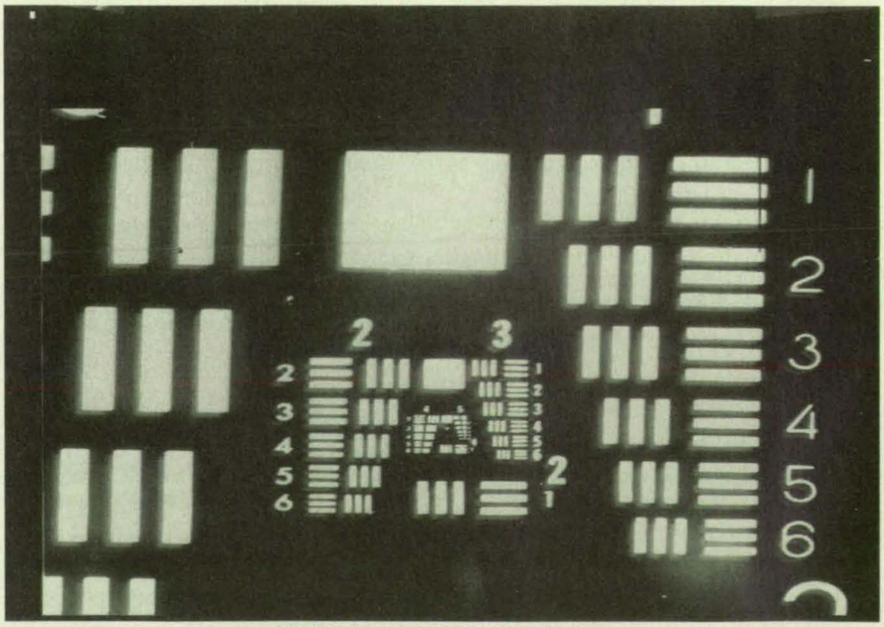

IMAGE FROM OVEREXPOSED CCD
OPERATED IN ANTIBLOOMING CLOCKING MODE

Figure 1. These **Images From an Overexposed CCD** illustrate the benefit of the antiblooming clocking scheme.

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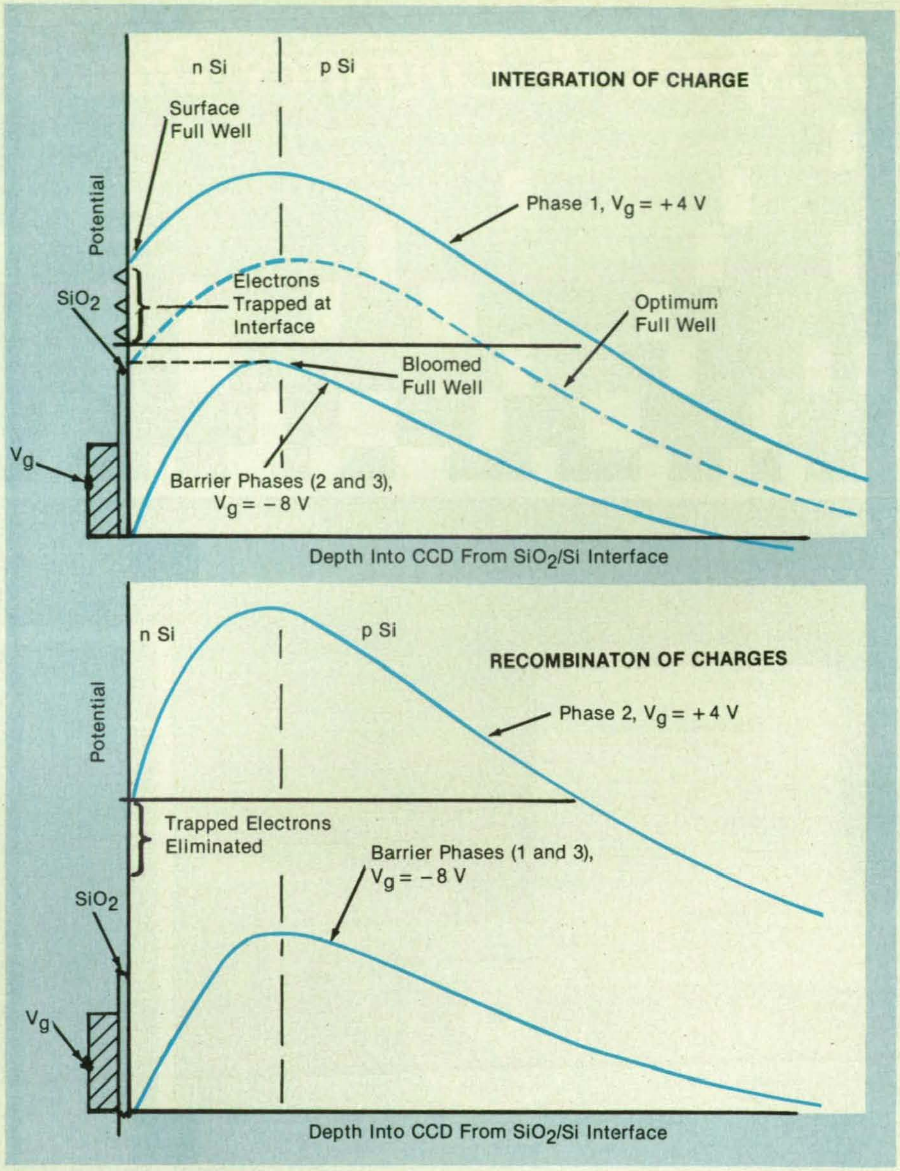

Figure 2. These **Potentials Are Applied in Sequence** to the phases of a three-phase CCD in the antiblooming clocking scheme.

to prevent charge from blooming and reaching the barrier phases. When integration is terminated, the normal CCD-readout sequence of clock signals is resumed.

This work was done by James Janesick of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 71 on the TSP Request Card.* *NPO-18363*

Spatial Light Amplifier Modulators

Unlike other spatial light modulators, these would provide gain.

NASA's Jet Propulsion Laboratory, Pasadena, California

Spatial light amplifier modulators (SLAM's) are conceptual devices that would, as the name suggests, effect two-dimensional spatial modulation (including switching) in optical computing and communication systems. The spatial light modulators (SLM's) in use at present are characterized by optical losses because they effect modulation through variations in absorption, reflection, refraction, and/or diffraction. Unlike SLM's, SLAM's could also provide optical gains.

Optical processors that incorporate SLAM's could be designed to operate in the reflection or transmission mode (see Figure 1). Each element of a planar SLAM array would be an optical amplifier — e.g., a surface-emitting diode laser. The array would be addressed electrically with ac modulating signals superimposed on dc bias currents supplied to the lasers.

One of the advantages of the configuration of a reflection-mode processor is that it would permit the incorporation of a thermoelectric cooler in the back plane of the reflecting array (see Figure 2). As a result,

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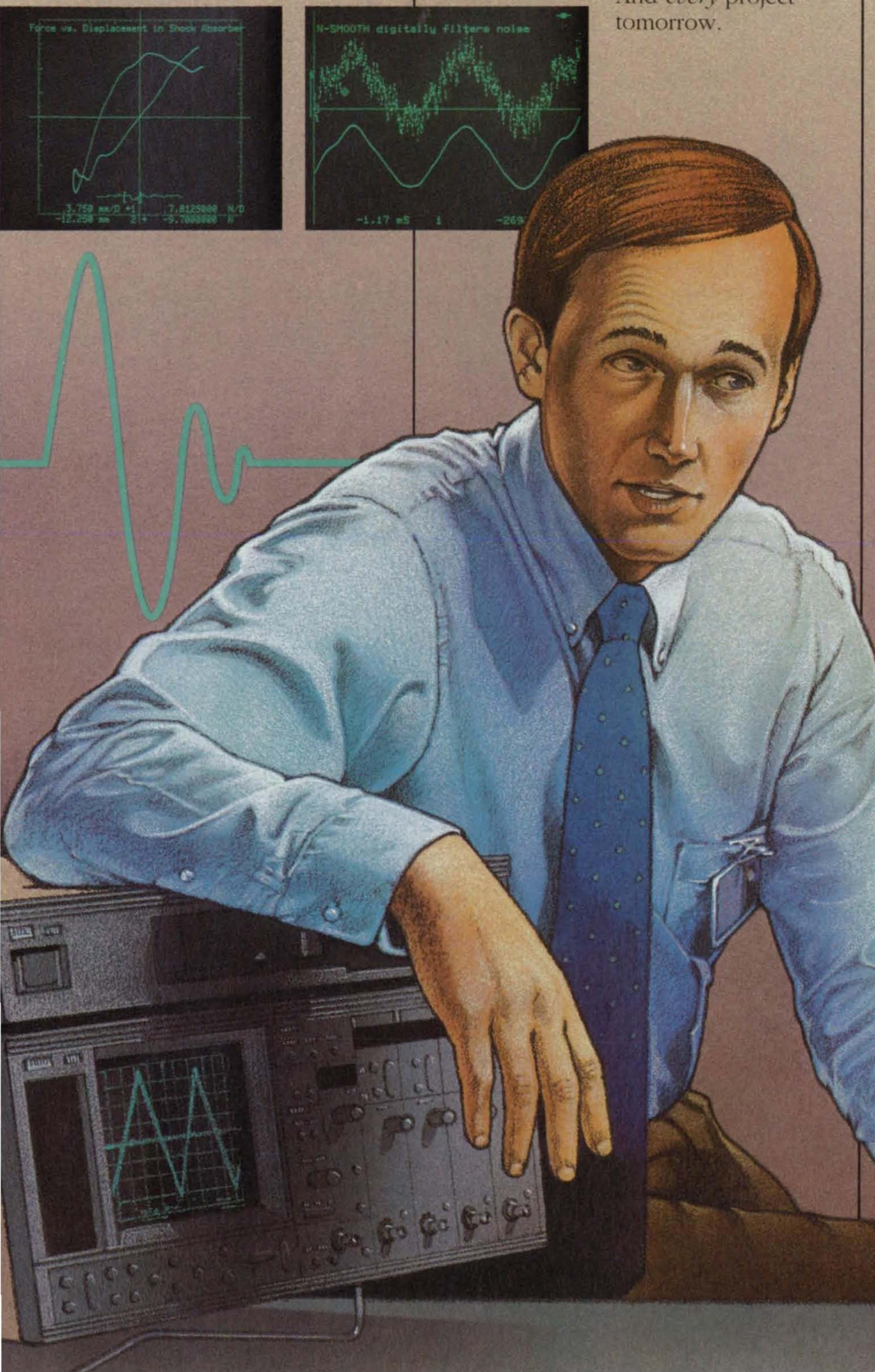

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the limit on power to be dissipated could be extended by an order of magnitude, and as a further consequence, it might also be feasible to increase the size of (and number of picture elements in) the array.

The feasibility of the concept was demonstrated by use of a channel substrate buried heterostructure (CSBH) InGaAsP laser excited by light from a commercial laser at a wavelength of 1,299 nm. The CSBH InGaAsP laser could be made to operate not only as an amplifier but also as a switch, modulator, or detector, depending on the optical excitation and on the dc and ac components of the electrical input. Optical isolation as high as 50 dB and optical gain as high as 20 dB were attained in dc operation. The combination of an on/off ratio of 22 dB with a gain of 10 dB was achieved in pulse operation. Small-signal gain modulation at a frequency of 1 GHz was found to be possible. When the CSBH InGaAsP laser was used as a signal-monitoring tap with simultaneous gain, it exhibited a maximum detection responsivity of 12 V/W.

In general, solid-state laser devices that are candidates for use as SLAM switching elements should exhibit sufficient gain in the "on" state and sufficient loss in the "off" state to provide a large dynamic range. At the same time, the spontaneous emission should be low enough not to disturb the detection of the amplified and modulated signal. To complete the development of a SLAM, a satisfactory surface-emitting diode amplifier must be developed. In the favored arrangement, two surfaces of an epitaxial layer would serve as the reflecting surfaces of the resonator, and the light output would be taken perpendicularly from the surface of the substrate.

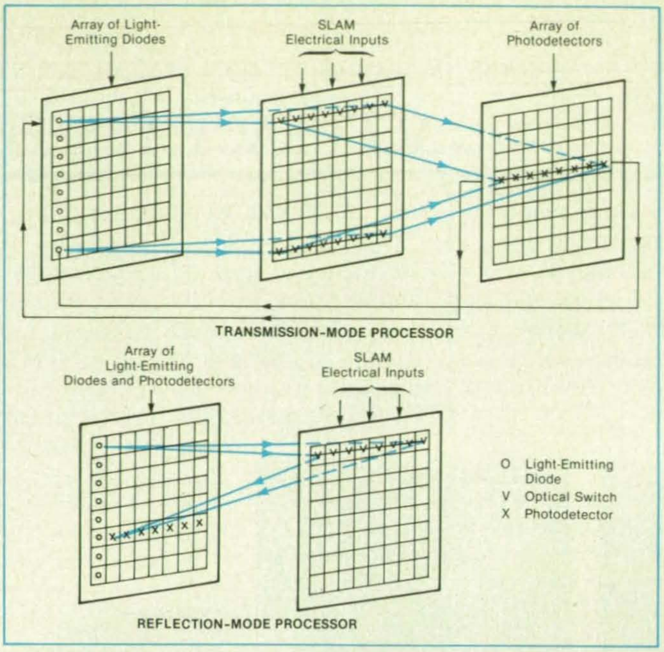

Figure 1. **Optical Processors** could incorporate SLAM's operating in the transmission or reflection mode.

A suitable SLAM device could provide both the desired modulation and enough optical gain to enable the splitting of the output signal into many optical fibers without excessive loss of power. The optical amplifiers in the SLAM would also be designed to provide amplification and detection simultaneously. For typical computing, switching, and processing applications, the array should contain at least one million resolution cells, have a contrast ratio of at least 100, have a dynamic range of at least 20 dB, and have a framing speed of the order of megahertz.

This work was done by Sverre T. Eng of Caltech and N. Anders Olsson of AT&T Bell Laboratories for **NASA's Jet Propulsion Laboratory** *For further information, Circle 95 on the TSP Request Card.* *NPO-17567*

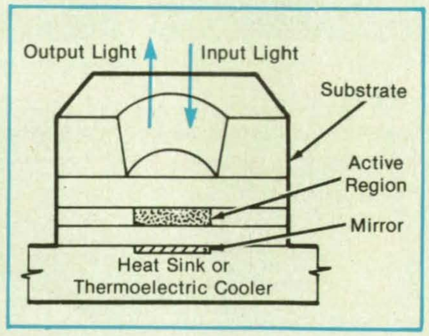

Figure 2. Each **Picture Element of a Reflection-Mode SLAM** would include a diode laser. A heat sink or thermoelectric cooler could be built into the back plane.

Cooled Low-Noise HEMT Microwave Amplifiers

The potential advantage is lower cost with a more-reliable refrigeration system.

NASA's Jet Propulsion Laboratory, Pasadena, California

Several prototype cooled low-noise microwave amplifiers are based on high-electron-mobility transistors (HEMT's) integrated with impedance-matching microstrips and microstrip-to-waveguide transitions. Amplifiers of this type are being considered as replacements for the cooled ruby masers that are now used as low-noise receiver-front-end amplifiers in communi-

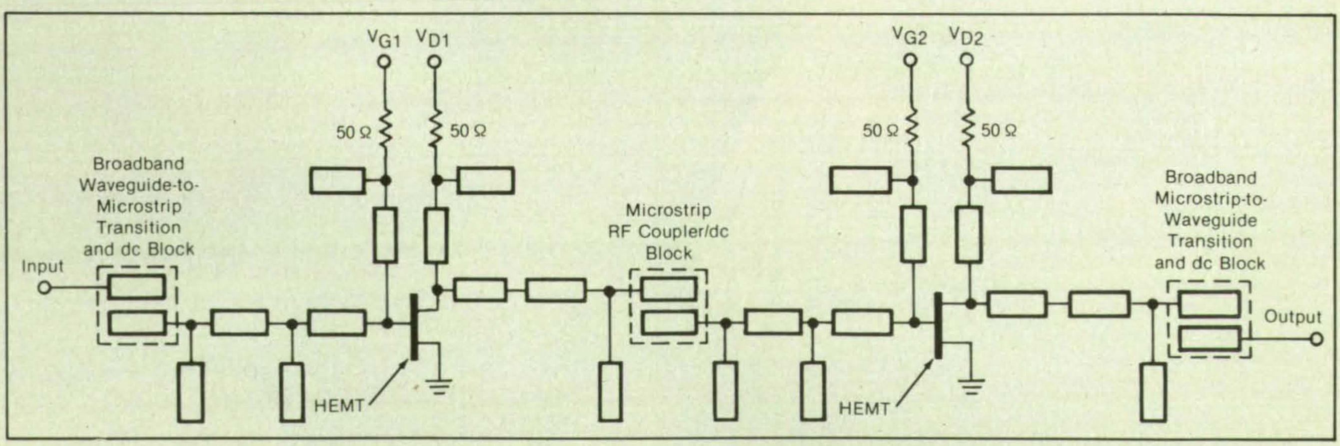

Figure 1. This **Two-Stage Amplifier** contains two HEMT's optimized to provide high gain and low noise at an operating temperature of about 12 K.

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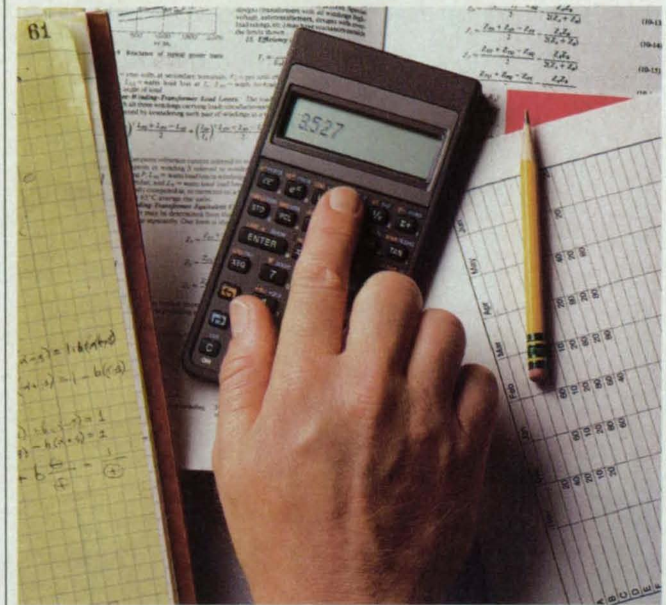

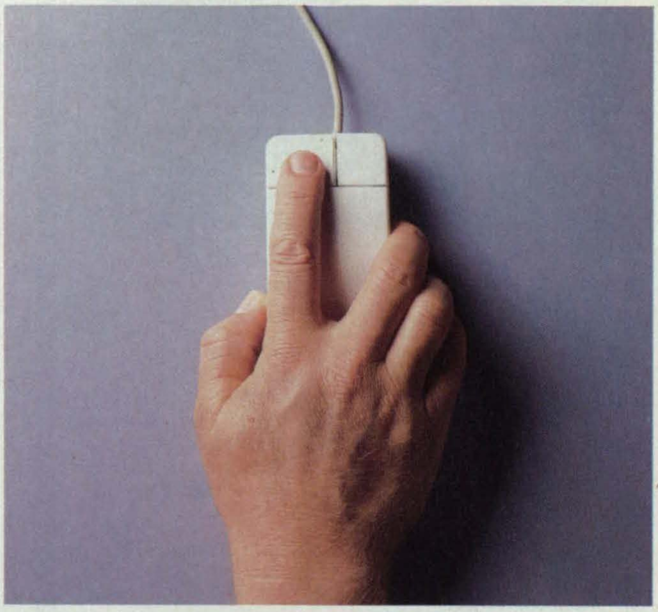

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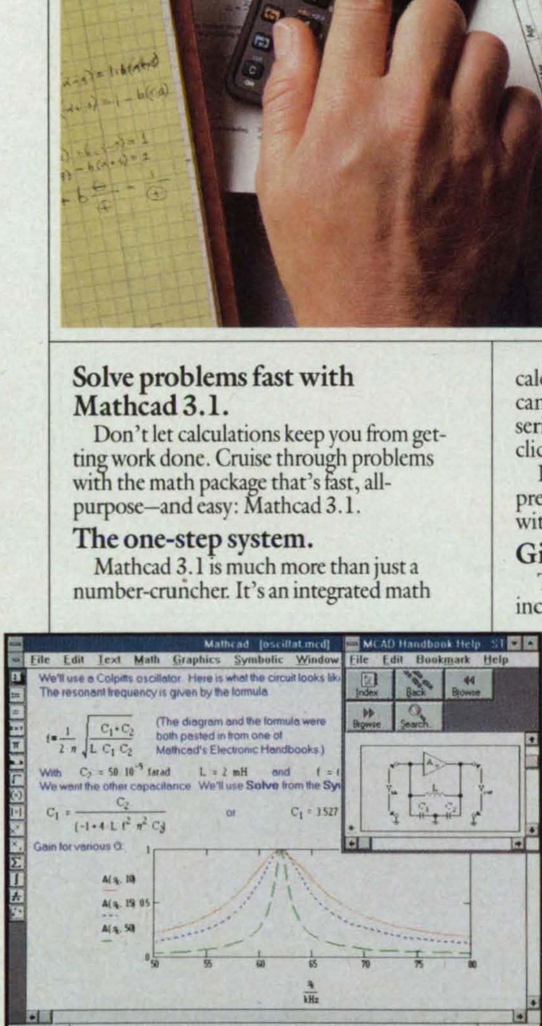

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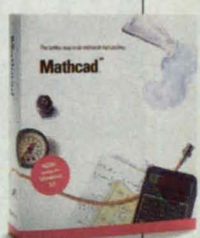

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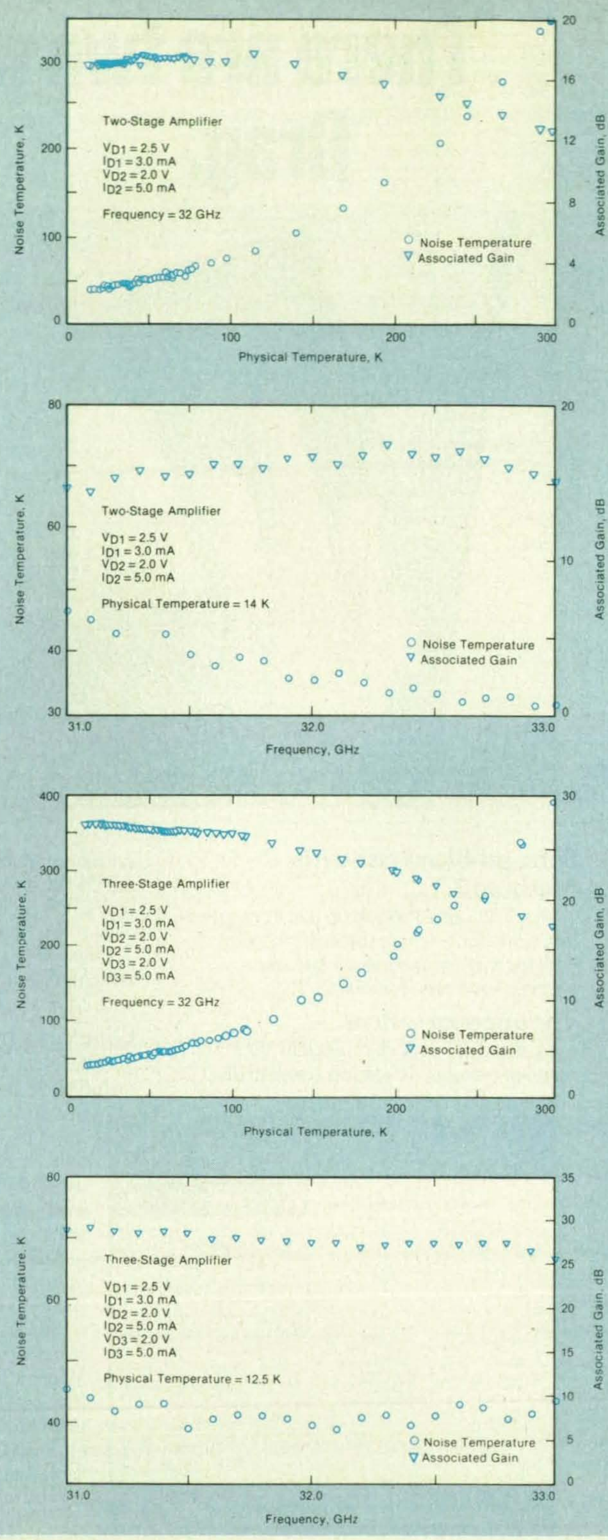

Figure 2. These **Performance Data** were obtained in tests of two- and three-stage HEMT amplifiers.

cations, radio science, radar systems with electronically steerable antennas, radio astronomy, and telemetry. Whereas a ruby maser requires a complicated and expensive cooling system to provide an operating temperature of 4.5 K, an HEMT amplifier of the present type is designed to operate at 12 K; consequently, it requires less cooling power and can be operated at lower cost with a simpler and, therefore, more-reliable cooling system.

The HEMT's were fabricated on selectively n^{+}- and n-doped $Al_xGa_{1-x}As/GaAs$ heterostructures grown by molecular-beam epitaxy. All levels were defined by electron-beam lithography. On the basis of previous studies, the concentration of n dopant (10^{18} cm^{-3}) and the mole fraction, x, of aluminum (0.23) were chosen to provide a compromise between the desired high-gain, low-noise performance at low temperature and the need to suppress photoconductivity. Ti/Pt/Au gate electrodes with T-shaped cross sections were made by a trilayer resist technique to obtain low gate resistance.

The length of the gates was chosen to be 0.25 μm, which is the conventional value for reliable, high-gain, low-noise HEMT's. The width of the gates was chosen to be 75 μm on the basis of compromises among optimum matching of impedances, bandwidth, intermodulation distortion, and the capability to handle and dissipate power.

Two- and three-stage amplifiers (see Figure 1) designed for optimum performance at a frequency of 32 GHz were built and tested at operating temperatures from 12 to 300 K. The data from the tests (see Figure 2) show, among other things, that the lowest noise temperature for the two-stage amplifier at 32 GHz was 35 K, with an associated gain of 16.5 dB. For the three-stage amplifier, the lowest noise temperature was 39 K, with an associated gain of 26 dB. Both amplifiers were found to be insensitive to light.

This work was done by J. Javier Bautista and Gerardo G. Ortiz of Caltech and Kuanghann George Duh of General Electric Co. for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 123 on the TSP Request Card.*
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Degradation of charge-transfer efficiency by energetic particles is reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

Notch charge-coupled devices are imaging arrays of photodetectors that operate much like other charge-coupled devices but are designed to satisfy two special requirements: (1) to exhibit the high charge-transfer efficiencies that are necessary for proper operation in an ultra-large array; and (2) to be less vulnerable to degradation by energetic protons, neutrons, and electrons. The first requirement pertains to high-resolution imaging in general; the second pertains to imaging in high-radiation environments like those encountered in the nuclear industry and in military and outer-space applications.

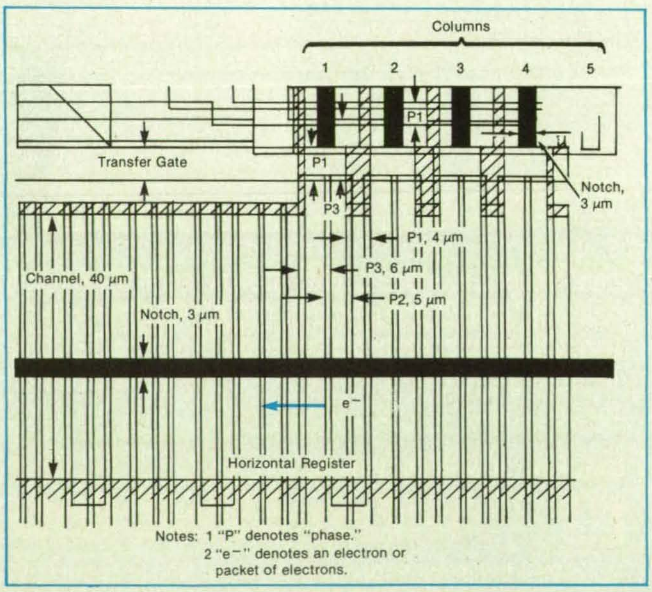
As shown in Figure 1, the main channel of a horizontal register in a notch charge-coupled device includes a deeper and relatively narrow inner channel (the notch). Small packets of charge remain confined to the notch as they are transferred along the channel. Larger packets of charge spill over into the rest of the channel and are transferred in the usual way.

Imperfections in the crystal lattice of the device, some of which are generated by impacts of energetic particles, are distributed throughout the device. These imperfections can degrade the charge-transfer efficiency by trapping some of the charges. Confinement to the notch reduces the number of imperfections encountered by packets as they are moved along, thereby reducing the amount of charge trapped and restoring some charge-transfer efficiency.

The notch concept has resulted in charge-transfer efficiencies as high as 0.9999995: at this high efficiency, for example, only 1 electron would be lost from a packet of 2,000 electrons transferred along a row of 1,000 picture elements. The notch charge-coupled device has also been tested in a high-radiation environment, where it exhibited a significantly smaller loss of signal charge at low signal levels than did a conventional charge-coupled device (see Figure 2).

This work was done by James Janesick of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 65 on the TSP Request Card.*
NPO-18362

Figure 1. This **Notch Charge-Coupled Device** includes narrow inner channels (the notches) in its row and column channels.



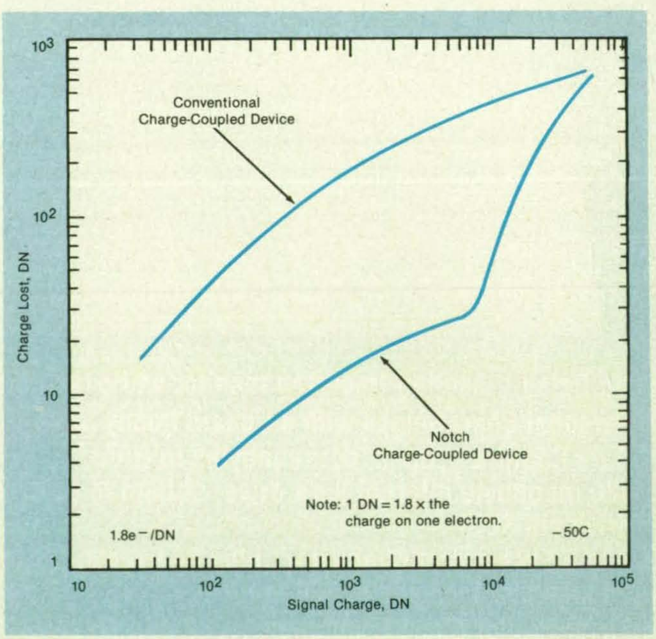


Figure 2. The **Losses of Signal Charges** were measured in two 1,024x1,024 charge-coupled devices that were irradiated with energetic protons. As the signal charge increases and spills over into the rest of the channel, the behavior of the notch device becomes more like that of the conventional device.

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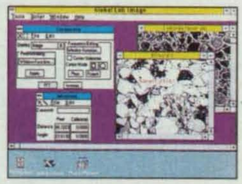

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Books and Reports

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.

Designing a Beam Waveguide for Multiple Frequencies

Defocusing caused by diffraction at lower frequencies can be reduced by shaping the input pattern.

A theoretical paper addresses some interrelated defocusing and diffraction effects that are important in the design of a beam waveguide. (A beam waveguide is a quasi-optical, quasi-antenna structure that includes such components as a waveguide terminated in a feed horn, reflectors, and/or antennalike electromagnetic lenses.) In this study, the basic design requirement is that the beam waveguide feed power to a large paraboloidal primary antenna reflector at two or more widely different frequencies.

The electromagnetic behavior of the beam waveguide can be characterized by the approximations of geometric optics more closely at the higher frequency, but diffraction plays a greater role at the lower frequency. A more precise analysis that takes account of diffraction effects shows that the phase center of the beam waveguide at the lower frequency differs from the focal point of geometric optics. If the antenna system is optimized for the higher frequency, this shift in the phase center causes some defocusing, with consequent loss of signal, at the lower frequency.

This study poses the problem of compensating for the defocusing loss by reshaping the amplitude and phase distribution of the input to the beam waveguide at the lower frequency. A beam waveguide that includes a feed horn, an offset first reflector, and a second reflector is mathematically modeled as two circular apertures, and the illumination of the first reflector is considered to be circularly symmetrical. Various distributions of amplitude of the illumination pattern are considered, ranging from a purely Gaussian function of radius through partly Gaussian and partly uniform to uniform. The aperture phase surface is assumed to be spherical. Diffraction effects between the two apertures are treated by the theory of physical optics, using a spherical-wave expansion, and the computations are performed for various sizes and separations of the apertures.

The numerical results indicate that design tradeoffs on spillover loss (the portion of power lost because of diffraction between the reflectors) and defocusing can be accomplished by changing the amplitude and phase distribution of the input wave front. For a given distance between small reflectors, it is found that there is little control of defocusing; this problem is typically encountered at low frequencies. One way to avoid this problem is to design a beam-waveguide system such that the phase of the high-frequency input wave is modified to bring its output phase center to the location of the low-frequency output phase center.

This work was done by Victor Galindo, William A. Imbriale, and Sembiam R. Rengarajan of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Amplitude and Phase Shaping Effects in Beamwaveguides," Circle 164 on the TSP Request Card.*
NPO-18341

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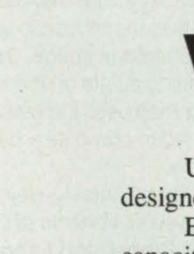

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Electronic Systems

Predictive Display for Teleoperation With Delay

The predictive image helps the operator control the remote manipulator.

NASA's Jet Propulsion Laboratory, Pasadena, California

A computer-graphical simulator helps an operator control a robotic manipulator located so far away that controlling and monitoring signals are delayed significantly in transmission. The simulator displays a phantom image of the robot superimposed on the delayed "real" monitoring image of the robot (see figure). The phantom responds to control signals immediately — that is, without transmission delay. Its motion predicts that of the real robot. After the transmission delay, the real image of the robot follows the motion of the phantom image.

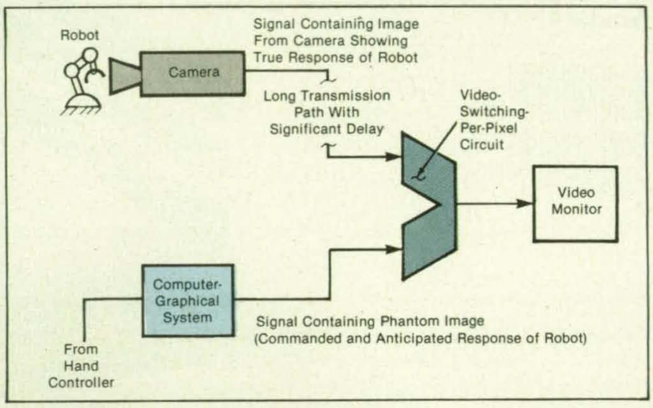
The system includes a high-fidelity, real-time computer-graphical display. It gives the user depth, perspective, and lighting cues that improve control.

The simulator operates in conjuction with a bilateral force-reflecting hand controller, which gives the operator force feedback (delayed, of course, by the transmission time). The delay between the issuance of a command and the reception of a force response to it makes the operator lose a sense of cause and effect, and performance suffers. By effectively eliminating the delay in the visual feedback, the simulator enables the operator to compensate partly for the delay in the force feedback, thereby exerting more-effective control.

The hand controller drives the graphical phantom image of the robot in real time by use of the same mathematical transformation that is used to drive the real robot. The simulator includes a commercial computer workstation for both computation and graphical display. It can draw 400,000 three-dimensional vectors or 40,000 four-sided polygons per second with lighting and removal of hidden surfaces. Thus, the images of the robot can easily be updated at the 60-Hz frame rate of the workstation.

The phantom image of the robot arm is constructed from only six types of graphical objects: 6 boxes, 12 cylinders, 1 forearm, 1 upper arm, 1 wrist, and 4 finger halves. Special circuits in the computer-graphical equipment perform the calculations pertaining to lighting and the removal of hidden surfaces.

The operator uses a mouse and popup menus on the screen to select viewing angles and positions of lights, control the robot arm, and calibrate the camera. Calibration involves alignment of the phantom image of the robot with the real image to establish a reference condition for computations of images during future manipulations. The operator uses the mouse to pick out points on the phantom image, then picks out corresponding points on the real image. The simulator then uses the calibration data thus obtained to compute a camera-calibration matrix.



Delayed Real Images and Prompt Phantom Images of a robot are superimposed on the screen of the video monitor. The operator can thus view both the anticipated response of the robot (as indicated by the phantom image) and the true response of the robot after transmission delay (as indicated by the real image).

This work was done by Antal K. Bejczy, Won S. Kim, and Steven C. Venema of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 104 on the TSP Request Card.*
NPO-18277

Phosphor Scanner for Imaging X-Ray Diffraction

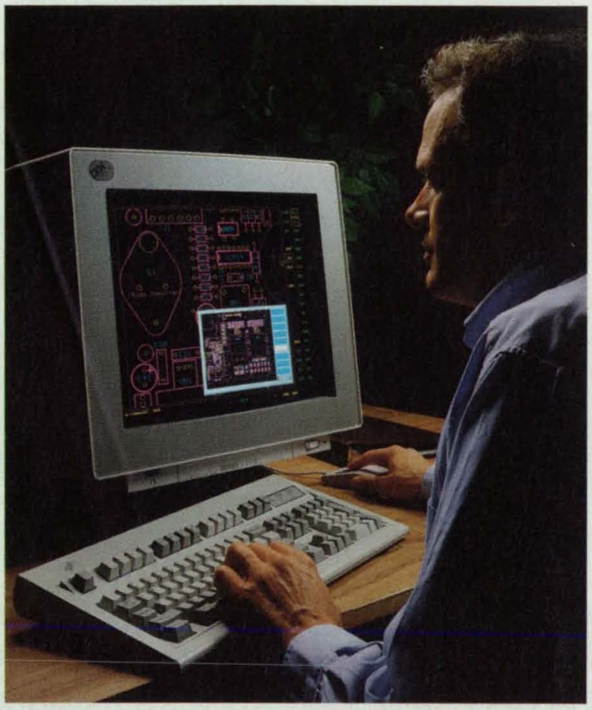
Sensitivity and resolution exceed those of previously available scanners.

Marshall Space Flight Center, Alabama

An improved optoelectronic scanning apparatus is used in conjunction with a phosphor (e.g., the fluorohalide BaFX:Eu) to generate a digitized image of an x-ray diffraction pattern or other x-ray image recorded in the phosphor. The scanner-and-phosphor combination is intended for use in x-ray crystallography, medical radiography, and molecular biology. It is designed to offer sensitivity greater than that of imaging phosphor detectors based on charge-coupled devices and to eliminate the skewing of edge picture elements and some of the background optical noise that occur in prior mechanical-scanning imagers based on photomultipliers.

When stimulated with light from a helium/neon laser, the phosphor luminesces in proportion to the intensity of the stored x-ray image. In the scanning apparatus (see figure), light from the laser is sent along an optical fiber to one side of an integrating sphere, then from the other side of the sphere along another optical fiber to a scanning probe, and the luminescence is reflected back along this fiber to the integrating sphere. The probe holds the end of the fiber close to the phosphor. The diameter of a pinhole at the end of the fiber governs the resolution, which is $\leq 100\ \mu m$.

LISTEN.



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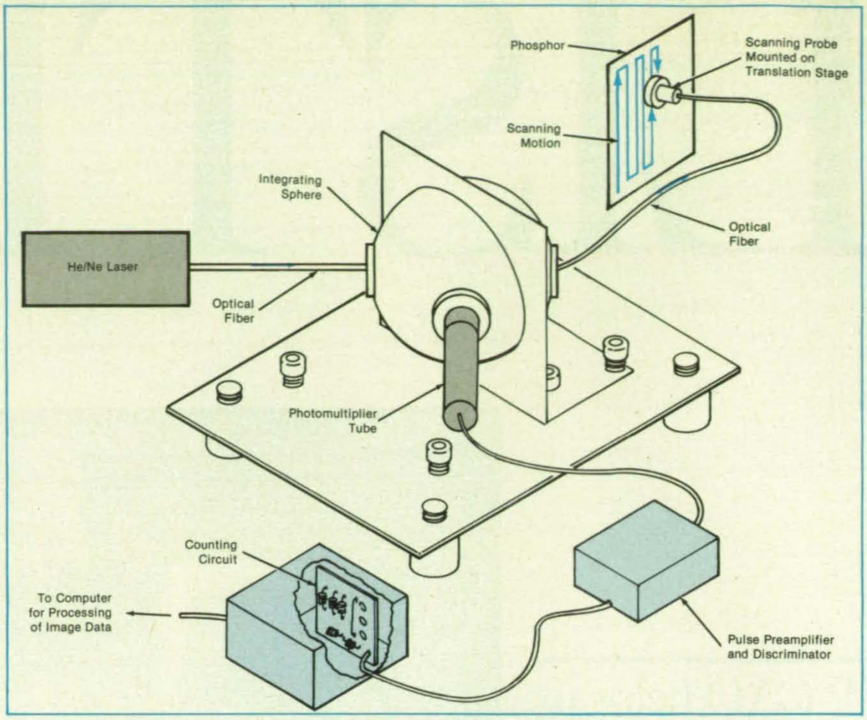
For More Information Circle No. 514

The scanning probe is pressed lightly against the phosphor to insure proximity of the end of the fiber, thereby maximizing both resolution and the collection of luminescence. The scanning probe is coated with polytetrafluoroethylene to enable it to slide smoothly across the phosphor.

The luminescence carried back to the integrating sphere is detected by a photomultiplier tube. A blocking filter prevents light of the laser wavelength from entering and damaging the photomultiplier. A pulse preamplifier and discriminator convert the raw output pulses from the photomultiplier into transistor/transistor-logic-level photon-counting pulses.

The scanning probe is stepped horizontally and scanned vertically across the phosphor by a two-axis translation stage, which is omitted from the figure for the sake of clarity. The horizontal motion is produced by a stepping motor, while the vertical motion is produced by a dc gearhead motor equipped with a shaft-angle encoder for measurement of the vertical position. Part of the circuit that counts photon pulses also counts encoder pulses, so that each photon count can be identified by position. Each encoder pulse represents an increment of 10 μm. The resolution can be changed easily by changing the number of encoder pulses counted before the count of photon pulses is latched and sent to the computer that processes the image data.



The **Scanning Fiber-Optic Probe** supplies laser light that stimulates luminescence in the areas of the phosphor previously exposed to x rays. The luminescence passes back through the probe and fiber to an integrating sphere and photomultiplier.

This work was done by Daniel C. Carter, Diana L. Hecht, and William K. Witherow of **Marshall Space Flight Center**. *For further information, Circle 55 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-28563.

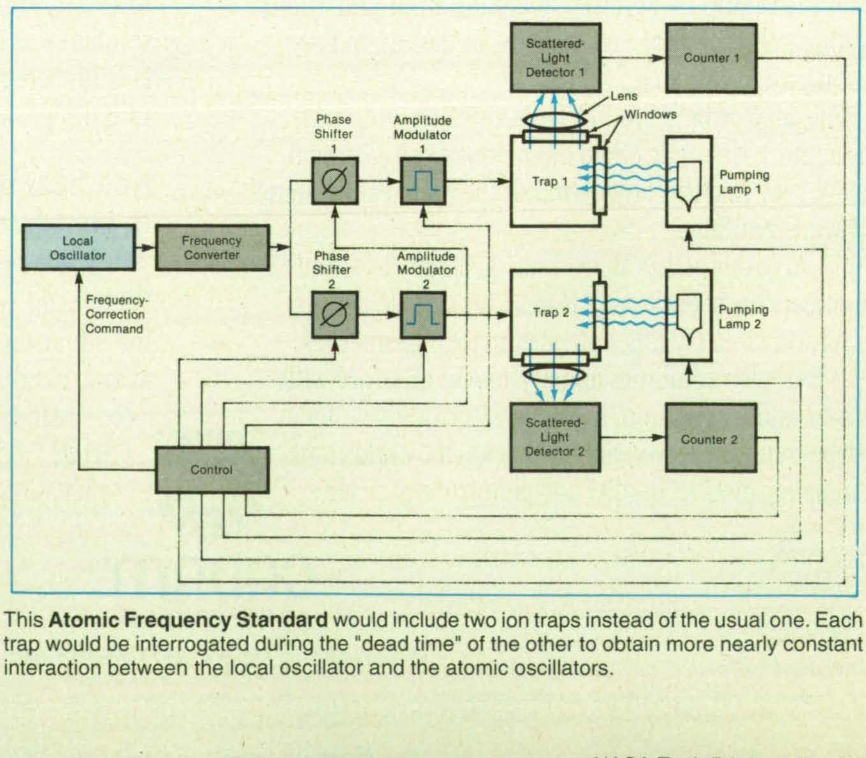
Dual-Ion-Trap Frequency Standards With Overlapping Cycles

Degradation of performance by fluctuations in local oscillators would be reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed scheme for enhancing the performances of atomic frequency-standard apparatuses calls for two or more ion traps (instead of one trap) per apparatus interrogated in alternation by radio-frequency pulses. The scheme would provide a more nearly constant level of interaction between the atomic oscillators (the trapped ions) and the quartz-crystal or other electronic oscillator that generates the interrogating radio-frequency signal; stated somewhat differently, the scheme would provide more nearly constant feedback gain or sensitivity, thereby providing more nearly constant corrections for fluctuations in the frequency of the local oscillator.

In a one-trap frequency-standard apparatus of the type in question, the ions (typically, $^{199}Hg^{+}$ ions) are first illuminated to "pump" them into a desired quantum state, then irradiated with one or two interrogating radio-frequency pulses nominally of the frequency to be determined (about 40.5 GHz in the case of ^{199}Hg); these pulses induce a precisely known atomic-level transition, putting some of the ions into another desired quantum state,



This **Atomic Frequency Standard** would include two ion traps instead of the usual one. Each trap would be interrogated during the "dead time" of the other to obtain more nearly constant interaction between the local oscillator and the atomic oscillators.

in which they scatter light. The intensity of scattering as a function of time is measured and used to correct the frequency of the oscillator. The operating cycle and the various optical and radio pulses are of the order of seconds or fractions of seconds long.

The best performance would theoretically be obtained if the sensitivity or feedback gain could be maintained constant and the observation time could be infinitely long. In practice, the sensitivity is not constant with time during the interrogation portion of the cycle. Furthermore, the sensitivity is necessarily zero during the "dead time" (which includes the optical-illumination period needed to prepare for the interrogation period of the next cycle) because during this time the atomic-interrogation process cannot be used to sense and correct the frequency of the oscillator: any fluctuations in the frequency of the oscillator during this time remain uncorrected, with consequent degradation of overall performance.

The figure illustrates a frequency-standard apparatus according to one version of the proposed scheme. The two traps would be operated in alternation, each being interrogated by double radio-frequency pulses during the dead time of the other. The cycles could be timed to provide some overlap of the alternating interrogation periods. The radio-frequency pulses would also be amplitude-modulated to compensate for the inherent variation of the gain of the interrogation interactions with time, yielding an overall feedback gain that would be nearly constant with time.

This work was done by G. John Dick and John D. Prestage of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 106 on the TSP Request Card.*
NPO-18447

Real-Time Connected-Element Radio Interferometry

Differences between times of arrival of signals are measured with high accuracy.

NASA's Jet Propulsion Laboratory, Pasadena, California

Connected-element interferometry (CEI) is a form of radio interferometry in which the differences between times of arrival of signals at two antennas are measured more accurately than they are in very-long-baseline interferometry (VLBI). In CEI, the baseline between antennas is typically of the order of tens of kilometers — much shorter than the intercontinental baselines of VLBI. The increase in accuracy of the time measurements offsets the effect of the shortening of the baseline, so that the accuracies of the angular positions of radio sources observed by CEI approach those of VLBI.

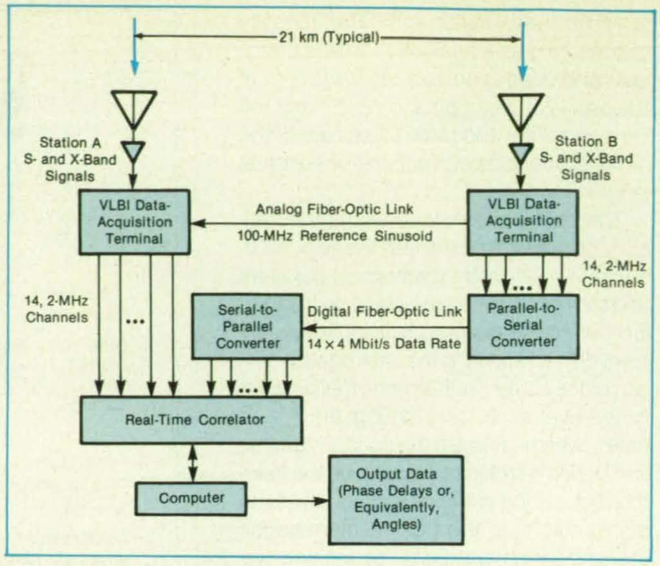
CEI is being developed at the Goldstone Deep Space Communications Complex, primarily to track the angular positions of spacecraft. Some of the techniques of CEI may also be adaptable to radio laboratories and navigation systems that require the distribution of precise time signals and accurate measurements of time. In CEI, a common clock signal and a common standard frequency signal are fed along optical fibers to receiving stations at both antennas to provide fully coherent operation. In addition to enabling more precise time and frequency references, the shorter CEI baseline (in comparison with VLBI) greatly diminishes the differential effects of atmospheric propagation, which can corrupt the observed interferometric observables; the errors are reduced so much that the more-precise phase delay between signals can be used in CEI (instead of the less-precise group delay used in VLBI). The fiber-optic links can also be used to transmit the raw observed signals in real time to a correlation processor (instead of recording them on magnetic tape for postprocessing).

The figure gives an overview of the planned CEI system at Goldstone. The standard-frequency signal — a 100-MHz sinusoid — will be generated at station B and transmitted to station A along an optical fiber. Incoming S- and X- band signals at each station will be fed to a VLBI data-acquisition terminal, which will perform downconversion to baseband, sampling, quantization, time-tagging, and formatting.

As many as fourteen, 2-MHz channels will be sampled, providing a maximum aggregate bit rate of 56 Mbit/s. The 14 parallel channels of data formatted at station B will be converted to a high-rate serial bit stream, modulated onto an optical carrier, and transmitted along a second optical fiber to station A, where the 14 parallel channels of digital data will be recovered from the serial bit stream.

The streams of data from both stations will be fed to a real-time correlator. A computer will generate mathematical models for use by the correlator, collect the outputs of the correlator, and generate the final output data.

This work was done by Charles D.



Analog and Digital Fiber-Optic Links along a relatively short baseline will enable the transmission of precise timing signals and real-time digital processing to determine phase delays between signals received at stations A and B.

Edwards, Jr., of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 48 on the TSP Request Card. NPO-18309*

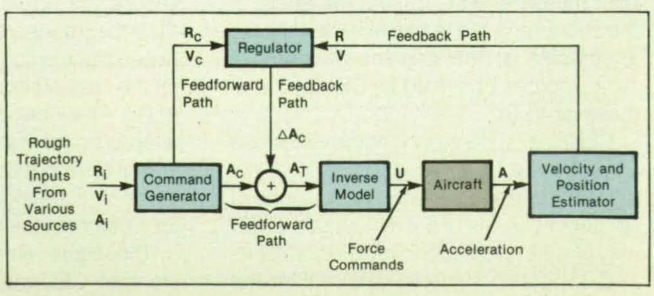
Automatic Flight Controller With Model Inversion

The system assists the pilot in coping with nonlinear responses and extreme flight conditions.

Ames Research Center, Moffett Field, California

An automatic digital electronic control system based on the inverse-model-follower concept is being developed for a proposed vertical-attitude-takeoff-and-landing airplane. Like many other advanced aircraft, this one includes complicated, interacting sets of engine-controlling actuators and aerodynamic control surfaces, its aerodynamic and propulsion characteristics include large nonlinear features, and it would be called upon to maneuver precisely under extreme flight conditions that include various combinations of inclement weather, darkness, high acceleration, high velocity, and proximity to other objects (aircraft, land vehicles, vessels, or terrain features).

These features and requirements are expected to impose a large workload and demands for great skill and endurance on the pilot. The automatic control system is needed to ease the pilot's burden. For example, the system could enable the pilot



This **Inverse-Model-Follower Control System** provides for direct command of the trajectory of an advanced aircraft.

to command a precise position and velocity with relative ease while performing a precise and difficult maneuver like landing in the vertical attitude on a fixture on the side of an aircraft carrier at night in bad weather.

Inverse-model-follower control has been discussed in previous articles in *NASA Tech Briefs*. The basic idea is to place an inverse mathematical model of the dynamics of the controlled plant (in this case, an inverse model of the force- and torque-generating processes of the airplane) in series with the control actuators of the controlled plant (in this case, the real airplane) so that the response of the combination of model and plant to a command (in this case, a commanded acceleration) is unity (that is, the actual acceleration approximates the commanded acceleration closely). Of course, the control system also includes feedback to compensate for uncertainties in the mathematical model and for disturbances imposed from without.

The figure is a simplified block diagram of the control system and airplane. The system receives rough trajectory commands ($\mathbf{A}_i$, $\mathbf{V}_i$, $\mathbf{R}_i$) (where **A**, **V**, and **R** denote acceleration, velocity, and position, respectively). These commands can be supplied, for example, by the pilot, by an air-traffic-control system, or as predetermined trajectory commands stored in a computer. These rough commands may be incomplete or discontinuous; they are processed through a command generator, which converts them into complete, smooth, executable commands ($\mathbf{A}_c$, $\mathbf{V}_c$, $\mathbf{R}_c$). A regulator compares feedback indications of the actual velocity and position (**V**, **R**) with the commanded velocity and position ($\mathbf{V}_c$, $\mathbf{R}_c$) to produce a differential acceleration command ($\Delta\mathbf{A}_c$). $\mathbf{A}_c$ and $\Delta\mathbf{A}_c$ are then added to obtain the total acceleration command, $\mathbf{A}_T$, which is fed to the control actuators via the inverse model.

To generate the approximate inverse model from the forward model of the dynamics with all zeros removed, six computer passes are made through the forward model in the forward direction with small perturbations of six control and attitude variables. The data thus generated are used to construct a 6×6 Jacobian matrix of partial derivatives. The matrix is then inverted and used to convert $\mathbf{A}_T$ into force commands, **U**. In a computer simulation, the complete inversion procedure was carried out in a computer cycle of 0.05 second.

This work was done by George Meyer of **Ames Research Center** *and G. Allan Smith of Yale University. For further information, Circle 21 on the TSP Request Card.*
ARC-12849

Encoding Television Signals for Better Color

A zigzag scan replaces the standard interlace.

John F. Kennedy Space Center, Florida

A coding scheme for the transmission of color-television pictures reduces the crosstalk between the chrominance and luminance signals. The scheme is applicable to color-video cameras with solid-state image-sensing devices using the National Television System Committee (NTSC) standard color-television system and can be modified for use in other television systems or tube-type cameras.

In the camera, the identical image is projected optically onto three image sensors — one for each of the three primary colors red, green, and blue. Each image sensor contains a rectangular array of photodetectors (one for every picture element) arranged in 488 rows and 1,344 columns. In the odd-numbered rows, the picture elements are centered in the odd-numbered columns. In the even-numbered rows, the picture elements are centered in the even-numbered columns (see figure). Altogether, there are 327,936 picture elements.

The odd and even arrays are each sampled in about 1/60 second by progressive horizontal and vertical scanning. A matrix circuit converts the raw signals from the sampled picture elements into horizontally and vertically progressive wideband luminance and color-difference (red-minus-yellow and blue-minus-yellow) signals.

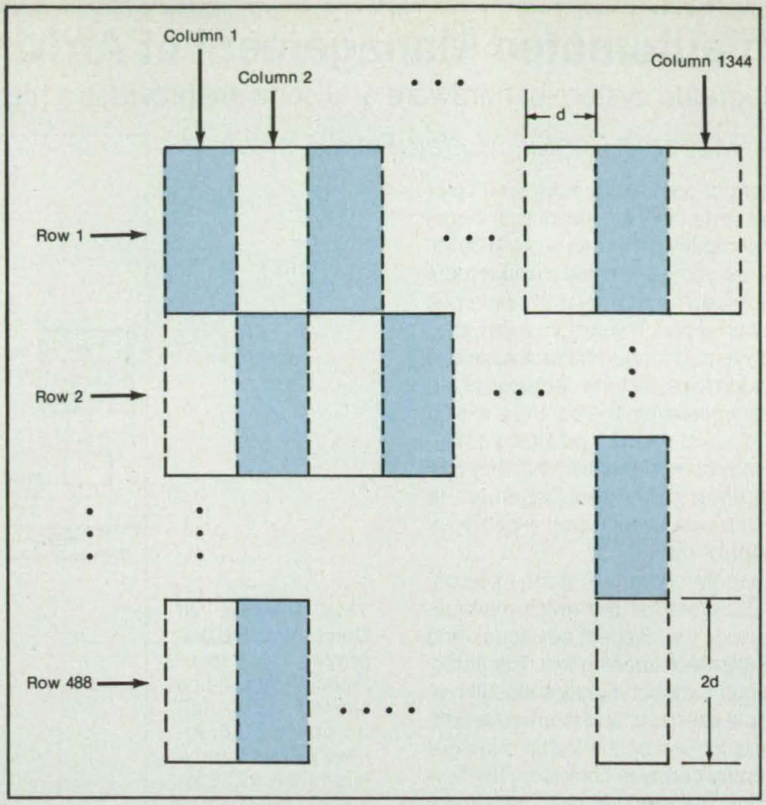
A luminance scan converter processes the luminance signal into a horizontally and vertically interlaced wideband luminance signal having four fields per frame and a frame duration of about 1/15 second. Within the luminance scan converter, the picture-element sampling signal is shifted in phase by 180° every row interval. The phase is advanced by an additional 90° during fields 2 and 4 with respect to fields 1 and 3, respectively.

In field 1, the picture elements are sampled in the following sequence: row 1, columns 1, 5, 9, 13 ...; row 3, columns 3, 7, 11, 15 ...; row 5, columns 1, 5, 9, 13 ...; and so forth. In field 2, the sequence is as follows: row 2, columns 2, 6, 10, 14 ...; row 4, columns 4, 8, 12, 16 ...; row 6, columns 2, 6, 10; and repeated similarly for the rest of the even-numbered rows and columns. Likewise, in fields 3 and 4 the remaining odd and even picture elements, respectively, are sampled at four-column intervals in each row.

The color-difference scan converters process the two horizontally and vertically progressive wide-band color-difference signals into two horizontally and vertically interlaced narrow-band color-difference signals. The picture elements are sampled in contiguous groups of seven odd or even columns in each row. The color-difference value is averaged over the seven columns to obtain a single value for each group and assigned to the physical position of the element in the column at the middle of the group. The groups are sampled in zigzag, interlaced fashion in a manner similar to that of the luminance signal.

The two horizontally and vertically interlaced outputs of the color-difference scan converters are used to modulate a chrominance subcarrier. The resulting chrominance signal is combined with the horizontally and vertically interlaced output of the luminance scan converter to form the composite color signal. Standard blanking, synchronizing, color-burst, equalizing, and vertical-interval-reference signals are added for NTSC standard transmission. The transmitted signal can be used as is by an NTSC standard receiver. However, for further reduction of chrominance/luminance crosstalk, the receiver can use scan converters to recover the horizontally and vertically progressive scans in displaying the red, green, and blue images.

This work was done by R. H. Marchman of Lockheed Corp. for **Kennedy Space Center**. *For further information, Circle 51 on the TSP Request Card.* KSC-11359



The **Picture Elements** are arranged in a zigzag pattern to accommodate the scanning sequence.

Semiautomated Management of Arriving Air Traffic

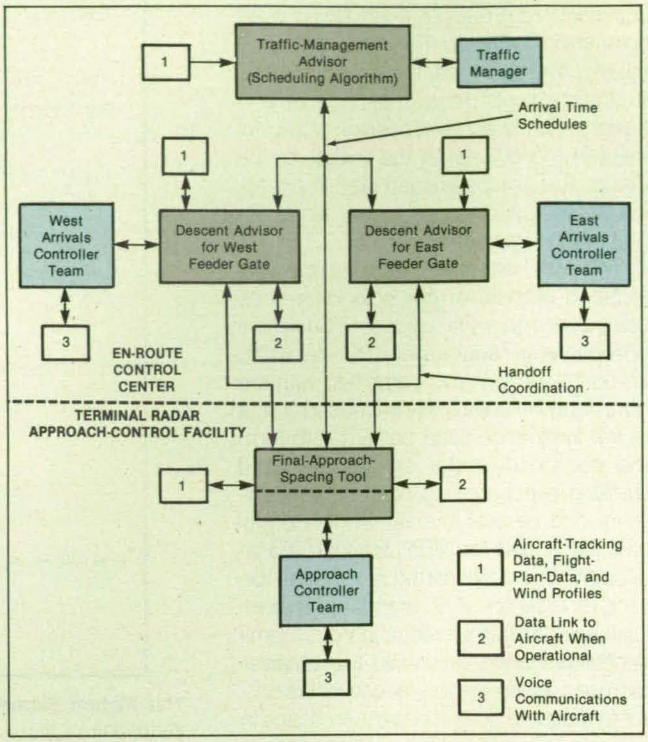
An integrated system of hardware and software provides a hierarchy of advisory information.

Ames Research Center, Moffett Field, California

A system of computers, advanced color graphical computer workstations, and specialized computer programs is being developed for the semiautomated management of the approach and arrival of numerous aircraft at an airport. The system is designed with high regard for human factors and is not intended to restrict the decisions of air-traffic controllers. On the contrary, it is intended to assist them by providing a hierarchy of advisory information that they can use, according to their best judgement, to achieve the safe, orderly, and expeditious movement of traffic.

The system comprises three interconnected subsystems: the traffic-management advisor, the descent advisor(s), and the final-approach-spacing tool. The traffic-management advisor includes algorithms, a graphical interface, and interactive software tools for use by the traffic manager at the control center in controlling the flow of traffic into the terminal area. The primary algorithm is a real-time scheduler that generates efficient landing sequences and landing times for approaching aircraft that are within about 200 nmi (370 km) from touchdown. The graphical interface enables the traffic manager to modify the computer-generated schedules for specific aircraft while allowing the automatic scheduler to continue generating schedules for all other aircraft. The graphical interface also provides convenient methods for monitoring the traffic and changing scheduling parameters during operation.

The descent advisor(s) generate(s) information that is integrated into a plan-view display of traffic on a high-resolution color monitor. Estimated arrival times of aircraft are presented graphically on a time line, which is also used interactively in combination with a mouse input device to select and schedule times of arrival. Other graphical markers indicate the locations of fuel-optimum top-of-descent points and the separation distances between aircraft at designated points. Advisory notices generated by computers provide speed and descent clearances, which the controller can issue to pilots to help them arrive at the scheduled times or with specified separation distances. Any of several horizontal guidance modes, selectable by the controllers, provides advisories for managing the horizontal flightpaths of aircraft under various conditions.



This **System of Computers and Displays**, which interfaces with existing sensors and air-traffic-control equipment assists controllers in the management of heavy arriving air traffic.

The final-approach-spacing tool is used by the controllers at the terminal radar approach-control facility. These controllers assume responsibility for each aircraft when it arrives at a feeder gate, which is a designated point in the sky about 30 nmi (56 km) from the airport at an altitude of 10,000 ft (3 km) above the ground. These controllers merge the traffic converging on the final approach path while making sure that aircraft are properly spaced. If the controllers at the control center have delivered aircraft to the feeder gates on time by use of the descent advisor, the controllers at the terminal radar approach-control facility will ordinarily need to make only small corrections in the relative positions of aircraft to obtain the desired spacing. The final-approach-spacing tool assists the controllers in making these corrections with high accuracy and a minimum number of heading vectors and speed clearances. The precise spacing of aircraft on final approach will ensure that the rate of landing will be close to the theoretical capacity of the runway. Another subsystem helps controllers to replan traffic quickly in response to missed approaches, changes in runways, and unexpected conflicts.

This work was done by Heinz Erzberger of **Ames Research Center** *and William Nedell of San Jose State University. Further information may be found in NASA TM-102201 [N89-24290], "Design of Automated System for Management of Arrival Traffic."*

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

ARC-12631

Onboard System Processes SAR Data

Data can be assessed almost immediately instead of after days or months of postflight analysis.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Aircraft Flight Correlator (AFC) is a computing system that is mounted in an airplane along with the AIRSAR synthetic-aperture-radar (SAR) system operated by NASA's Jet Propulsion Laboratory. Heretofore, the SAR data have been recorded on high-density digital tape for postflight (only) analysis, which took days or months. The AFC supplements the recording and postflight analysis, processing a portion of the stream of SAR data in real or nearly real time to provide limited imagery for rapid evaluation, thereby facilitating diagnosis of the SAR equipment or adjustment of the parameters of the SAR experiment

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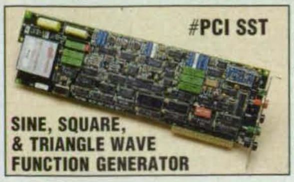

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For More Information Circle No. 366

COMMUNICATIONS

Opto-Isolated RS-422 Converter Protects Your PC

Your computer can be protected at the power supply, but suffer a devastating shock from power surges picked up over long data lines. The **COMH 262** converter module from **Telebyte Technology** serves double-duty, providing both high-speed RS-232 to RS-422 conversion *and* optical isolation.

- **Optical isolation exceeds 10,000 Volts**
- Earth ground connection
- Switch selection of DCE or DTE
- LED status indicators on data lines
- Wall transformer powers the unit
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- RS-232 Connector: DB-25 (select Male/Female)
- RS-422 Connector: 4 screw terminals + ground

#COMH 262	Isolated RS-232 to RS-422 Converter Module	**$139**

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- Complete with *Easy Sense* Menu-Driven Software, Drivers in BASIC & C, and a specially-designed Screw Terminal Panel.

#UPC 601	20 KHz Direct Sensor Input Card w/Software & Term. Panel	**$1795**
#UPC 608	20 KHz Direct Sensor Acquisition Card with 2 D/A's & 16 DIO's	**$2395**

For More Information Circle No. 360

RACK-MOUNT COMPUTERS

Elma Rack-Mount Keyboards

If you use a standard keyboard with your rack-mount system, you know what a nuisance and a hazard it can be. These industrial keyboards are designed to fit easily into any EIA 19" rack. Rugged and reliable, these keyboards are made in the U.S.A. by a Swiss electronics company & demonstrate classic Swiss craftsmanship.

- 101-key layout & full-travel construction with tactile feel for touch-typing
- **#OIX 3010** drawer-mounted/**#OIX 6010** (shown) slides out with locking door
- Occupies only 1 rack space (1.75" high)

#OIX 3010	Low-cost, Drawer-Mounted Rack-Mount Keyboard	**$295**
#OIX 6010	Slide-out, Rack-Mount Keyboard w/locking drawer	**$395**

For More Information Circle No. 373

Low-Cost Multiplexers Provide More Channels

Taking measurements to ensure that a process is within specifications can often involve far more than the 16 sensors a data acquisition board is designed to monitor. If you have 40 test points, you'd normally need three LSDAS-16 boards to monitor all of them.

Now **Analogic** has a more affordable solution. The new **MUX 16TC** multiplexes 16 differential low-level analog signals to one A/D board channel. **MUX 16TCEX** panels may be daisy-chained off of the **MUX 16TC** to provide *up to 128 channels* in all, sampled by a single **HSDAS** or **LSDAS** data acquisition board. The **MUX 16TC** allows full access to the remaining A/D, D/A, & Digital I/O channels on your DAS board, with CJC on either a DAS board input or a multiplexer channel. C software libraries included.

#MUX 16TC	16-Channel Thermocouple/Low-Level Analog Multiplexer	**$399**
#MUX 16TCEX	16-Channel Extension Multiplexer Panel (for inputs #17-128)	**$325**

For More Information Circle No. 365

Rugged, Industrial Rack-Mount PC's

These are the toughest PC's available **anywhere**. Each unit includes such features as: A heavy steel chassis to eliminate EMI/RFI problems, a 12-slot passive backplane, a single-board CPU which protects system components from shock and vibration, and a protective door to cover the disk drive opening. Additional protective features include a shock-isolated mounting panel for a 3.5" hard drive, an industrial-quality power supply to provide line filtering with surge suppression, and dual fans to pull air through a modacrylic filter.

#IPC 386-25S	Industrial Rack-Mount 25 MHz 80386sx Computer	**$2995**
#IPC 386-33	Industrial Rack-Mount 33 MHz 80386 Computer	**$3695**
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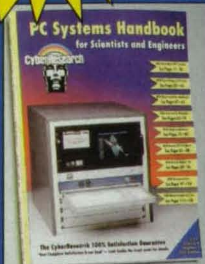
For More Information Circle No. 366

FREE PC Systems Handbook for Scientists & Engineers



This Combination Tutorial/Catalog Includes Many Examples of PC-based Systems

The CyberResearch *PC Systems Handbook for Scientists & Engineers* describes over 1400 unique and hard to find items for PC-based engineering. Packed with useful technical information and easy-to-read diagrams, this invaluable reference should be part of every engineer's library.

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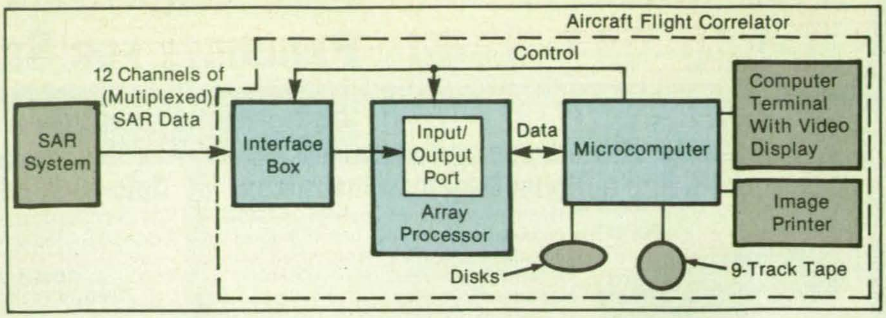
(e.g., aircraft trajectory or polarizations of the radar signals). The AFC can also be used as an aid to navigation.

The AIRSAR operates in 4 combinations of transmitting and receiving polarizations at each of 3 frequencies, yielding SAR data in a total of 12 channels. A principal component of the AFC is the interface box, which is a custom-made digital subsystem that acts as an "intelligent" interface between the 12 channels of the AIRSAR system and the rest of the AFC (see figure). The interface box can be programmed to demultiplex and synchronize the "live" signal from 1 of the channels or to pass along all 12 signals to the input/output port of a 40-Mflop array processor that augments a microcomputer. In addition, the signals are always passed to the high-density recorders for conventional recording to allow postflight processing. The microcomputer in the AFC is equipped with (in addition to the array processor) three 1.2-Gbyte disks, a 9-track tape drive, a text printer, a gray-level image printer, and a video image-display subsystem.



The **Aircraft Flight Correlator** processes data from 1 of 12 SAR channels into lower-resolution imagery in real time or higher-resolution imagery in nearly real time.

The real-time data rate of the AIRSAR system is limited, by the capability of the high-density digital recorders, to 10 Mbytes/s. The data rate of the AFC is limited, by the capabilities of the bus and disks of the microcomputer, to about 1 Mbyte/s. However, the interface box and the interface between the input/output port and memory of the array processor can handle data at rates up to 10 Mbytes/s. If data are to be stored on a disk in real time, the rate at which data come out of the array processor — i.e., processed data — must be reduced by a factor of about 10.

The AFC has been programmed in FORTRAN. Subroutines that run on the array processor are also programmed in FORTRAN, with calls to scientific subroutines provided by the manufacturer of the array processor. At present, the software provides for operation in either of two modes: One is the "quick-look" mode, in which the data from one of the channels are recorded on disk for 68 seconds, then processed in about 10 minutes into a high-resolution image, which can be displayed on the video terminal and/or printed by the gray-level printer. The other mode is the "real-time" mode, in which the data from a selected channel are processed in real time to a reduced resolution consistent with the capability of the array processor. In this mode, the stream of output data is reduced by filtering and/or look summation to a rate within the capability of the disks.

This work was done by Richard E. Carande of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 38 on the TSP Request Card.*
NPO-18252

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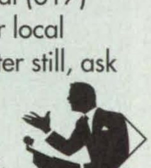

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Books and Reports

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.

Spaceborne Radar Would Measure Rain and Clouds

Measurement data would contribute to understanding of atmospheric phenomena.

A report describes the conceptual design of a spaceborne radar system that would map precipitation (principally, rain) and clouds at mid-latitudes. The proposed system would be placed in operation shortly after the year 2000, to provide data for a program of research on global weather and climate.

The system would include one satellite placed in a precessing orbit of 60° inclination at an altitude of 400 km. In principle, global coverage with adequate space-time sampling would require two satellites in polar orbit at a greater altitude, but this would cost too much. The proposed single-satellite system would cost less, yet provide adequate diurnal sampling over a period of about 6 weeks. The system would not scan the entire Earth, but the resulting loss of data may be acceptable because the portions poleward of ±60° account for only about 5 percent of the global precipitation.

The radar would operate at two frequencies. The lower frequency, 35 GHz, would provide vertical profiles of rainfall at rates up to about 20 mm/h and would enable the probing of cirrus clouds but would be inadequate for quantitative measurement of the reflectivities of stratus clouds. The higher frequency, 94 GHz, would enable the detection and quantitative measurement of clouds of all types and would provide rain profiles at rates up to about 10 mm/h.

The dual-frequency beam would be transmitted and received by a fixed cylindrical-reflector antenna with an aperture of 5 m by 5 m and steered electronically by use of a phased array of radiating elements. After pulse averaging to enhance the detection sensivity, the system would achieve a horizontal resolution of 4 km in a swath 300 km wide across the ground track, and a vertical resolution of 500 m.

The radar system should be able to detect precipitation at the tops of rain cells (at the bases of clouds) ranging from light (0.1 mm/h) to intense (100 mm/h) and precipitation on the ground at rates from 0.1 mm/h to the aforementioned moderate rate of 20 mm/h. The radar system should be able to detect virtually all cloud systems. By taking averages of about 100 independent samples of radar data, it should

A Gold Mine Of Ideas

This December, the nation's top technology managers will gather in Baltimore, MD to explore a gold mine of innovative ideas they can use to solve engineering problems, create new products, and help their businesses grow.

The event is Technology 2002, and you are invited.

Sponsored by NASA and *NASA Tech Briefs* magazine, Technology 2002 is more than a conference...more than a trade show...it is a vital resource that will put you in direct contact with the premier technology developers and tech transfer experts in federal laboratories and industry.

Technology 2002 will show you how to tap into the government's $70 billion technology storehouse and turn taxpayer-supported innovations into profitable products. And it will alert you to a wealth of patent licensing and cooperative R&D opportunities in areas defined by the White House as critical to the nation's future.

You can attend dozens of meetings this year and spend countless hours searching for new ideas to improve your business...or you can invest three days at Technology 2002 and discover — in one place, at one time — the best technology America has to offer.

Technology 2002 will feature:

▲ Over 100 presentations spotlighting important new inventions in Materials, Manufacturing, Information and Communications, Biotechnology and Life Sciences, and Energy and Environment — areas defined as National Critical Technologies;

▲ Information-packed sessions on university-based and international technologies U.S. industries can use to bolster their competitiveness and productivity;

▲ A special workshop on how to do business with federal agencies and laboratories, covering patent licensing, cooperative R&D agreements, and Small Business Innovation Research grants;

▲ 60,000 square feet of exhibits by govt. agencies, their prime contractors, and other high-tech companies, universities, and state organizations with cutting-edge innovations available for license or sale;

▲ The third annual Technology Transfer Awards Dinner, offering an unparalleled opportunity to network with government leaders and industry executives in an elegant setting—the Hyatt Regency's Grand Ballroom. Norman Augustine, CEO of Martin Marietta Corp., will be the dinner speaker.

Technology 2002 Program

Tuesday, Dec. 1	
8:30 - 9:45 am	Welcome and Keynote Address
10:00 - 11:30 am	National Critical Technologies (6 Tracks)
1:00 - 3:00 pm	National Critical Technologies
4:00 - 6:00 pm	Workshop: How To Do Business With The U.S. Government

Wednesday, Dec. 2	
8:30 - 8:55 am	Wednesday Keynote Address
9:00 - 11:00 am	National Critical Technologies (6 Tracks)
1:00 - 3:00 pm	National Critical Technologies
4:00 - 6:00 pm	University Technology Transfer Opportunities (Track #1) International Technology Forum (Track #2)
7:00 - 10:00 pm	Technology Transfer Awards Dinner

Thursday, Dec. 3	
8:30 - 8:55 am	Thursday Keynote Address
9:00 - 11:00 am	National Critical Technologies (6 Tracks)
1:00 - 3:00 pm	University Technology Transfer Opportunities (Track #1) International Technology Forum (Track #2)

Exhibit Hall Hours

Dec. 1-3: 10:00 am - 5:00 pm

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Mail your completed preregistration form with check or money order (if applicable) payable to the Technology Utilization Foundation, or fax it with credit card data to (212) 986-7864. To register by phone, call (800) 944-NASA. Government organizations may register using a purchase order. Deadline for preregistration is November 20.

Choose from four types of registrations:

- ▲ Complete registration—includes symposia, workshops, and exhibits for all three show days; tickets to the opening reception on Monday evening, Nov. 30 and to the Awards Dinner on Wednesday, Dec. 2; and a set of the official Technology 2002 proceedings;
- ▲ Three-Day Symposia/Exhibits—covers symposia, workshops, and exhibits Tuesday through Thursday;
- ▲ One-Day Symposia/Exhibits;
- ▲ Exhibits Only.

Early-Bird Bonus: The first 100 paid registrants will receive a complimentary Technology 2002 T-shirt.

	By 11/20	On-Site
Complete Registration	$240	$285
Three-Day Symposia/Exhibits	$150	$195
One-Day Symposia/Exhibits	$75	$95
Exhibits Only	— No Charge —	

Additional tickets to the Awards Dinner may be purchased for $95 using the preregistration form or by calling (800) 944-NASA.

Special Hotel Discounts

Hotel space is limited, so act early to secure these special conference rates:

	single	double
Hyatt Regency (headquarters hotel) (800) 233-1234	$103	$115
Holiday Inn (301) 685-3500	$63	$64
Omni Inner Harbor (800) 843-6664	$63	$63

The Hyatt is connected by walkway to the convention center; the other hotels are in easy walking distance. When making reservations, you must identify yourself as a participant in the Technology 2002 conference to receive the special rates.

For more information about Technology 2002, or to find out how your company can exhibit at this important national event, call Wendy Janiel or Joseph Pramberger at (800) 944-NASA.

Technology 2002
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❑	Complete Registration	$240
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❑	Exhibits Only (circle day(s): Tues. Wed. Thurs.)	Free
❑	Awards Dinner only (number of tickets: ______)	$95

Total: $____________

Registrations and Awards Dinner reservations are transferable, and may be cancelled until November 20, 1992 subject to a $50 cancellation fee. After that date no cancellations will be accepted and no money refunded.

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be possible to estimate reflectivities to accuracies of better than 20 percent. Other characteristics, such as the heights of clouds, the thicknesses of clouds and rain cells, and the horizontal extents of cells, could also be extracted from the data.

Some extension of present technology would be required to implement the proposed radar system. It would be necessary to develop 2.5-W, 35-GHz solid-state transmitting/receiving devices, which would be embedded in elements of the feed array (at present, a typical device capable of operating at 35 GHz puts out only 0.5 W). Power supplies rated at 40 kW and packaging for electron-beam amplifiers operable at 94 GHz must be designed for the particular spaceborne application. A quasi-optical feed and distribution network must be developed. Finally, there is a need to develop an electronic subsystem and computer program to compensate for phase distortion produced by the antenna structure.

This work was done by Eastwood Im and Kent H. Kellogg of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Spaceborne Radar for Rain and Cloud Measurements — a Conceptual Design," Circle 43 on the TSP Request Card.*
NPO-18274

Digital Extraction of Doppler Shift in an Advanced Receiver

The ARX II outperformed the Block IV receiver.

A report describes a demonstration of the ability of the Advanced Receiver II (ARX II) to extract Doppler shifts in radio telemetry signals from spacecraft by digital processing. The ARX II is the successor to the ARX I, which was unable to extract the Doppler shift because the frequency of its sampling clock was not fixed but was, instead, an integer multiple of the telemetry-symbol rate.

In the ARX II, the frequency of the sampling clock is fixed and is derived from a frequency-and-timing subsystem. Although this can result in a noninteger number of samples per symbol, it enables the digital extraction of the Doppler shift. The ARX II includes a phase-locked loop that tracks the residual carrier component of the received signal. The loop can be closed by analog or digital means, switching between them by means of a software command. In digital extraction of the Doppler shift, the estimate, by the phase-locked loop, of the phase of the incoming waveform is "tagged" with time according to the frequency-and-timing subsystem.

In the demonstration, the ARX II was operated along with an older receiver of a type called "Block IV." Both receivers were operated simultaneously, tracking signals from the Pioneer 10 and the Voyager 2 spacecraft. The Doppler-tracking outputs of the receivers were recorded along with other data relevant to performance. The recorded data were analyzed, using the Allan variances of the Doppler residuals as measures of performance. [The Doppler residual is defined by

$$f_{\Delta} = f_{DO} - f_M - f_T$$

where f_{Δ} is the Doppler residual, f_{DO} is the Doppler observable (the Doppler shift as indicated by the output of the receiver), f_M is the Doppler shift computed from a mathematical model of the trajectory of the spacecraft), and f_T is the correction for the effect of propagation of the signal through the troposphere.] The analysis showed that the ARX II performed at least as well as, and in most cases better than, the Block IV receiver did.

This work was done by Sami M. Hinedi, Peter W. Kinman, Roland P. Bevan, Hector M. Del Castillo, and Remi C. La Belle of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Digital Doppler Extraction Demonstration With the Advanced Receiver," Circle 88 on the TSP Request Card.*
NPO-18199

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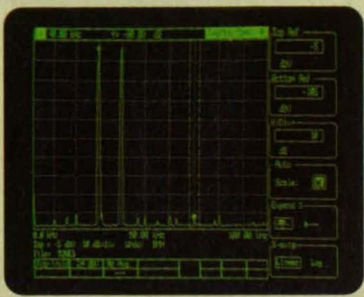
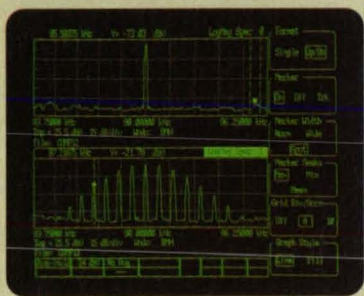


Analysis Capabilities

Easy to use analysis functions are included. Data tables monitor up to 200 frequencies.

Spectral Comparisons

Menu selected math operations can be used to measure spectral differences.



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For More Information Circle No. 445

Physical Sciences

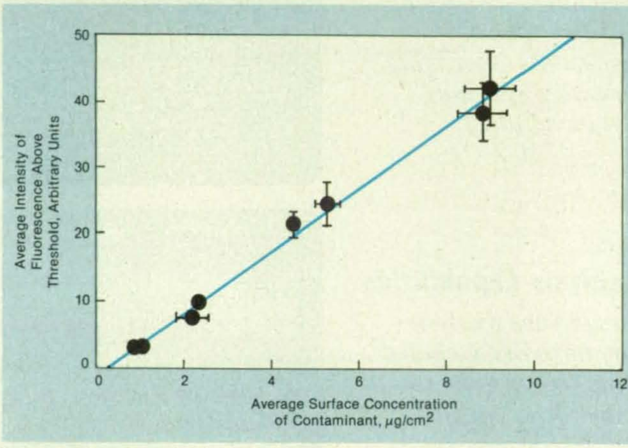
Fluorescence Imaging Reveals Surface Contamination

Contaminants are illuminated with ultraviolet light to make them fluoresce.

Marshall Space Flight Center, Alabama

In a technique to detect surface contamination, the object to be inspected is illuminated by ultraviolet light to make the contaminants fluoresce, and a low-light-level video camera is used to view the fluorescence. The source of ultraviolet light is a 100-W mercury discharge lamp. Optical interference filters allow the fluorescence light to travel to the camera lens while blocking scattered or ambient light. Image-processing techniques enable quantification of the distribution of contaminants on the inspected surface. If the intrinsic fluorescence of a material that is expected to contaminate a surface is not intense enough, that material can be tagged with a low concentration of a fluorescent dye.

In experiments designed to test the sensitivity of this technique, low-level contamination of the surface of a clean, sandblasted mild steel plate was simulated by the application of anticorrosion oil doped with dye at 200 parts per million and applied in a solvent that then evaporated. As shown in the figure, this procedure resulted in the detection and quantification of contaminant surface concentrations as low as 2 μg/cm². In this case, doping with fluorescent dye increased the detection efficiency by a factor ≥ 40; oil without dye was detected at approximately 80 μg/cm².



Tests Using Anti-corrosion Oil Doped With Fluorescent Dye indicated that contaminants in surface concentrations as low as 2 μg/cm² can be detected by this technique.

This work was done by Richard Schirato and Raulf Polichar of Science Applications International Co. for **Marshall Space Flight Center**. *For further information, Circle 156 on the TSP Request Card.*
MFS-28615

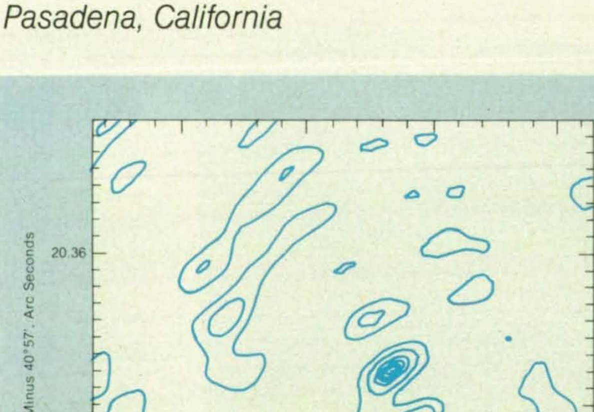
Stronger Source as Reference for Weaker Source in VLBI

The stronger source serves as a phase reference, enabling longer observations.

NASA's Jet Propulsion Laboratory, Pasadena, California

Observation of a weak astronomical radio source [e.g., a star, pulsar, or quasi-stellar radio source (quasar)] by very-long-baseline interferometry (VLBI) can be enhanced by using, as a phase reference, a relatively strong astronomical radio source that lies within a small angular distance from the weak source. This is a variant of a technique that has been used in geodesy to determine movements of surface points via measurements of differences between times of arrival of signals from the same quasar at those points.

The limit upon the sensitivity of a VLBI array is imposed by the limit on the observation time during which signal data can be integrated. The observation time must be limited to prevent the loss of coherence that would otherwise be caused by fluctuations in the troposphere and instabilities in the independent clocks used in the stations of the VLBI array. Consequently, a weak radio source for which the required



This **"Dirty Map"** of the radio appearance (at 5 GHz) of the stellar system Algol was made with the help of the nearby (in terms of viewing angle), stronger extragalactic radio source 0309+411, which was used as a phase reference. Contour levels are 20, 57, 75, 85, 90, 95, and 99 percent of the peak.

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For More Information Circle No. 646

signal-to-noise ratio cannot be built up by integrating over a coherence time of a few minutes cannot be observed by conventional VLBI.

In this VLBI technique, the strong source and the weak source are observed alternately for a few minutes each during an entire measurement session, which can last several hours. The observations of the strong source make it possible to monitor the fluctuations in the troposphere and instabilities in the clocks. Direct detection of signals from the strong source provides reference delays and rates of change of delays that can be used to integrate the instantaneous radio visibilities of the weak source during each observation period of a few minutes. The integrated visibilities are then added coherently over the entire measurement session, using the observed phases of the strong source as references. The addition is done by Fourier inversion of the integrated visibilities to produce a phase-referenced "dirty map" that shows the weak source in angular coordinates of right ascension and declination relative to the angular coordinates of the strong source.

The technique was applied in observations of the stellar system Algol (see figure). The reference source for these observations was the extragalactic radio source known as 0309+411, which lies about 1° away in the field of view. These sources were monitored for 7 h at a frequency of 5 GHz at radio observatories in California, New Mexico, West Virginia, Massachusetts, and Germany. The measurements were conducted on a cycle of 150-s integration of time for Algol, 30-s time to slue the antenna, and 120-s integration time for 0309+411. The combination of the individual VLBI observations yielded an effective coherent integration time of 4.2 h for Algol, with a consequent effective signal-to-noise ratio of 12.

This work was done by Jean-Francois Lestrade and Robert A. Preston of Caltech and A. E. E. Rogers, A. R. Whitney, A. E. Neill, and R. B. Phillips of Haystack Observatory for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 165 on the TSP Request Card.*
NPO-18165

Fields of View of X-Ray-Telescope Collimator Tubes

The shape of a tube may be important in screening out background radiation.

Goddard Space Flight Center, Greenbelt, Maryland

A theoretical analysis was conducted to determine the fields of view and the irradiation patterns of collimator tubes of various shapes, on the assumption that no radiation penetrates the walls of the tubes. The results of the analysis indicate that, while the background flux incident on the surface at the outlet end of a tube is determined mainly by the ratio between the diameter and length of the tube, the shape of the cross section of the tube may also be important.

In conducting such an analysis, which is applicable to a tube of any cross-sectional shape, one first derives an equation for the two-dimensional shape of the field of view. Because the outlet end of the tube is not merely a point but has a finite area, the shape of the field of view is not necessarily the same as that of the cross section of the tube. For example, the field of view of a tube of triangular cross section is hexagonal, but the field of view of a tube of square or hexagonal cross section is square or hexagonal, respectively.

Next, one calculates how the received flux depends on the direction of the inci-

dent radiation. For this purpose the direction of incidence is specified by (1) its "zenith" angle, measured from the axis of the tube, and (2) its "azimuth" angle, measured around the axis of the tube. A question of particular interest is how the received flux, integrated over the zenith angle (across the field of view), varies as a function of azimuth. This would be a factor to consider if the axis of the tube were pointed stably in a given direction but the tube remained free to rotate about the axis. In such a case, the variation of the received flux with changes in azimuth would give rise to a variation in the ratio between the signal flux and the background flux, which variation might complicate the analysis of measured fluxes.

Calculations of the azimuthal variation of received flux were carried out for a few selected shapes, on the assumption that the background radiance is constant over the field of view. Of course, if the radiance were constant, the total received flux, integrated over the entire field of view, would not depend on the azimuthal orientation of the tube, but the azimuthal variation would still provide a meaningful measure of the effective deviation of the tube from circularity. (For a circular tube, the total received flux would not depend on the azimuthal orientation, even if the background radiance were nonuniform over the field of view.)

The results of the calculation show that, for an equilateral triangular shape, a variation of about 16.6 percent can be expected; for a square shape, the variation should be about 3.9 percent; for a regular hexagonal shape, it is expected to be about 0.7 percent. Thus, a hexagonal shape is clearly better than a square shape, as would be expected. However, if the degree of variation is not critical, then a square shape might be considered; this could be so especially if, for example, it is easier to fabricate an array of square tubes than to fabricate an array of hexagonal ones.

This work was done by Harvey G. Safren of **Goddard Space Flight Center**. *No further documentation is available.*
GSC-13429

Self-Collimating Unstable-Resonator Diode Lasers

External collimating optics would not be needed.

NASA's Jet Propulsion Laboratory, Pasadena, California

Unstable-resonator diode lasers of a proposed type would produce collimated output beams without the help of external collimating optics. Heretofore, most unstable-resonator diode lasers have included diverging and/or flat mirrors, which give rise to strongly divergent output beams that must be collimated externally. One device proposed in 1986 would include confocal internal mirrors configured to produce a collimated beam without external optics, but the beam would have a hole in the middle. The new proposed lasers would produce solid beams and would be somewhat simpler to construct (see Figure 1). There is a large potential market for these single-lateral-mode diode lasers, which would operate at powers of ½ to 10 W: they could be used as pumps for optical-fiber amplifiers in telecommunications, pumps for other solid-state lasers, and sources of light for free-space communications.

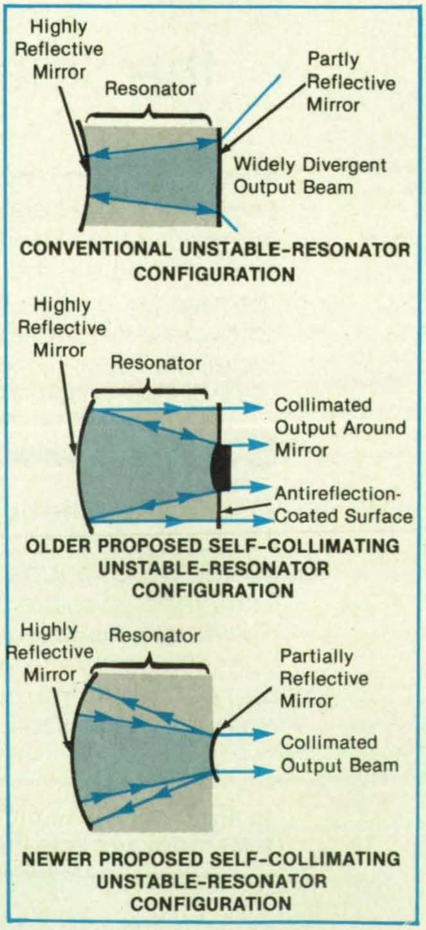
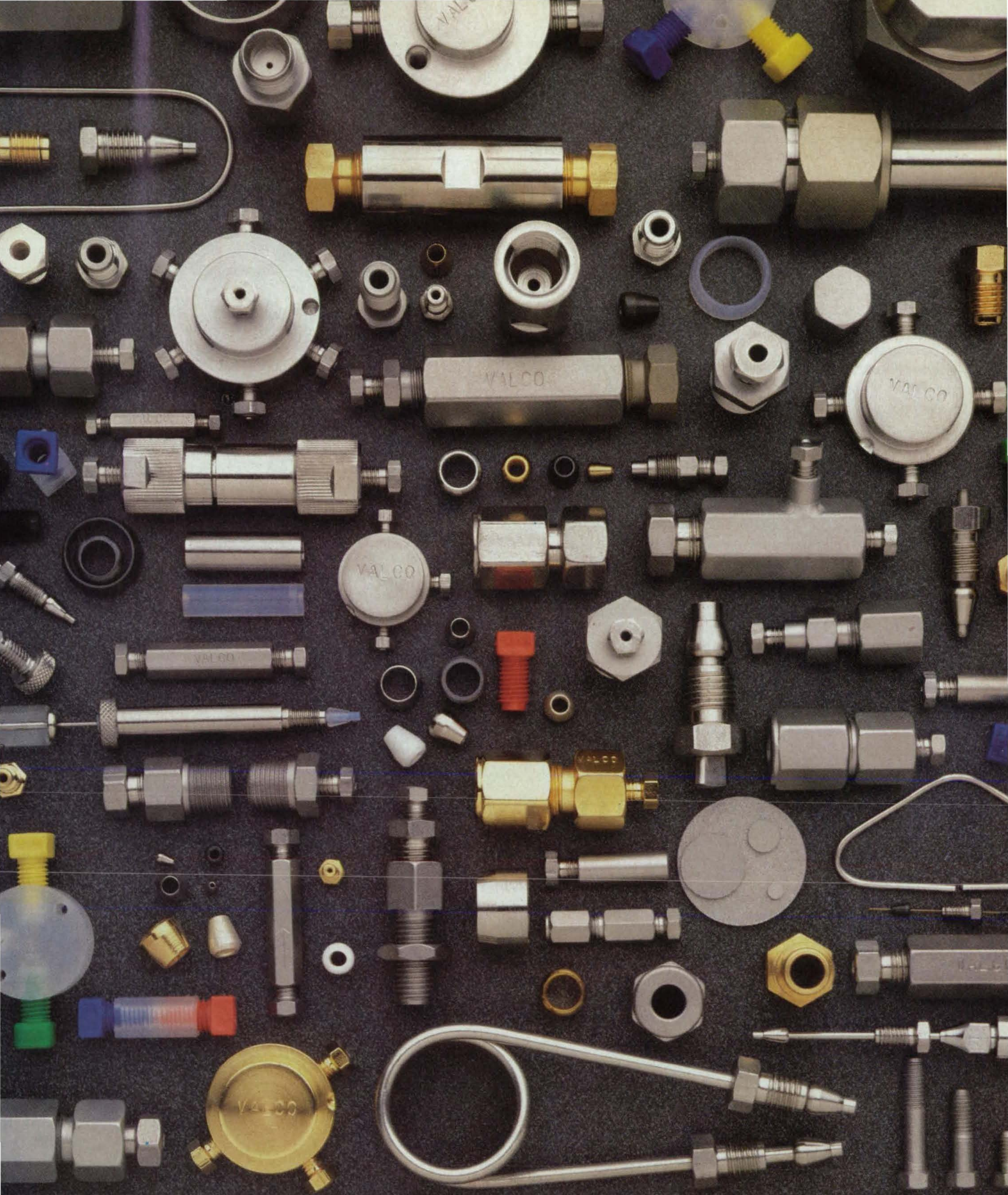


Figure 1. **These Three Mirror Configurations** of unstable-resonator diode lasers collimate the output beams in different ways.



A laser of the new type would include a highly internally reflective mirror facet of larger radius R_1 and an anti-reflection-coated (partly reflective) output mirror facet of smaller radius R_2 (see Figure 2). The design of the laser involves calculations of the relationships among R_1; R_2; the longitudinal distance, ℓ, between mirror facets; the widths and angles of convergence or divergence of the beam at various locations; and the index of refraction, n, of the laser-resonator material. Given n, one chooses R_1, R_2, and ℓ to satisfy (1) the geometrical constraints on an unstable resonator; (2) the requirement that the output beam refracted through the R_2 surface be a narrow, diffraction-limited, collimated beam; and (3) the requirement that the beam not come to a focus within the laser resonator.

Calculations for an AlGaAs laser like the one shown in Figure 2 show that a self-collimating unstable resonator without an internal focal spot is possible if the magnification is chosen to be less than 1.833. The lower part of Figure 2 shows the relative dimensions at a magnification of 1.5.

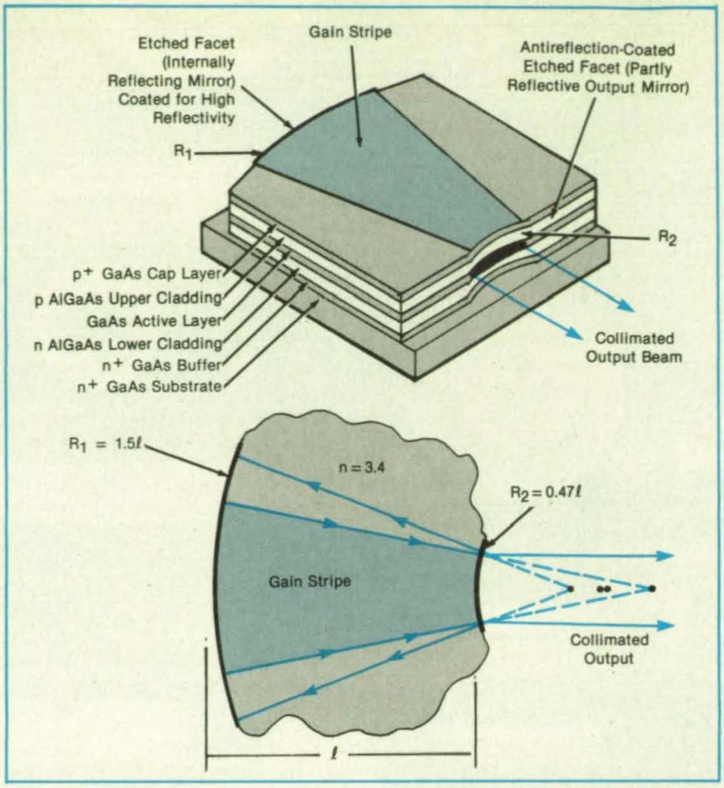


Figure 2. This **AlGaAs Laser** exemplifies the proposed self-collimated, unstable-resonator concept.

This work was done by Robert J. Lang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 69 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-18386.

Magnetic Lens for Plasma Engine

Electromagnet coils would reduce the divergence of the plasma beam.

NASA's Jet Propulsion Laboratory, Pasadena, California

Low-field electromagnet coils placed slightly downstream of a plasma engine, polarized oppositely to a higher-field but smaller radius coil in the nozzle of the engine, would reduce the divergence of the plasma jet generated by the engine, according to new calculations. It is desirable to reduce the divergence because so doing increases the fraction of the total kinetic energy directed along the axis of the engine, thereby increasing the efficiency of the engine.

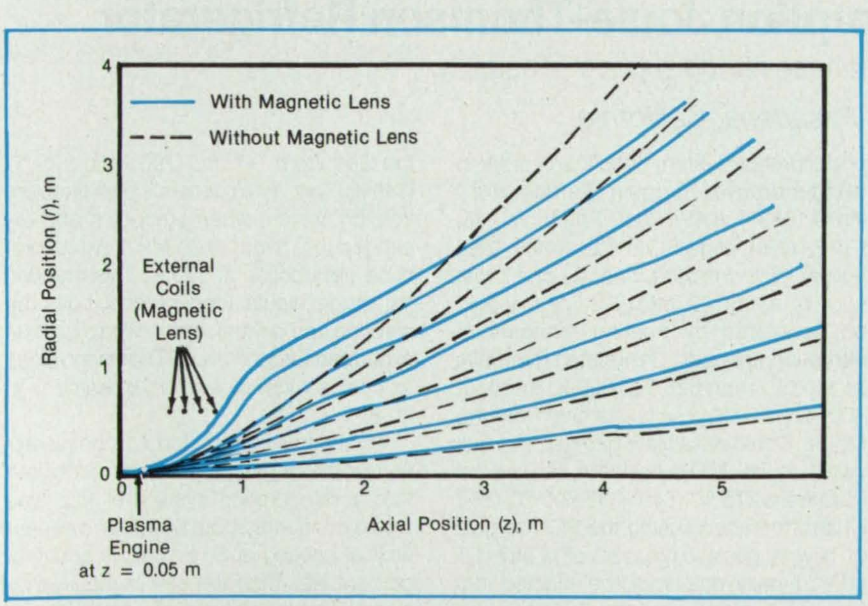
The concept was tested by computer simulation based on a simplified mathematical model of the plasma, engine, and coils. The plasma was assumed to be cold, collisionless, and quasi-neutral. The effects of random thermal energy were neglected, consistent with the cold-plasma approximation, except that the energy associated with the electron cyclotron motion (with small Larmor radii) was taken into account because this motion imparts diamagnetism to a plasma. The motion of the plasma was treated by the Lagrangian formulation of fluid mechanics for an electron fluid and an ion fluid that interact via an induced ambipolar field to enforce the quasi-neutrality.

The engine, plasma, and coils were taken to be axisymmetric. The equations of motion were written in the r, θ, z (radius from the z axis, azimuthal angle about the z axis, distance along the z axis) coordinate system. Because of the axisymmetry, the electrical current in the plasma was taken to flow in the azimuthal direction only; because of the quasi-neutrality, the r and z coordinates of the ion and electron fluid elements were taken to be equal. These assumptions resulted in a set of ordinary first-order differential equations that were amenable to numerical solution by computer.

The engine was assumed to be located at $z = 0.05$ m and to generate a plasma with initial electron kinetic energies of 200 eV. The electromagnet coil in the nozzle of the engine was assumed to have a radius of 0.2 m and a current of 2.5×10^4 A. Each external (magnetic-lens) coil was assumed to have a radius of 0.6 m and a current of -100 A; there were assumed to be four such coils, located at $z = 0.4$, 0.525, 0.65, and 0.775 m.

The equations of motion were solved numerically, with and without the current in the external coils, to obtain streamlines of seven plasma fluid elements. The seven streamlines started from $z = 0.05$ m and from $r = 0.005$, 0.010, 0.015, 0.020, 0.025, 0.030, and 0.035 m. The figure is a plot of the computed trajectories. The trajectories are noticeably less divergent in the presence of the magnetic lens.

This work was done by Joel C. Sercel of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 147 on the TSP Request Card. NPO-18188*



Computed Trajectories of fluid elements representing plasma flowing fron a plasma engine show the converging effect of the magnetic lens.

Compact Visible and Infrared Spectrometer

This small, lightweight spectrometer covers wavelengths from 3,700 to 11,700 Å

Marshall Space Flight Center, Alabama

Compact spectrometers of a new type operate over broad wavelength ranges with moderate spectral resolution. The prototype is designed to measure the spectral intensity simultaneously at all wavelengths from 3,700 to 11,700 Å, with a resolution of about 12 Å. This instrument is readily portable: it weighs only 15 kg and fits within an envelope of 37 by 37 by 48 cm. Heretofore, one or more larger, heavier spectrographs, possibly equipped with scanning mechanisms, would have been necessary to obtain spectral coverage like that of this instrument.

As shown in Figure 1, light from the source to be analyzed enters the instrument through a rectangular hole in a baffle and strikes an off-axis paraboloidal mirror, which images the field of view onto an entrance slit. The slit is followed in the optical train by four side-by-side concave laser-ruled holographic diffraction gratings, each of which is independently adjustable and optimized for a 2,000-Å portion of the overall 8,000-Å wavelength range. Each grating is corrected for aberrations and acts as a dispersing, focusing, and field-flattening element combined into one.

The portion of the spectrum from each grating is focused onto one of four strips on a 40-mm-diameter photocathode on the faceplate of an image intensifier. Half the faceplate is coated with S1 photocathode material (sensitive primarily in the near infrared); the other half is coated with S20 photocathode material (sensitive primarily in the visible). The output of the image intensifier is coupled and minified by a fiber-optic taper onto an 11.4-by-8.8-mm charge-coupled-device array (see Figure 2). Both the photocathode and the charge-coupled device are cooled by Peltier devices.

The optical portion of the spectrometer is moderately fast (aperture about 1/6 the focal length) and suitable for the observation of such weak phenomena as nocturnal airglow. The instrument has a dynamic range of 10^5, so that it is also suitable for observation of bright auroras and dayglow.

This work was done by Marsha R. Torr of **Marshall Space Flight Center**. *For further information, Circle 100 on the TSP Request Card.*
MFS-28570

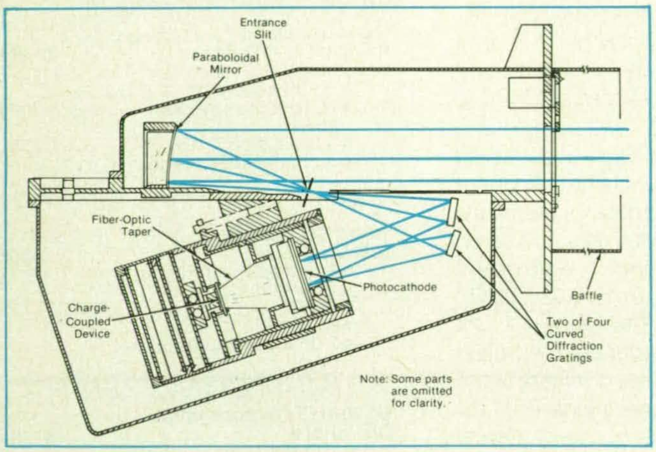


Figure 1. This **Compact Spectrometer** offers high sensitivity, wide dynamic range, and electronic readout of a broad spectrum with moderate spectral resolution.

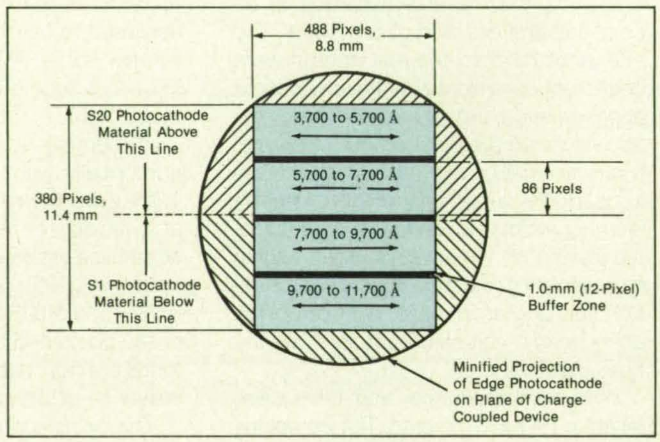


Figure 2. The **Spectrum Is Imaged Onto Strips** on the photocathode, then coupled via a fiber-optic taper onto a charge-coupled-device imager.

Manganese Nitride Sorption Joule–Thomson Refrigerator

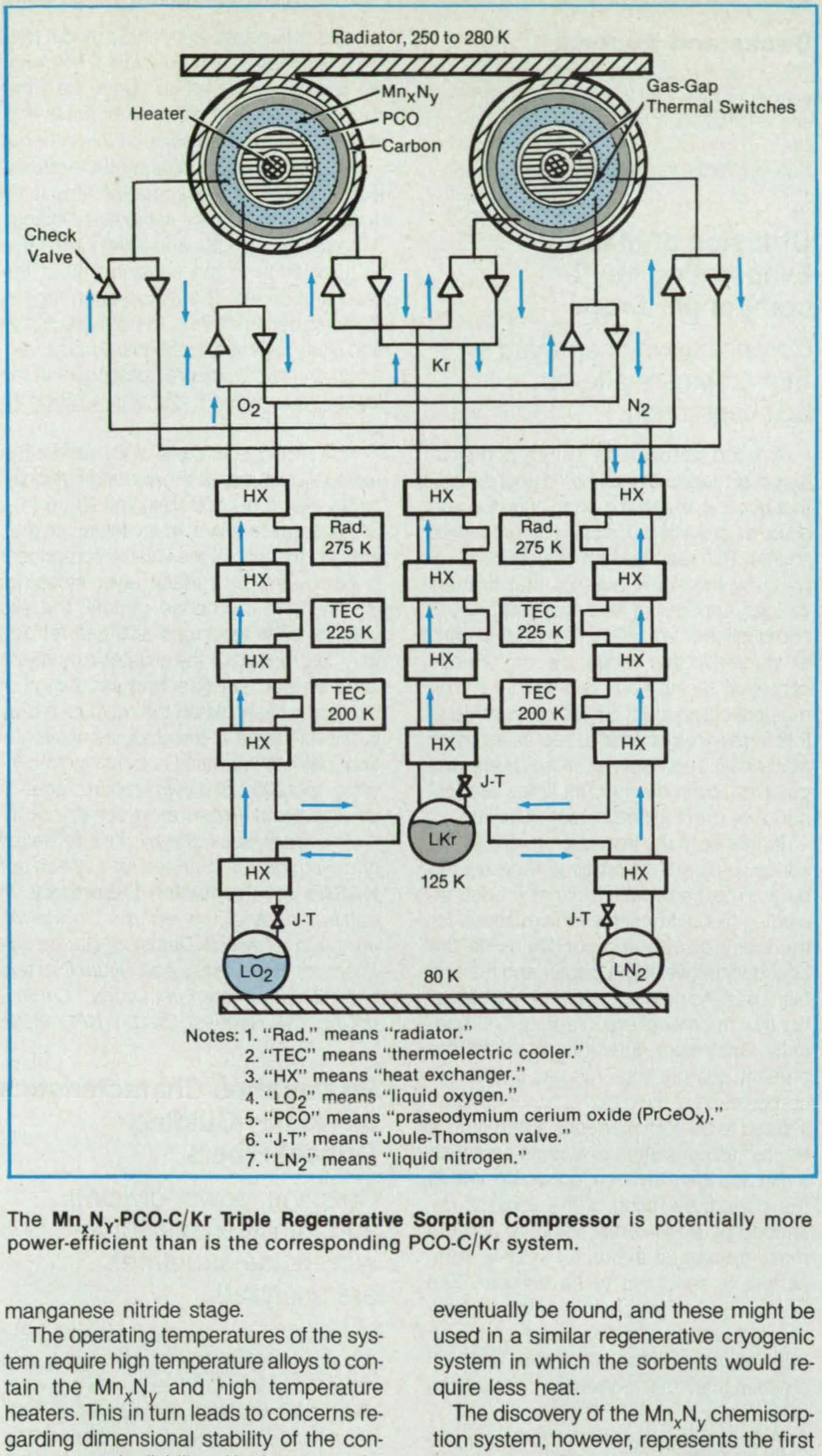
Measurements of sorption in manganese nitride suggest feasibility.

NASA's Jet Propulsion Laboratory, Pasadena, California

Measured pressure-vs.-composition isotherms for the reversible chemisorption of N_2 in Mn_xN_y suggest that it may be feasible to incorporate an Mn_xN_y chemisorption stage in a Joule–Thomson cryogenic system. With their lack of vibration and with few moving parts subject to wear, sorption refrigeration systems have distinct advantages in situations in which long life is crucial. Unfortunately, however, sorption refrigeration systems that cool to about 80 K tend to require more power than do mechanical refrigerators.

To obtain a sorption refrigeration system of increased power efficiency, it has been proposed to combine an Mn_xN_y sorption refrigeration stage with the $PrCeO_x$ (PCO) chemisorption compressor and C/Kr physisorption system described earlier in "Regenerative Sorption Refrigerator" (NPO-17630), *NASA Tech Briefs*, Vol. 15, No. 3 (1991), page 51. In this system (see figure), high-pressure nitrogen at a pressure of about 32 atm (3.2 MPa) would be generated by heating manganese nitride compounds, designated generally as Mn_xN_y, from 625 °C (898 K) to about 900 °C (1,173 K). The waste heat from the Mn_xN_y would pass via a gas-gap thermal switch to the PCO subsystem, heating the PCO from 275 °C (548 K) to 600 °C (873 K) and thereby causing the PCO to give off oxygen gas at a pressure of 14 atm (1.4 MPa). Finally, gas would be injected into the gas gap between the PCO and the carbon/krypton sorption stages, heating the C/Kr from −13 °C (260 K) to 275 °C (548 K). This would generate high-pressure krypton, which, when precooled and expanded to 2.5 atm (0.25 MPa), would produce net cooling at 125 K. This precooling stage would then precool both the nitrogen and oxygen, which would both be expanded through Joule–Thomson valves to cool an instrument or experiment to 80 K.

On the basis of the Mn_xN_y chemisorption isotherm data, it has been estimated that a refrigeration system of this type would consume about 68 W of power per watt of cooling at 80 K. This is about 12 percent less than the power required by a comparable refrigeration system to produce the same cooling effect without the



The **Mn_xN_y-PCO-C/Kr Triple Regenerative Sorption Compressor** is potentially more power-efficient than is the corresponding PCO-C/Kr system.

manganese nitride stage.

The operating temperatures of the system require high temperature alloys to contain the Mn_xN_y and high temperature heaters. This in turn leads to concerns regarding dimensional stability of the containment and reliability of both the containment vessel and the heaters. It should also be noted that the kinetics of the system have been found to vary with purity, and additions of iron may be required to catalyze the chemisorption process.

The above considerations, coupled with present technology, suggest that the PCO-C/Kr system without Mn_xN_y may be preferable for sorption Joule-Thomson refrigeration systems in the 75-K range. Other high-loading oxides and/or nitrides may eventually be found, and these might be used in a similar regenerative cryogenic system in which the sorbents would require less heat.

The discovery of the Mn_xN_y chemisorption system, however, represents the first known reversible nitrogen chemisorption compression system, and it may have potential in such areas as nitrogen-isotope separation, nitrogen purification, or contamination-free nitrogen compression, just as the advance of hydrides has done for hydrogen.

This work was done by Jack A. Jones and Wayne M. Phillips of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 105 on the TSP Request Card.* *NPO-17811*

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.

Diffusion of Mass in Evaporating Multicomponent Drops

Compositions of sprayed fuel drops are altered by evaporation.

A report summarizes a study of the diffusion of mass and the related phenomena that occur in the evaporation of dense and dilute clusters of drops of multicomponent liquids. This report is one of a series of reports by the same authors that discuss various aspects of the evaporation and combustion of sprayed liquid fuels. In earlier studies in this series, the drops have consisted of single-component liquids. The multiple-component liquids considered in this study are intended to represent more realistically such fuels as oil, kerosene, and gasoline, each of which includes components of greater and lesser volatility.

In this as in the previous studies in the series, a cluster of drops is represented by a simplified mathematical model, including global conservation equations for the entire cluster and conditions on the boundary between the cluster and the ambient gas. As before, the differential equations of the model are integrated numerically. One major difference between the present and previous models is that the composition of the drops is no longer considered to be homogeneous. Each drop is treated as consisting of a liquid core with a thin boundary layer on its surface. Within the core, the motion of the liquid is described by a Hill-vortex solution, and the mass fraction of the highly volatile component is assumed to be uniform. The boundary layer is considered to be quasi-steady because it is assumed that the circulation time of the Hill vortex is much smaller than the regression time of the drop.

A parameter, B_e, which represents the ratio between the rate of regression of mass and a characteristic volatile diffusion rate appears naturally in the analysis. The assumption of the quasi-steady boundary layer is consistent with $B_e \ll 1$ when diffusion is important and inconsistent with $B_e \gg 1$ when diffusion is not important. When $B_e \gg 1$, the transfer of the high-volatility fuel from the liquid core to the gas phase is no longer controlled by diffusion into the boundary layer, but instead by surface layer stripping; that is, by the rate of regression of the drop.

It is further assumed in this model that the kinetic rate of evaporation of the volatile component is much larger than the sum of the rates of diffusion of mass and of loss through regression of the surface.

As in previous studies by the authors, it is found that the evaporation time is insensitive to turbulence in the surroundings if the cluster is dilute and is very sensitive to turbulence in the surroundings if the cluster is dense. The evaporation time is found to be insensitive, in both the dense and dilute regimes, to the initial mass fraction of the highly volatile component in the liquid phase when it does not exceed 10 percent.

Most important, plots of B_e versus the residual drop radius show that diffusion of mass exerts a controlling influence in a dilute spray but not in a dense cluster, wherein the loss of the volatile component is dominated by surface layer stripping. Basically, in the dense regime, the slip velocity between drops and gas relaxes very fast because the cluster exposes a large area to the gas, and circulation in the drop ceases when the residual radius is still very large. In the absence of circulation, diffusion of mass is too slow to control evaporation, and evaporation proceeds at a basically frozen drop composition.

This work was done by Josette Bellan and Kenneth G. Harstad of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "On the Importance of Mass Diffusion During the Evaporation of Dense and Dilute Clusters of Multicomponent Fuel Drops," Circle 2 on the TSP Request Card.* NPO-18206

Propagation Characteristics of Weakly Guiding Optical Fibers

Coupling, power-dividing, and transition dielectric-waveguide structures are analyzed.

A report discusses the electromagnetic propagation characteristics of weakly guiding optical-fiber (and, equivalently, of dielectric-waveguide) structures that have complicated shapes with cross-sectional dimensions of the order of a wavelength. In this study, the basic data on propagation characteristics were computed by the scalar-wave, fast-Fourier-transform (SW-FFT) technique, which is based on the numerical solution of the scalar version of the wave equation by a forward-marching fast-Fourier-transform method. When applied to a given structure, the SW-FFT technique yields the spatial configuration of the electromagnetic field in and around the structure and the power intensity on the cross section and along the guiding dimension(s). A subsequent spectral analysis of the power-intensity data yields characteristics of electromagnetic modes; e.g., propagation constants and relative amplitudes.

SW-FFT computations were performed for three widely used optical-fiber/dielectric-waveguide structures. The first structure was a fiber-optic coupler consisting of two close, parallel, round optical fibers, in each of which the index of refraction decreased parabolically with radius from a peak on the axis. The odd and even modes and coupling characteristics of this structure were analyzed. The second structure was a round fiber or waveguide with a conical transition between two sections of different diameter. For this case, the effect of the degree of taper on mode conversion was studied. The third structure was a branching junction at which one fiber or waveguide is split into two. For this structure, the analysis focused on the mode-filtering and/or power-dividing properties.

The algebraic and numerical results for the coupled parallel fibers show that power is handed back and forth between them with a spatial periodicity characterized by a coupling length. The coupling length was found to increase with either the radius of the fibers or the distance between them. The variation of the coupling length with distance was found to become steeper with increasing distance for a given constant radius.

In the case of the conical-transition waveguide, one major design objective is to enable the local normal mode of lowest order to propagate without cumulative transfer of power to local normal modes of higher order. The SW-FFT analysis of such a structure showed that, as one would expect intuitively, there is more mode conversion at tapers of greater slope. The analysis also showed (nonintuitively) that the proportion of power fed to modes of higher order is fairly insensitive to the slope at both high and low slopes but sensitive at intermediate slopes.

For the branching fiber or waveguide, the results of the SW-FFT analysis indicate that various degrees of mode splitting and division of power between the branches can be obtained, depending on the specific configuration. As expected from previous theoretical and experimental studies, it was found that (1) such a structure acts as a power divider at larger slopes and as a mode splitter at smaller slopes and that (2) in the case of asymmetrical branching at low slope, no power is propagated into the narrower branch.

This work was done by Farzin Manshadi of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Propagation Characteristics of Optical Fiber Structures With Arbitrary Shape and Index Variation," Circle 90 on the TSP Request Card.*
NPO-18108

For More Information Circle No. 601

Modeling Characteristics of Surfaces for Radar Polarimetry

Mathematical models for the interpretation of polarized radar backscatter are discussed.

A paper reviews mathematical models, developed by the authors of this and other papers, of the polarimetric radar backscattering characteristics of various types of terrain; e.g., forests, grasslands, and lava fields. The paper represents an approach to imaging radar polarimetry in which one accumulates models that predict realistic polarization signatures and represent distinct scattering processes, without necessarily attempting full vector solutions of Maxwell's equations in all cases. The idea is to develop the ability to invert the models to identify unknown terrain depicted in polarimetric radar images.

Different models are required for different types of terrain. For bare surfaces, one can choose among semiempirical models, models based on the known scattering characteristics of distributed bodies of simple shape, and models that represent the statistical distribution of surface height. General vegetated surfaces have been modeled in the radiative-transfer approach, in the random medium approach (in which the vegetated layer is considered to be a continuous medium of randomly fluctuating electrical permittivity), and in the discrete-scatter approach (in which each component of vegetation structure is represented by a simple shape for which the complete polarimetric scattering can be computed).

The authors model grasslands by use of long, thin dielectric cylinders that are oriented statistically about the vertical and that stick up out of a slightly rough dielectric surface. They take account of direct backscatter from the grass, direct backscatter from the ground, and forward scattering from the ground followed by bistatic scattering from the grass. The authors model forests by use of a discrete-scatterer model in which a bottom layer of nearly vertical dielectric cylinders represents the trunks of trees and a top layer of randomly oriented dielectric cylinders represents the leaves and branches.

The paper describes the models, major scattering characteristics predicted by the models, and the interpretation of those characteristics in terms of dominant scattering mechanisms. The authors find that, for the most part, the models predict realistic polarization signatures.

The authors' approach to the inversion of the models involves the computation of a distance, d, between the measured and predicted Stokes matrices (which express the polarimetric backscattering characteristics) according to

$$d = \sum_{i=1}^{4} \sum_{j=1}^{4} W_{ij} [P_{ij} - M_{ij}]^2$$

where P denotes the measured Stokes matrix, M denotes the Stokes matrix predicted by the model, W is a weighting coefficient, and i and j represent the row and column, respectively, of a given matrix element. The inversion algorithm varies the parameters of the model until the minimum distance (taken to represent the best fit) is obtained. This approach is illustrated by applying it to the predicted and measured Stokes matrices for a lava surface. From stereoscopic photography from a helicopter, it was deduced that the root-mean-square (rms) height of surface roughness lay in the range between 2.28 and 5.06 cm. The rms surface-roughness height inferred from the Stokes matrices was 4.13 cm.

This work was done by Jakob J. Van Zyl, Howard A. Zebker, and Stephen L. Durden of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Approaches to Modeling Polarization Characteristics of Surfaces for Radar Polarimetry," Circle 74 on the TSP Request Card.*
NPO-18064

Materials

Hardware, Techniques, and Processes

Bacteriorhodopsin Film for Processing SAR Signals

Erasable "instant" film would enable processing in nearly real time.

NASA's Jet Propulsion Laboratory, Pasadena, California

"Instant" photographic film based on the semisynthetic retinal pigment bacteriorhodopsin has been proposed for use in the optical processing of synthetic-aperture-radar (SAR) signals. Because such a film requires no chemical development, it would enable optical SAR processing in nearly real time. The fast response and high resolution (> 2,000 lines/mm), of bacteriorhodopsin film are well suited for this application. In addition, bacteriorhodopsin film can be reused, with concomitant reduction in the cost of SAR processing.

Figure 1 illustrates conventional optical SAR processing. The radar return signal is used to generate a line-scan image on a cathode-ray tube while exposing a conventional photographic film moving perpendicularly to the scan, thereby creating a raster-format hologram on the film. The film is developed, then used as an input mask in the optical SAR processing apparatus: this film is rolled along the input plane of the apparatus, while a second film is rolled along an output plane to record the processed image. In the case of bacteriorhodopsin film, processing would be similar except that the input image would be recorded on the film by use of a laser operating at the writing wavelength of the bacteriorhodopsin, and the output image would be recorded on a computer by use of a standard frame-grabber.

Figure 2 is a simplified schematic diagram of the photoinduced transitions among quantum states of the bacteriorhodopsin molecule. A photon at the writing wavelength (λ_1) induces a transition from the normal state (called "BR570" by specialists in the field) through a short-lived excited state called "BR*" to a relatively long-lived intermediate called "M412." In the M state, the molecule can absorb a photon at the reading wavelength (λ_2), causing it to make a transition through a short-lived excited state M* back to the normal state BR570. Thus, in regions of the film exposed to light at λ_1, the film becomes absorptive at λ_2; that is, a negative of the image can be seen by illuminating the film with light at λ_2.

A major problem is posed by the fact that in restoring the film to the normal state, the readout process erases the image. The problem is solved by making the reading laser beam much weaker than the writing laser beam so that the holographic image remains for a time long enough to complete the generation of the final SAR image. In any event, the λ_2 images in bacteriorhodopsin films fade in the dark in times that range from a few seconds to a few hours; these times are long enough so that adequate two-dimensional raster patterns can be recorded and read out before the patterns deteriorate appreciably.

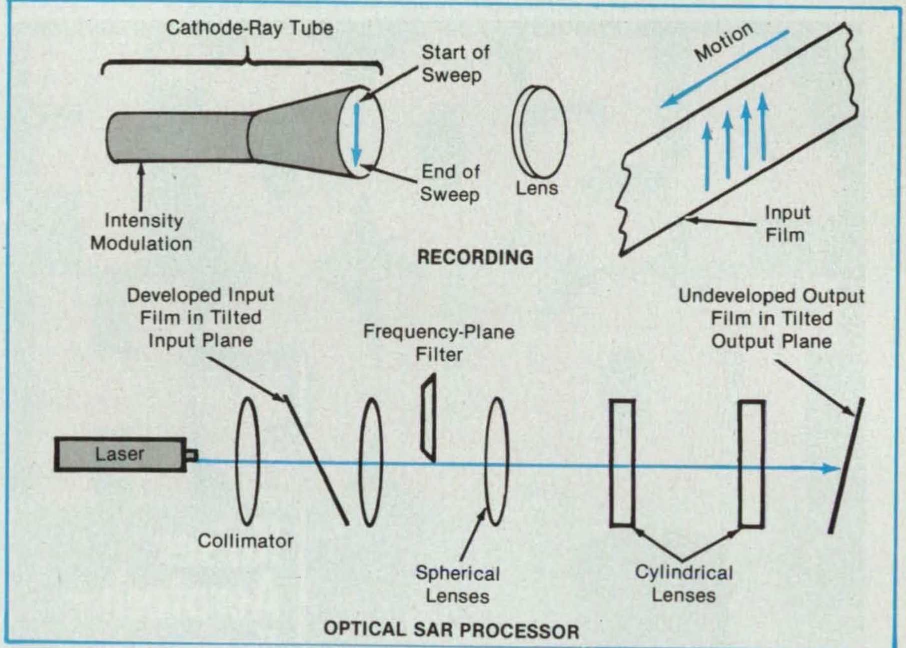


Figure 1. In a **Conventional Optical SAR Processor**, a holographic image on an input photographic film is converted into an image of the scene on an output photographic film.

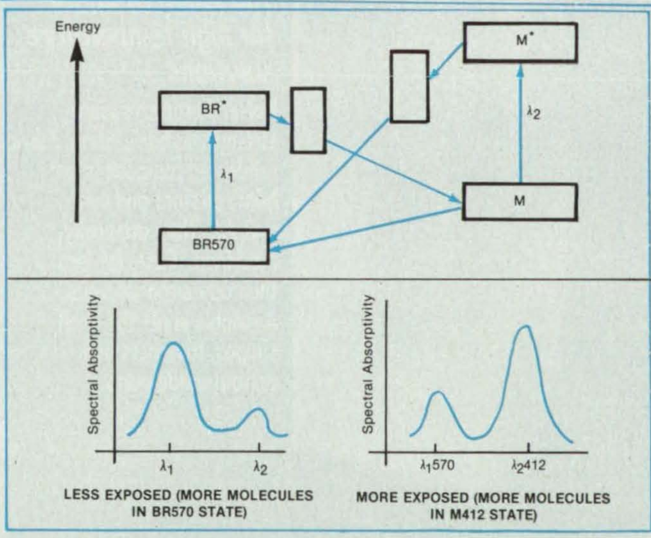


Figure 2. **Photoinduced Transitions** among the quantum states of the bacteriorhodopsin molecule can be exploited to write and read images.

This work was done by Jeffrey W. Yu, Tien-Hsin Chao, Ruth Margalit, and Li-Jen Cheng of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 4 on the TSP Request Card.*
NPO-18242

Durable, Low-Surface-Energy Treatments

A chemical treatment produces durable nonwettable surfaces.

NASA's Jet Propulsion Laboratory, Pasadena, California

A chemical treatment for the creation of durable, low-surface-energy coatings has been developed for glass, ceramics and other protonated surfaces. The treatment, which is easily applied, creates a very thin semipermanent film with extremely low surface tension. The coating exhibits excellent stability, and surfaces can be retreated to renew the effect if the coating becomes damaged or eroded. The many possible uses of this treatment include water-repellent surfaces, oil-repellent surfaces, antimigration barriers, corrosion barriers, mold-release agents, and self-cleaning surfaces.

Very few low-surface-energy treatments, are commercially available, and these products all lack permanence. The new treatment employs (1) chemical groups that create a strong bond to the substrate, and (2) a synergistic chemistry that results in very-low surface tensions.

The treatment involves applying an alcohol solution to the clean surface to be modified. The solution consists of methanol containing the following ingredients:

- 0.8 percent of a linear or branched perfluoroalkyl silane, such as tridecafluoro-1,1,2,2-tetrahydrooctyl-1-methyldichlorosilane,
- 0.2 percent of a liquid-crystal silane, such as a long chain alkyl (trimethoxysilyl)-propyl ammonium chloride,
- 0.2 percent of a crosslinking agent, such as tetraethyl orthosilicate, or bis-1,2-(trimethoxysilyl)-ethane,
- 0.1 percent of a condensation catalyst; typically a tertiary amine compound organotin, or titanate.

The perfluoroalkyl silane provides the low-surface-energy groups, which become strongly oriented at the surface in the presence of the liquid-crystal silane. In this manner, the entropy is decreased and the activity of the fluorinated groups is enhanced. The crosslinking agent also assists in this orientation and further promotes bonding to the substrate. The condensation catalyst promotes chemical reactions between these compounds, the mixture now having a synergistic effect.

This solution is "autophobic" and reacts instantly with glass, producing a surface that cannot be wetted, even with its own treating solution. The thickness of the resulting layer is estimated to be about 100 Å, and the surface tension has been determined to be about 11 dynes/cm. The resulting film resists wetting by water, alcohols, hydrocarbon solvents, and silicone oil. The film also has moderate resistance to abrasion, such as rubbing with cloths and compression molding to polymers and composite materials.

This work was done by Paul B. Willis, Paul M. McElroy, and Gregory S. Hickey of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 61 on the TSP Request Card.*

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

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-18041, volume and number of this NASA Tech Briefs issue, and the page number.

12-Crown-4 Ether Improves Rechargeable Lithium Cells

The ionic conductivity is increased, and the charge-transfer resistance is reduced.

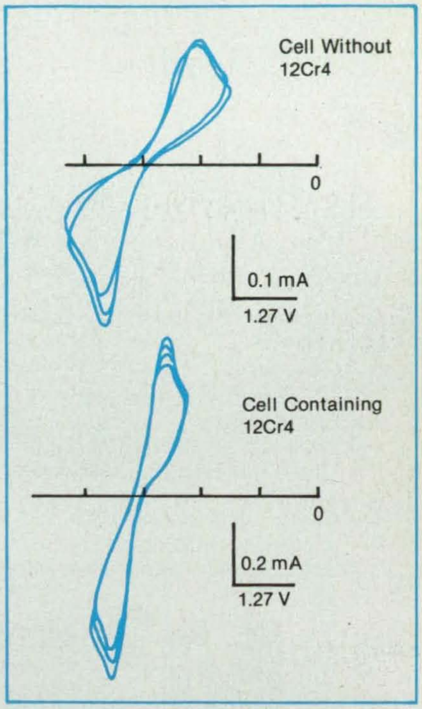
NASA's Jet Propulsion Laboratory, Pasadena, California

Experiments show that the addition of 12-crown-4 ether (12Cr4) to a thin film of polyethylene oxide (PEO) and $LiBF_4$ reduces the charge-transfer resistance of the film and enhances the performance of an electrochemical cell in which the film is the electrolyte, the anode is made of lithium, and the cathode is made of Li_xCoO_2. By increasing the conductivity of the electrolyte, the 12Cr4 reduces polarization loss; this, in turn, enables the cell to sustain higher current. The net result is a new type of rechargeable lithium cell.

In previously developed secondary lithium cells, those solvents that contain lithium are vulnerable to reductive decomposition. Also, dendrites form in these cells at the lithium anodes during charging. Efforts to overcome these disadvantages led to the investigation of polymer electrolytes and oxide cathodes for all-solid-state secondary lithium cells.

Initial electrochemical measurements on a cell of the type $Li/electrolyte/Li_xCoO_2$ with 12Cr4 in the $PEO/LiBF_4$ electrolyte show that with an operating temperature of 60 °C, the performance of this cell was superior to that of a comparable cell that did not contain 12Cr4 in the electrolyte (see figure). A cell of this type is assembled in the discharged state, and the open-circuit voltage is about 3.8 V. In the charged state, the open-circuit voltage could be as high as 4.4 to 4.6 V.

This work was done by Ganesan Nagasubramanian and Alan I. Attia of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 93 on the TSP Request Card.*
NPO-18289



These **dc Cyclic Voltammograms** were made at a scanning rate of 1 mV/s. The addition of 12Cr4 to the electrolyte increases the current. At this scanning rate, there are well-defined cathodic and anodic peaks. The smaller peak splitting in the cell that contains 12Cr4 in the electrolyte indicates a greater reversibility, which is attributed to a reduction in charge-transfer resistance.

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,*
Phone (706) 542-3265 ; FAX (706) 542-4807
The University of Georgia, 382 East Broad Street, Athens, Georgia 30602

Computer Programs

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

Mathematics and Information Sciences

General-Purpose Software for Computer Graphics

NASADIG provides flexible capabilities for the creation of plots and drawings.

The NASA Device Independent Graphics Library (NASADIG) is a general-purpose computer-graphics package for use in many computer-based engineering and management applications. The library gives the user the opportunity to translate data into effective graphical displays for presentation. The software offers many features that give the user flexible capabilities for the creation of graphics. These include two- and three-dimensional plotting, spline and polynomial interpolation, control of blanking of areas, multiple log and/or linear axes, control of legends and text, control of thicknesses of curves, and multiple text fonts (18 regular, 4 bold).

NASADIG contains several groups of subroutines. Included are subroutines for definition of areas and axes of plots; setup and display of text; blanking of areas; setup of style, interpolation, and plotting of lines; control of patterns and of shading of colors; control of legends, blocks of text, and characters; initialization of devices; setting of mixed alphabets; and other useful functions. The usefulness of many routines depends on the prior definition of basic parameters. The control structure includes a serial-level construct with each routine restricted for activation at some prescribed level(s) of definition of problem.

There are three VAX command procedure files that contain the NASADIG source code and font files. When executed, they automatically extract and compile the source code, build the NASADIG object library, create the NASADIG fonts, and compile and link the sample demonstrations.

The NASADIG Library is currently 100-percent compatible with 10 leading operating systems and 11 leading output-device drivers.

Porting this code to a new host and/or operating system or interfacing NASADIG to a previously unsupported output device are both relatively simple tasks. For a new host system, the specific system calls that are required to perform system-level operations are placed in the generalized system routine, starting with a "C" in column one of each line, and then following with a descriptive name that suggests the hardware/software host combination. To add a new device driver to NASADIG, an existing driver can be used as a template, and the appropriate substitutions can be made with the necessary commands to perform the initialization, move/draw operations, and the like. These commands are found in the operating manuals typically supplied by the device manufacturer at purchase time.

NASADIG is written in FORTRAN 77 (ANSI X3.9-1978 standard) for DEC VAX-series computers operating with VMS 5.0 or higher. The program is available on a 9-track, 1,600-bit/in. (630-bit/cm) magnetic tape in VAX BACKUP format (standard medium) or in VAX BACKUP format on a TK50 tape cartridge. Note: porting the program requires access to a DEC VAX computer to create the ASCII source-code files.) NASADIG is available either independently (MSC-21801) or bundled with TRASYS, the Thermal Radiation Analysis System (COS-10026).

DEC, VAX, VT-240, and VMS are trademarks of Digital Equipment Corp. PostScript is a registered trademark of Adobe-Systems Inc. IBM, AT, and PC are trademarks of International Business Machines Corp. Tektronix is a trademark of Tektronix, Inc. HP Lasergrafix is a trademark of Hewlett-Packard, Inc.

This code was written by Joseph E. Rogers of **Johnson Space Center**. *For further information, Circle 78 on the TSP Request Card.*
MSC-21801

Displaying Data as Movies

The user can choose among a variety of formats to enhance comprehensibility.

The NMSB_Movie computer program was developed to solve the problem of how to display large sets of data (more than a million individual values) in a meaningful way. The program, originally written to present data from three-dimensional ultrasonic scans of damaged aerospace composite materials, has also been used to illustrate data acquired by thermal-analysis systems that measure the rates of heating and cooling of various materials.

The presentation by NMSB_Movie is dynamic, rapidly displaying sequential image "frames" in the main "movie" window. (Single-step advance and reverse through the data are also implemented.) Any sequence of two-dimensional sets of data that can be scaled between 0 and 255 (1-byte resolution) can be displayed as a movie. Thus, time- or slice-wise progression of data can be illustrated. Areas of nonuniform density, temperature, stress, or other quantities represented by values on the scale of 0 to 255 appear as areas colored differently in each image frame. As successive frames appear in the movie, a comprehensible view of changing features throughout the data set is generated.

The format of movie files has been kept simple to enable many data-sampling systems to use NMSB_Movie. Each file consists of a two-integer heading that specifies the number of points in the *X* and *Y* directions, followed by a series of byte image frames. Features of the movie program include optional ruler strips around the movie window for accurate reading of the positions of areas of interest, an intensity-distribution histogram displayed beside the main window with an adjustable threshold bar, and quarter-size reference snapshots of individual frames generated as the movie is running.

Any frame can be made to display a three-dimensional surface, bar histogram, or exploded contour plot, and Macintosh PICT files of the windows can be saved for use in other graphical software. Several color tables, including a gray scale, are available for the displays. Movies can also be made to show only those values above or below specified thresholds. Row- and column-profile plots of data currently under the cursor can be displayed, and a text file of the profile information can be generated at any time.

NMSB_Movie was developed on a Macintosh IIx computer with an 8-bit color display adapter and 8 megabytes of memory using Symantec Corporation's Think C, version 4.0. The program has been implemented on a Macintosh SE computer under OS 6.0.5. The executable program occupies 180 KB of disk space. 1 MB free memory is required (2 MB recommended) to run NMSB__Movie. The program can be executed on a computing system equipped with a monochrome display, but a color display is recommended for meaningful presentation of the data.

Macintosh IIx and Macintosh SE are trademarks of Apple Computer, Inc.

This program was written by Judith G. Moore of Analytical Services & Materials, Inc., for **Langley Research Center**. *For further information, Circle 33 on the TSP Request Card. LAR-14490*

Software for Animated Graphics

GAS enables the user to view and render two- and three-dimensional objects.

The Graphics Animation System (GAS) is a software package developed in support of the work of scientists engaging in computational fluid dynamics (CFD) at NASA Ames Research Center. The role of GAS in the software cycle of the graphical analysis in CFD is to serve as an easy-to-use, menu-driven program that provides fast, simple viewing capabilities as well as more-complex features for rendering and animation. It is used to display two- and three-dimensional objects along with computed data and to record animation sequences on video digital disk, videotape, and 16-mm film. Some example applications have been the distribution of pressure inside the main engine of the Space Shuttle, vortex flows of the wing/strake surface of F-16 aircraft, and particle traces over the Space Shuttle orbiter.

The CFD cycle begins with the design of a test-geometry grid and the execution of such "flow solver" programs as INS3D (COSMIC Program ARC-11794) on a supercomputer. These programs solve the higher-order equations that govern flight characteristics, according to the test-geometry specifications (e.g., forward-swept-wing model with surrounding airspace), and simulation conditions (e.g., angle of attack, mach number, Reynolds number) supplied by the user as inputs. The numerical solution data thus generated are collected and converted into images of flows, distributions of pressure, shock waves, and particle traces by use of the PLOT3D/AMES (ARC-12777 through ARC-12789) graphics program. Then the surface-shading program SURF (ARC-12381) is used to enhance the images with shading and coloring. Finally, by use of device-independent standard graphical-function calls and file formats from ARCGRAPH (COSMIC Program ARC-12350) as input, animation sequences are generated and recorded with GAS.

GAS is a menu-driven program that provides for viewing windows and mouse controls. It provides for viewing and rendering two- and three-dimensional objects, including wire-frame or solid, hidden-surface, and shaded models. These objects can be scaled, rotated, translated, mirrored, colored, and combined with legends and text in animation sequences, which can then be recorded.

GAS is written in C language for two Silicon Graphics computers: the IRIS 2000/3000- and IRIS 4D-series workstations running the IRIX operating system. The workstation should have at least 4 Mb of display list memory, 32 bit planes, z-buffering, and z-clipping. GAS requires the Silicon Graphics "include" files (e.g., stdio.h, devices.h, gl.h, etc.). Also, it is assumed that a floating-point accelerator has been installed, but the need for a floating-point accelerator can be eliminated by removing certain compiler switches. The IRIS 2000/3000 version of GAS was developed in 1988. The port to the IRIS 4D-series workstations was done in 1991. The program is available on a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format.

Silicon Graphics, IRIS, and IRIX are trademarks of Silicon Graphics, Inc. UNIX is a registered trademark of AT&T.

This program was written by F. Merritt, G. Bancroft, and P. Kelaita of Sterling Software for **Ames Research Center**. *For further information, Circle 17 on the TSP Request Card.* ARC-12976

Mechanics

Hardware, Techniques, and Processes

Tapered-Fin Thermal Interfaces

Meshing tapered fins can be designed to have desirable thermal and mechanical properties.

Marshall Space Flight Center, Alabama

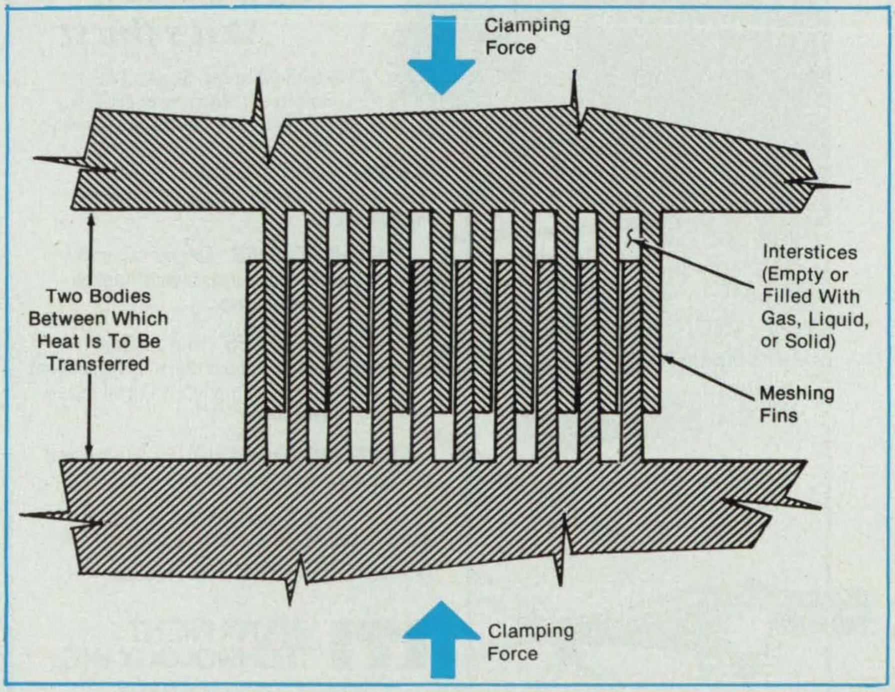
Two meshing sets of tapered fins (see figure) can be used as a thermal interface with relatively low clamping forces. Heretofore, the standard practice has been to clamp flat surfaces together with large forces to increase the contact component of the transfer of heat.

When in contact, the fins provide a large area for the transfer of heat, and the effective area of contact increases with the height of the fins. The taper ensures easy mating and demating of the two sets of fins. The taper also transfers the clamping force to the fin surfaces in contact; this improves the contact and the transfer of heat.

A number of parameters can be altered to achieve the best conductance: these include the height and thickness of the fins, the angle of taper, the fin material, the surface finish, the clamping force, and the distribution of pressure at the interface. The interstices between fins can contain a vacuum, liquid, or solid. The resulting heat-transfer performance therefore depends not only on direct surface contact but also on conduction and radiation through the interstitial material or vacuum, and the interstitial material or vacuum can be chosen to affect the performance in a desired way.

This work was done by Elizabeth C. Poulin of Foster-Miller, Inc., 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 18]. Refer to MFS-26165.



Tapered Fins Make Thermal Contact, providing high conductance with low clamping force. The fins may be arranged in rows, concentric rings, or other configurations. Each fin may be tapered on both sides as shown here, or on one side only.

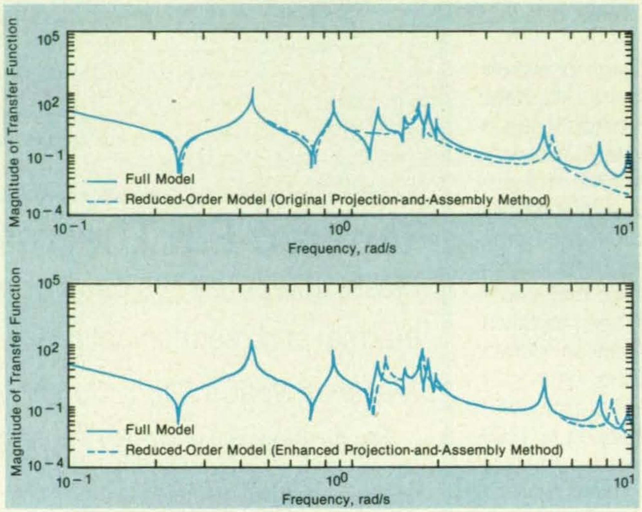
Enhanced Method of Reduction of Dynamical Models

Reduced models for use in suppressing vibrations of structures are made more accurate.

NASA's Jet Propulsion Laboratory, Pasadena, California

The enhanced projection-and-assembly method is a recent product of continuing efforts to model mathematically the dynamics of vibrations of large, flexible structures. The projection-and-assembly method (with or without enhancement) is one of several methods of approximating the dynamics by use of models of reduced order: one uses a truncated set of vibrational and rigid-body modes that capture the salient features of the dynamics with acceptable accuracy. These reduced-order methods could be used, for example, to obtain simplified models for designing control algorithms of control systems.

In the projection-and-assembly method, modes that contribute significantly to the control input and output points are selected at the system (overall structure) level, then projected (not physically, but in an abstract mathematical sense) onto the components of the system. The resultant reduced-order mathematical models of the components are assembled, yielding a reduced-order model of the system that exactly captures the selected modes of the system.



These **Bode Plots** computed for the mass-and-spring system problem show that the enhanced projection-and-assembly method results in a better match to the zeros of the transfer function of the system than the original projection-and-assembly method does.

One of the undesired effects of the projection-and-assembly method is that extraneous modes can appear in the reduced-order model. Another is that there can be mismatches between the zeros of the transfer functions of the full-order and reduced-order models. This second effect is particularly disadvantageous in that it can degrade control computations if the mismatched zeros lie near the bandwidth of the control system. The accurate reproduction of zeros in the transfer function of the reduced-order model is also important in the design of a high-gain control system because the closed-loop poles of such a system approach its open-loop zeros when the gain becomes large.

The development of the enhanced projection-and-assembly method addresses the issue of mismatches between the zeros. In the enhanced version, static correction modes capture the static contributions of those modes that are neglected in the reduced-order model. These correction modes, in the form of Ritz vectors, can be added either to the retained set of modes of the system (in a procedure called "system-level augmentation") or to the sets of modes projected onto the components (in a procedure called "component-level augmentation"). System-level mode augmentation is preferable because it has to be done only once, whereas component-level augmentation must be done as many times as there are components.

The enhanced projection-and-assembly method has been tested by computation on two problems: a 13-degree-of-freedom mass-and-spring system (see figure) and the Galileo dual-spin spacecraft as represented by a finite-element mathematical model of high order. The system-level and component-level augmentations produced almost identical numerical results. When applied to the Galileo problem, the system-level-augmented version of the enhanced projection-and-assembly method significantly alleviated the mismatches between zeros found in previous studies.

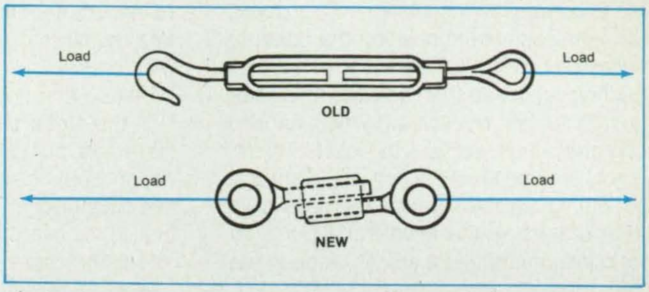
The enhanced projection-and-assembly method entails some disadvantages that may be addressed in future research. One disadvantage is that the addition of the static correction modes results in more extraneous modes than are generated in the original projection-and-assembly method. Another is that unlike the retained eigenvectors of the system, the added Ritz vectors depend on the spatial distribution of external loads, necessitating the use of different Ritz vectors when analyzing the responses of the system to different applied loads.

This work was done by Allan Y. Lee and Walter S. Tsuha of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 68 on the TSP Request Card.*
NPO-18402

Short Turnbuckle

End fasteners are offset to reduce length.

NASA's Jet Propulsion Laboratory, Pasadena, California



The **Offset Turnbuckle** provides for overlap between end fasteners, with consequent reduction in length.

A turnbuckle includes laterally offset eyebolts instead of the usual collinear end fasteners. Its end fasteners can overlap, unlike collinear fasteners, which abut each other (see figure). This reduces length, enabling the use of the new turnbuckle where a conventional turnbuckle might be slightly too long.

The offset turnbuckle ends are held together by a nut with parallel, oppositely threaded bores — clockwise for one eyebolt and counterclockwise for the other. The turnbuckle can be tightened, like any other turnbuckle, by turning the nut. A further advantage of the offset is that it tends to prevent the eyebolts from loosening when the load is applied.

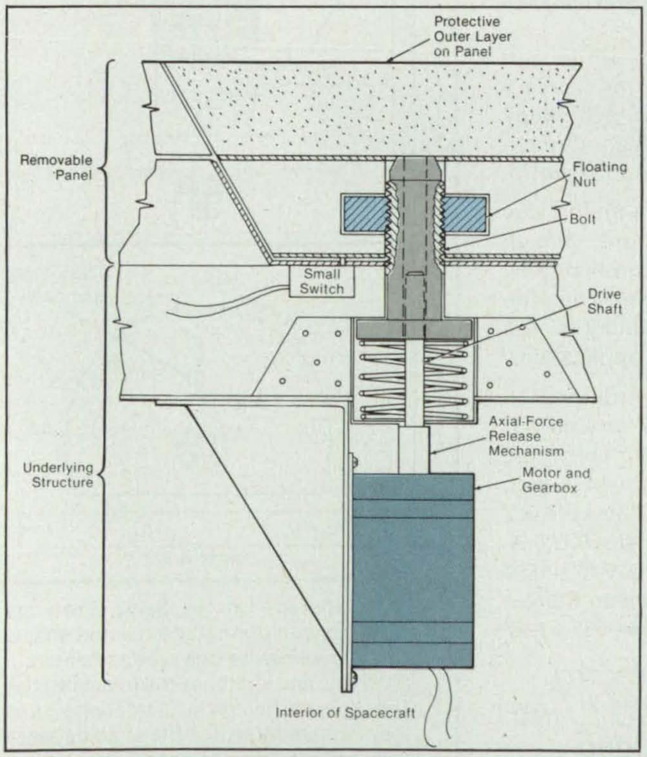
This work was done by Malcolm J. MacMartin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 19 on the TSP Request Card.*
NPO-18348

Hidden Fastening-and-Unfastening Mechanism

Access to the fastener would not be necessary.

Langley Research Center, Hampton, Virginia

A proposed mechanism to be placed behind a panel would fasten the panel to, or unfasten it from, an underlying structure. The mechanism could be used, for example, where the head at the outer end of a bolt or other fastener is covered with a protective outer layer on the panel and the opposite (inner) end of the bolt is inaccessible from any location. The principal advantageous effect of the mechanism would be to make it unnecessary to cut through the protective outer layer on the panel to join the panel to or separate it from the underlying structure.



The **Electric Motor** and gearbox would drive a bolt to engage or disengage a captive floating nut.

The bolt would be fitted with a coaxial drive shaft (see figure). A miniature electric motor and gearbox on the inner end of the fastener would turn the shaft and bolt. The assembly consisting of the motor, gearbox, shaft, and bolt would be mounted on the structure to which the panel is to be fastened.

To prepare for installation of the panel, a technician would position the panel to align the bolt with a hole in the panel. The technician would then activate the motor to turn the bolt clockwise (for right-handed threads) as viewed from the inside. The rotating tapered tip of the bolt would engage a floating nut in the panel. The bolt would thus draw the panel inward until the force of contact actuated a small switch at the interface between the panel and the underlying structure. This would turn off power to the motor. Alternatively, the increase in the motor current with the increased tightening torque could be used as a motor-stopping signal.

To separate the panel from the underlying structure, the technician would apply reverse current to the motor to make it rotate counterclockwise. This would unthread the bolt from the floating nut, freeing the panel so that it could be lifted away.

If the motor should fail, the bolt could be turned manually. In this case, the technician would have to remove the protective outer layer on the panel just above the bolt to expose the outer end of the bolt. The technician would apply inward force to the bolt and shaft to release them (via a release mechanism actuated by axial force) from the motor and gearbox, insert a key in the hollow hexagonal core of the bolt, and turn the bolt counterclockwise for removal.

This work was done by Ian O. MacConochie of Lockheed Engineering & Sciences Co. for **Langley Research Center**. *For further information, Circle 8 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-14485.

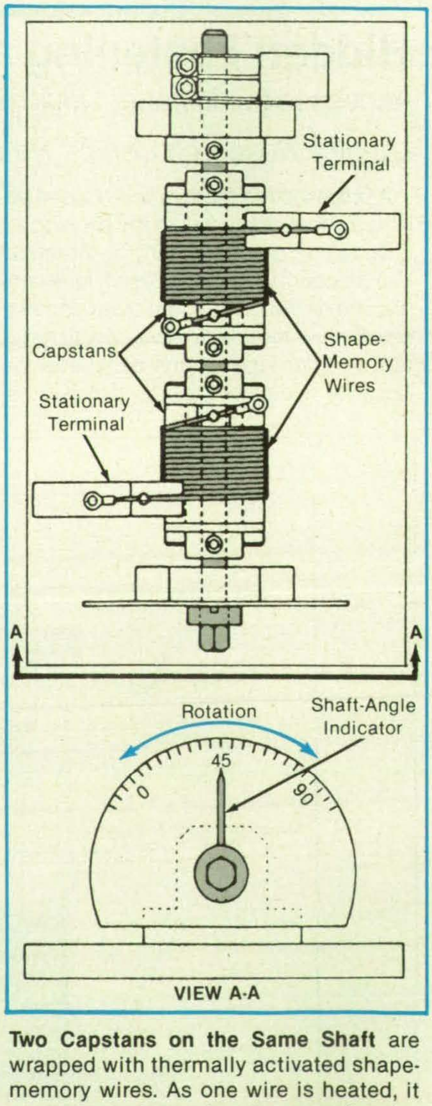
Shape-Memory Wires Switch Rotary Actuator

The length of a wire changes when the wire passes through a transition temperature.

Marshall Space Flight Center, Alabama

A thermomechanical rotary actuator is based on the shape-memory property of an alloy composed of equal parts of titanium and nickel. Below a transition temperature of 125 °F (52 °C), the alloy is in a martensitic low-strength state; above that temperature, the alloy is in an austenitic high-strength state. If the alloy is stretched while it is below the transition temperature, it reverts to its original length when it is heated to above the transition temperature.

A wire made of this alloy is wrapped around a capstan, with one end attached to the capstan and the other end attached to a stationary terminal (see figure). The wire is stretched by 2 percent of its length



Two Capstans on the Same Shaft are wrapped with thermally activated shape-memory wires. As one wire is heated, it contracts and stretches the opposite wire. The wires are heated in alternation so that they repeatedly switch the shaft between two extreme angular positions.

at room temperature when it is installed. A similar wire is wrapped around a second capstan on the same shaft and is pulled taut into tension with the first wire but is not otherwise stretched.

When the stretched wire is heated above the transition temperature by passing an electrical current through it, it shrinks quickly to its original (unstretched) length. This shrinkage applies a torque to the first capstan, causing both capstans and the shaft to rotate through an angle of about 90°. This shrinkage also results in a corresponding stretch of the second wire. Heating the second wire with an electrical current causes it to contract, thereby causing the shaft to turn back about 90° to the original angular position. Thus, by applying current to the two wires alternately, one can make the actuator alternate between two positions; e.g., the "on" and "off" positions of a rotary valve.

The capstans are made of a material of high thermal conductivity. Therefore, they carry heat away from the wires quickly so that they can return to the martensitic low-strength condition almost immediately after heating and contracting.

This work was done by Myron J. Brudnicki of Boeing Aerospace and Electronics for **Marshall Space Flight Center**. *For further information, Circle 162 on the TSP Request Card.*

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457(f)], to Boeing Aerospace & Electronics. Inquiries concerning licenses for its commercial development should be addressed to

Boeing Aerospace & Electronics
P.O. Box 399
Seattle, WA 98124-2499

Refer to MFS-28581, volume and number of this NASA Tech Briefs *issue, and the page number.*

Unified Optimization of a Structure and Its Control System

Costs are coupled via a parameter that becomes, in effect, a design variable.

NASA's Jet Propulsion Laboratory, Pasadena, California

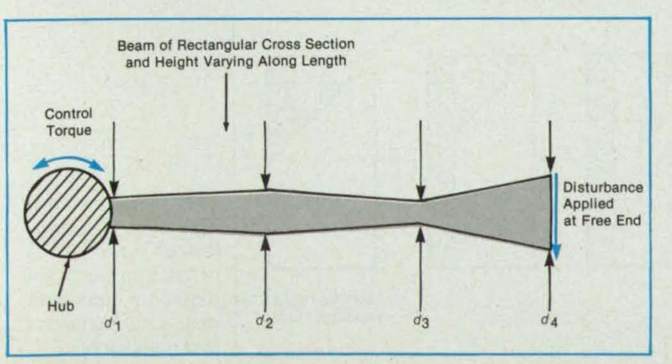
Continuing research on the active suppression of vibrations in large structures has led to a method for the unified optimization of a structure and its vibration-suppressing control system. Although the method was developed to optimize large, flexible structures to be erected in outer space, it is also applicable to such terrestrial problems as designing buildings with control actuators to prevent damage by earthquakes.

The method involves the extension of established techniques of optimization via an approach based on homotopy, in which the cost function that is used as the criterion for optimization of the control system (J_C) is coupled to the corresponding cost function of the structure (J_S) via a new parameter, λ. Heretofore, a typical design would be optimized by optimizing the structure first, then optimizing the control system based on the optimized structure; this involved the evaluation of different designs of the structure in the search for the one that minimized J_C, followed by the evaluation of different designs of control systems (consistent with the now-optimized structure) in the search for the one that minimized J_C.

Accordingly, in the present method, one seeks to minimize the cost functions of the structure and the control system simultaneously by minimizing

$$J_\lambda = (1-\lambda)J_S + \lambda J_C$$

where $0 \leq \lambda \leq 1$. Now, in addition to finding the optimal design parameters, one must also determine the correct value of λ. This is done by treating λ as, in effect, another one of the possibly many design parameters. Following an approach based on homotopy (or continuation), one starts at $\lambda = 0$ (which represents the first step of the conventional approach, in which J_S is minimized first), then follows the path that emanates from the solution of the optimization problem as λ is increased.



This **Simple Structure-and-Control Problem** illustrates the method of unified optimization of structural and control subsystems.

The method has been demonstrated by applying it to the design of a flexible beam attached to a rigid hub to which a control torque is applied to counteract a unit-impulse disturbance applied at the free end (see figure). The homotopy strategy was implemented by an iterative optimization in which J_S represented the mass of the beam and J_C represented a weighted sum of (1) the displacement at the free end and (2) the energy that had to be expended by the control actuators to minimize the displacement of the free end. The numerical results led to the following conclusions, among others:

- J_C decreased with λ while J_S increased with λ. This is consistent with the notion that a stiffer structure requires less control energy.
- At λ up to about 0.1, where the total mass dominates the minimization of J_λ, the optimal shape tends to have a small negative slope from d_1 to d_2 to d_3, followed by a sharper negative slope from d_3 to d_4. As λ increases, the minimization of J_S becomes less important, while the minimization of J_C becomes more important. As a result, the beam becomes gradually stiffer, and the monotonic negative slope associated with small λ gradually disappears at about $\lambda = 0.45$, and then gives way to a pronounced inflection of slope from d_3 to d_4 at $\lambda = 0.45$. This results in a larger allocation of mass to the tip. This type of shape is physically consistent with the requirements of the two parts of the control objective:
- A structure that is stiffer (heavier) near the hub and lighter toward the free end has the best distribution of mass while minimizing the tip-displacement response. On the other hand, a large mass at the tip (where the disturbance exists) makes the disturbance less effective — thus requiring less control effort.

This work was done by Mark H. Milman, Robert E. Scheid, Moktar Salama, and Robin J. Bruno of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 64 on the TSP Request Card.*
NPO-18306

More About Gravitational Bumps and Repeating Orbits

Bumps in the gravitational field of the Earth can be estimated with less computation.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved algorithm reduces the amount of computation needed to estimate the dynamics that affect the trajectory of a satellite in orbit around the Earth with an approximately repeating (within about 1 km) ground track. The underlying dynamical concepts were presented in "Computing Gravitational Bumps From Repeating-Orbit Data" (NPO-17925), *NASA Tech Briefs*, Vol. 15, No. 5 (May 1991), page 52. That article described the estimation of the orbital and dynamical parameters (including parameters that represent small perturbations in a simplistic initial estimate of the gravitational field) by application of an iterative least-squares algorithm to satellite-tracking data from the Global Positioning System (GPS).

A satellite with an approximately repeating ground track is presumed to undergo approximately the same gravitational perturbation upon each near-repetition. Tracking data from multiple nearly repeating arcs can be collected into segments called "bins" and processed together to reduce (by averaging) the effects of random errors and thereby obtain more-accurate estimates of the dynamical parameters. The perturbations for arcs with approximately the same ground track can be represented by a relatively small set of parameters, called the "bin parameters," that represent the dynamic effects of the local gravitational field. The epoch state (the initial velocity and position) is specific to each arc, and the bin parameters are common to all nearly repeating arcs.

The choice of nearly repeating ground tracks and the local gravitational field for mathematical modeling of the dynamics results in a representation that involves a sparse measurement matrix that can be partitioned and transformed in ways that reduce the amount of computation. More specifically, the improved algorithm is derived from a regression equation in which the measurement data from multiple arcs are combined and represented in the form of matrix A in the equation

$$\mathbf{y} = A\mathbf{x} + \epsilon$$

where $\mathbf{y}$ is the measurement column vector and ϵ is the measurement-noise column vector. The column vector $\mathbf{x}$ denotes the parameters that have been classified into arc-specific and arc-common parameters. The measurement matrix, A, contains the partial derivatives and can be partitioned into an arc-specific part and an arc-common part:

$$A = [A_1|A_2]$$

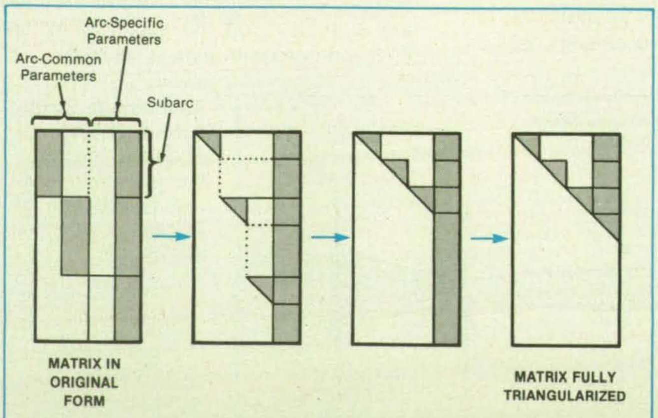
where the submatrix A_1 contains partial derivatives of arc-specific parameters and is block diagonal, with each block corresponding to one arc. The submatrix A_2 contains partial derivatives of arc-common parameters and is generally full.

The algorithm is based on the square-root information filter, which involves an orthogonal transformation of A and the measurement data to obtain the solution and its covariance. The algorithm includes the following five steps:

1. Partition A matrix by arc-specific and arc-common parameters.
2. Eliminate parameters that pertain to GPS clocks by use of double differencing or Householder transformation.
3. By use of the Householder transformation, partially triangularize the portion of A that pertains to each arc (see figure).
4. Combine the lower parts of the triangularized submatrices from all arcs to solve for the arc-common parameters; namely, the bin parameters.
5. Return to the upper part of the partially triangularized A submatrix of each arc to perform back-substitution and solve for arc-specific parameters, including the terms for adjustment of the initial state of the satellite.

These steps yield an accurate estimate of the trajectory without relying on a highly accurate mathematical model of the gravitational field obtained from other sources. As an additional benefit, an estimate of the gravitational field can be extracted with little additional computation.

This work was done by Jiun-tsong Wu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 5 on the TSP Request Card.*
NPO-18189



The Measurement Matrix Is Triangularized in a sequence of steps as part of the algorithm that estimates the dynamics and trajectory.

Self-Aligning, Spline-Locking Fastener

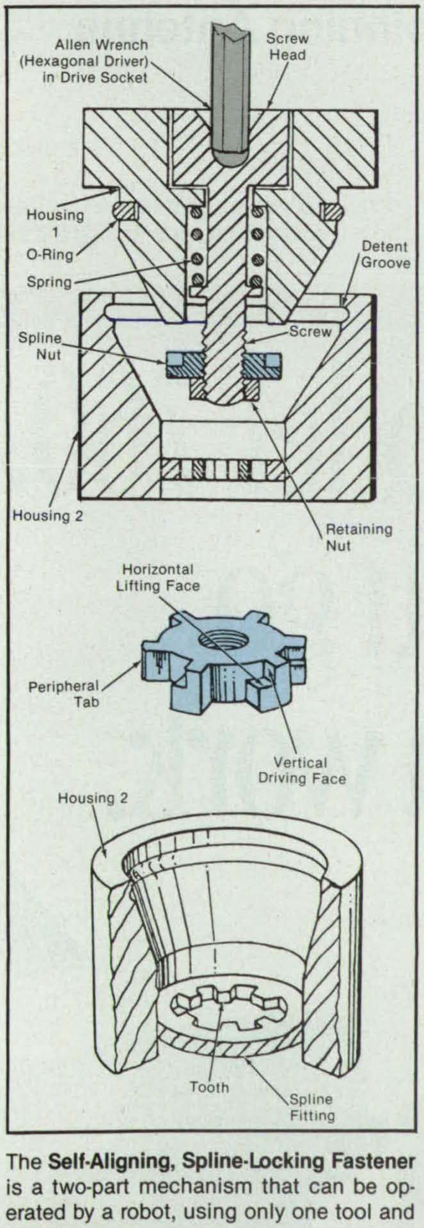
Self-alignment and actuation by simple movements facilitate operation by robot.

Goddard Space Flight Center, Greenbelt, Maryland

The mechanism shown in the figure (simplified for clarity) is a general-purpose fastening device that could be used, for example, to join two parts of a structure, to couple two vehicles, or to mount a payload in a vehicle. The actuation of the device requires only one tool and simple movements. Also it cannot be cross threaded despite the fact that it provides large force multiplication through a low lead thread. These features, coupled with its tolerance of initial misalignments, makes it suitable for both robotic and manual operation.

The mechanism includes two housings, each of which is attached to one of the two structures or other objects to be joined. A right-handed screw that turns in housing 1 includes a large head containing a drive socket, which receives an allen wrench or similar tool. The screw is spring-loaded toward housing 2 (downward as oriented in the figure). A spline nut turns freely on the threaded part of the screw near its lower end and is retained by a smaller nut on the lower end that is locked against turning once it is installed. The spline nut includes peripheral tabs that, when properly aligned, can pass freely in the axial (vertical in the figure) direction through the spaces between the teeth of a mating spline fitting in housing 2. Each vertical tab includes a vertical driving face and a horizontal lifting face.

Alignment is provided by mating con-



The **Self-Aligning, Spline-Locking Fastener** is a two-part mechanism that can be operated by a robot, using only one tool and simple movements.

ical surfaces on two housings, each of which is attached to one of the two objects to be joined. As the two objects to be joined are brought together, the conical protrusion on housing 1 settles into the conical receptacle of housing 2, and the O-ring on housing 1 snaps gently into the detent groove in housing 2 to act as a soft-docking spring. During this movement, the spline nut comes to rest on top of the spline fitting (unless by chance it was initially aligned to pass through) and pushes the screw upward against the spring in housing 1.

The operator or robot then inserts the tool in the drive socket and pushes downward while turning to the left to bring the spline nut into alignment with the spline fitting, at which point the spline nut passes downward through the spline fitting. Continuing to push downward, the operator or robot turns the tool to the right until the vertical driving surfaces on the spline nut come to rest against the corresponding surfaces of the teeth.

The operator or robot continues to turn the tool and screw to the right, causing the spline nut to ride upward on the screw thread until the horizontal lifting surfaces on the spline nut make contact with the bottom horizontal surfaces of the teeth on the spline fitting. Further turning to the right locks the housings together by building up an axial preload on the conical mating surfaces and the points of contact between the spline components. Turning is stopped when the operator or sensing-and-control circuitry in the robot determines that the applied torque has risen to the level that corresponds to the desired preload.

To detach the two objects, the operator or robot inserts the tool and pushes downward while turning to the left. Once the preload reaches zero, the spline nut turns to the left and becomes aligned to pass through the spline fitting. The operator or robot then withdraws the tool, allowing the spring to push the screw upward and make the spline nut pass upward through the spline fitting. This sequence of motions places the housings in the soft-docking condition, in which they can be pulled apart.

This work was done by John M. Vranish of **Goddard Space Flight Center**. *For further information, Circle 152 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 18]. Refer to GSC-13378.

Real-Time Estimation of Aiming Error of Spinning Antenna

Spinning-spacecraft dynamics and amplitude variations in the communications links are studied from received-signal fluctuations.

NASA's Jet Propulsion Laboratory, Pasadena, California

A mathematical model and an associated analysis procedure provide real-time estimates of (1) the aiming error of a remote rotating transmitting antenna that radiates constant power in a narrow, pencillike beam from a spinning platform and (2) the current amplitude, $A_r(t)$, of the received signal. The estimates of the aiming error and $A_r(t)$ are useful in analyzing and enhancing the calibration of the communication system, and are useful in analyzing complicated dynamic effects (e.g., the sloshing of fuel) in the spinning platform and the antenna-aiming mechanism.

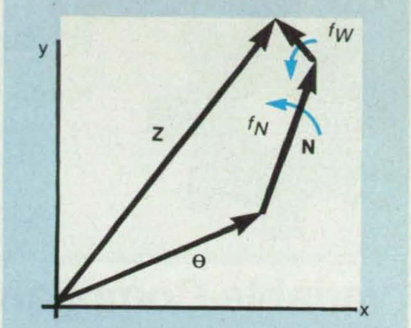
The model and procedure were conceived for use in analyzing spacecraft dynamics from signals transmitted from the spinning Galileo Spacecraft. However, they could be modified for application to other spacecraft (e.g., geostationary communication satellites). According to the model, the total aiming error ("pointing error" in aerospace parlance) is given by the vector equation

$$\mathbf{Z}(t) = \mathbf{\Theta}(t) + \mathbf{N}(t) + \mathbf{S}(t)$$

where t = time, **Z** denotes the total aiming error, **Θ** denotes the relatively slowly varying component of error comprising initial error plus drift, **N** denotes the component of error attributable to nutation of the spinning platform, and **S** denotes the component of error attributable to wobble of the platform at the frequency of spin. The vectors **N** and **S** rotate in the error plane with angular frequencies $\omega_N = 2\pi f_N$ and $\omega_W = 2\pi f_W$, respectively (see figure).

The beam radiated by the antenna is assumed to be symmetrical about the antenna-boresight axis, although a model of the antenna pattern is all that is needed; that is, the relative gain is assumed to depend only on $Z = |\mathbf{Z}|$. (In the case of the Galileo Spacecraft, the relative gain is proportional to $\cos^5[aZ(t)]$, where a is a constant.) It is assumed that $A_r(t)/A(t)$ = the relative gain. Then the problem is to (1) use the measured fluctuations in the signal and the known relative gain as a function of Z to estimate $|\mathbf{\Theta}|$, $|\mathbf{N}|$, and $|\mathbf{S}|$, and the phase relationships among them and (2) use these estimated quantities to reconstruct the spacecraft dynamics and to quantify $A_r(t)/A(t)$.

Assuming that the transmitting antenna occasionally aims precisely at the receiving antenna and that $A_r(t)$ reaches its maximum value on these occasions, one can use the observed maxima of $A_r(t)$ to estimate the presumably very slowly varying $A(t)$. Then using $A_r(t)/A(t)$, one can estimate $Z(t)$. In an algorithm being developed for the Galileo application, the $Z(t)$ thus estimated is processed into a discrete Fourier transform, from which estimates of f_N, f_W, $|\mathbf{N}|$, $|\mathbf{S}|$, and $|\mathbf{\Theta}|$ are derived. When the three components of error are phased correctly, a mathematical model of the dynamics contained in the algorithm yields the correct $A_r(t)/A(t)$. The parameters of the model are adjusted repeatedly via a software feedback loop to minimize rapid variations in that computed value of $A(t)$ that presumably is the best current estimate after correction for the modeled aiming error.



$$Z_x(t) = \Theta_x(t) + N\cos(\omega_N t) + S\cos(\omega_W t)$$
$$Z_y(t) = \Theta_y(t) + N\sin(\omega_N t) + S\sin(\omega_W t)$$

Looking Along the Line from the transmitter to the receiver, the error in the aim of the transmitting antenna is represented by the sum of the vectors **Θ**, **N**, and **S**.

This work was done by Shlomo Dolinsky of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 46 on the TSP Request Card.*
NPO-17829

Machinery

Hardware, Techniques, and Processes

Variable-Compliance Couplings for Heavy Lifting

Couplings can be made more or less stiff as needed.

Goddard Space Flight Center, Greenbelt, Maryland

Coupling devices of a new type contain manual or electronically controlled, motorized drives that vary their stiffnesses. These devices can be regarded as advanced flexible couplings intended for use in wrist joints of robotic manipulators and other industrial equipment that must lift heavy objects. It has been made to lift weights as low as ¼ lb (114 g).

The compliance in a device of this type is provided by short sections of cable clamped at their ends in brackets; in this respect, the devices resemble prior shock-isolating and flexible-coupling devices based on short sections of cable. However, in the present devices, the length-to-diameter ratios of the exposed portions of cable are made larger (the cables are "skinnier") to emphasize compliance and deemphasize hysteresis, and the positions of the brackets are made adjustable to adjust stiffness.

Figure 1 shows a relatively simple, nonmotorized version of a variable-compliance device on an 800-lb (360-kg) lifter. In this case, threaded rods are used to fix the distances between opposing angle brackets, to which the cables are clamped. This adjustment decreases or increases the stiffness by putting the cables in less or more tension, respectively.

In a more-advanced variable-compliance device, brackets that hold cables are moved by a stepping motor via a gearbox and ball screw. The motor operates under computer control with position feedback, and a brake stops the motor shaft when the brackets reach the position that provides the desired amount of stiffness or compliance. Thus, for example, the control computer of a robot can command greater stiffness during operations that require precise positioning. Alternatively, it can command greater compliance to accommodate manufacturing tolerances; for example, to insert a peg in a hole with which the peg might be slightly misaligned.

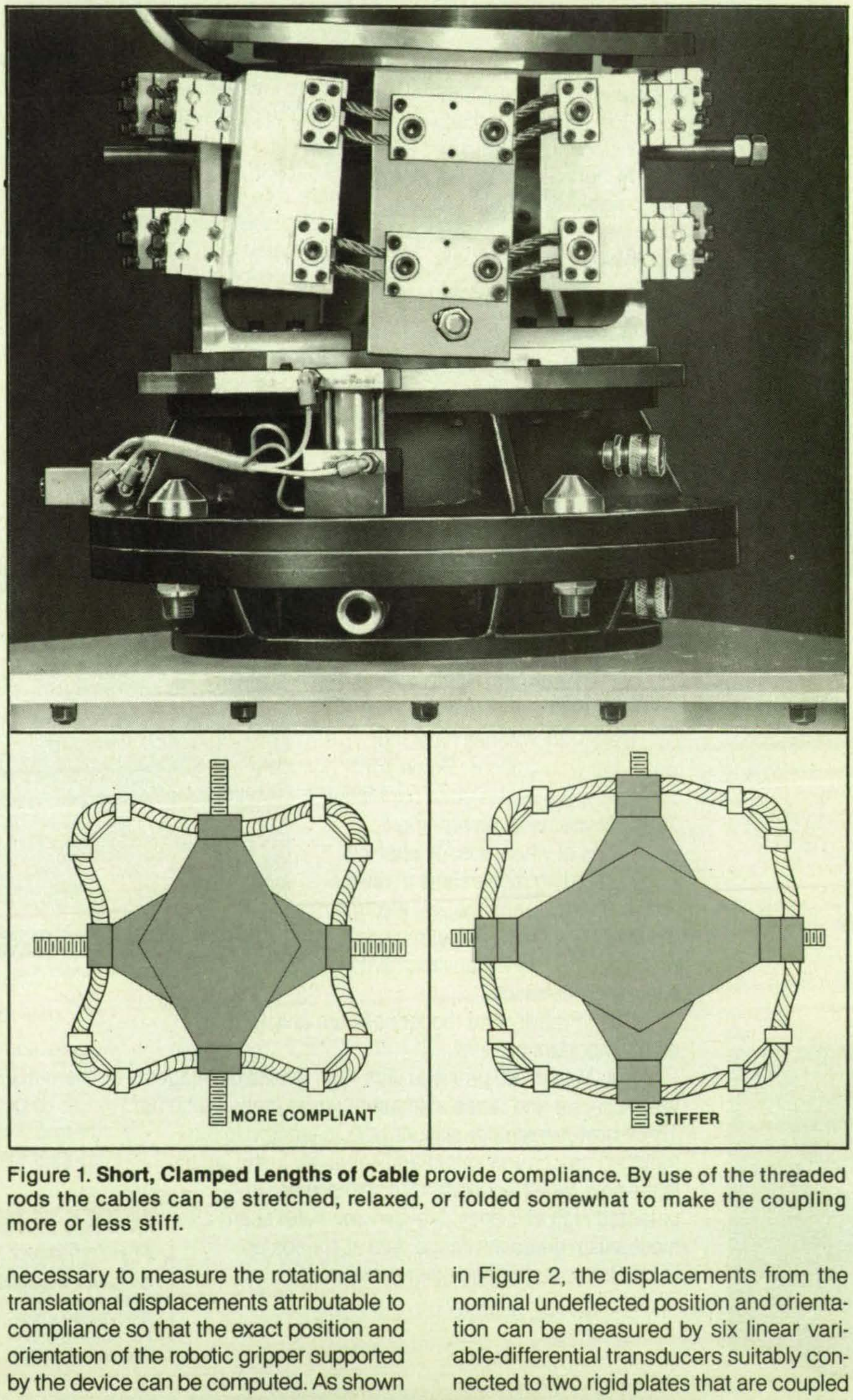


Figure 1. **Short, Clamped Lengths of Cable** provide compliance. By use of the threaded rods the cables can be stretched, relaxed, or folded somewhat to make the coupling more or less stiff.

A typical variable-compliance device provides six degrees of freedom (three translational and three rotational). In a robotic application in which both compliance and precise positioning are required, it is necessary to measure the rotational and translational displacements attributable to compliance so that the exact position and orientation of the robotic gripper supported by the device can be computed. As shown in Figure 2, the displacements from the nominal undeflected position and orientation can be measured by six linear variable-differential transducers suitably connected to two rigid plates that are coupled

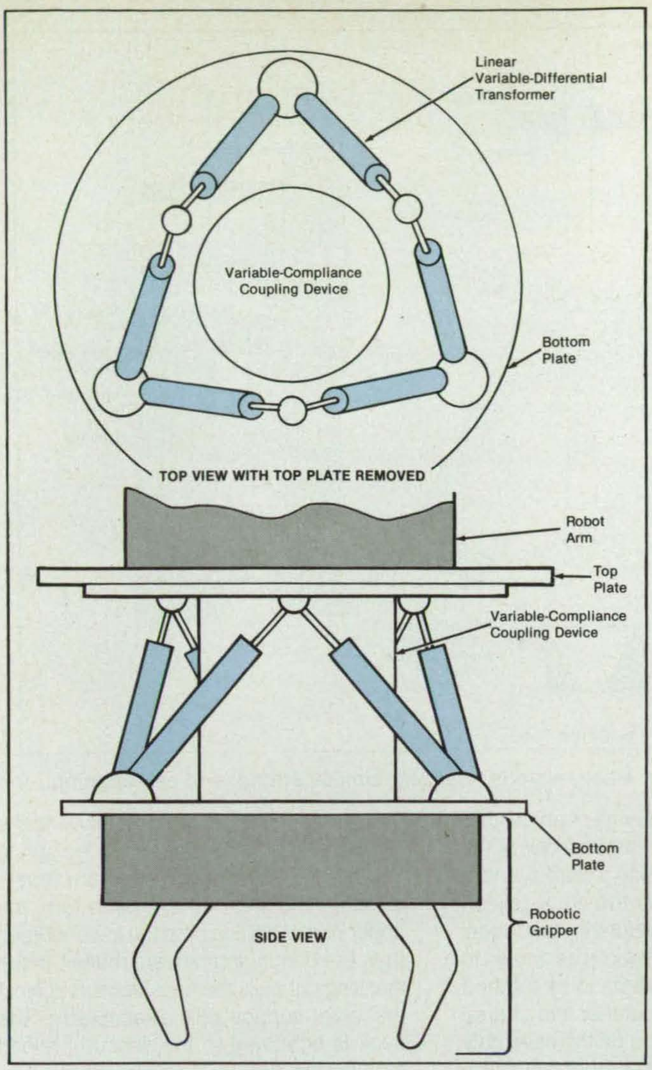


Figure 2. **Linear Variable-Differential Transducers** measure the displacements of the upper and lower plates (which plates are coupled by the variable-compliance device) from their nominal relative position and orientation.

by the variable-compliance device.

This work was done by James Kerley, Wayne Eklund, Raymond Burkhardt, and George W. Richardson of **Goddard Space Flight Center**. *For further information, Circle 30 on the TSP Request Card. GSC-13368*

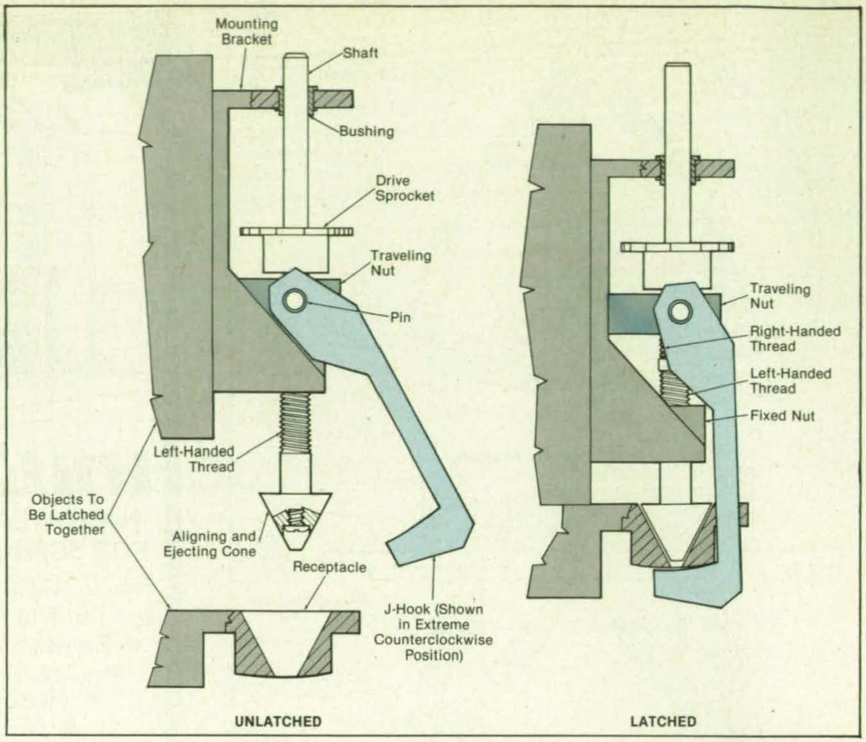
J-Hook Latching Mechanism

Advantages include relatively light weight and low actuation torque.

Goddard Space Flight Center, Greenbelt, Maryland

The J-hook latching mechanism is particularly suited to joining modules of equipment together and holding cargoes in vehicles. The mechanism offers several advantages over prior latching mechanisms:

- It is relatively simple.
- It has a high strength-to-weight ratio.
- The faying parts are exposed, permitting visual determination of the status (latched, unlatched, or otherwise configured).
- It provides a high latching preload when actuated with a relatively low torque; consequently, it can be driven by a relatively small motor.
- After being brought into coarse alignment, it pulls itself into fine alignment during the latching sequence.



The **J-Hook Latching Mechanism** is relatively simple, strong, and self-aligning.

The mechanism consists of an assembly of moving parts mounted on one of the two objects to be latched together and a receptacle mounted on the other object. At the beginning of a latching sequence, the mechanism is configured as shown in the figure. The two objects to be latched together are brought together into coarse alignment, with the cone on the assembly positioned loosely in the receptacle. The cone is mounted on a shaft that is turned by a motor or manual drive (not shown) connected to a drive sprocket.

The shaft has a left-handed thread that engages a nut fixed in the mounting bracket and a right-handed thread that engages a traveling nut. The J-hook pivots on a pin on the traveling nut and is spring-loaded to turn clockwise about this pin. Initially, the J-hook is held against the spring load in its extreme counterclockwise position by a cam surface on the mounting bracket that meets a cam surface on the J-hook.

The shaft is turned counterclockwise as viewed from above, causing the upper object, mounting bracket, and fixed nut to travel downward on the left-handed thread and the traveling nut to travel upward on the left-handed thread. This motion moves the camming surfaces apart, allowing the J-hook to turn clockwise under the spring load and reach around under the receptacle. As the shaft continues to turn, the upper object settles onto the lower object; then the continuing upward motion of the traveling nut pulls the hook upward against the lower surface of the receptacle. The hook is tightened to the desired preload by allowing the shaft to stall at the corresponding applied torque.

To unlatch the objects from each other, one simply reverses the torque, turning the shaft counterclockwise as viewed from above. The cone bears against the receptacle; the upper object is pushed upward as the shaft turns against the left-handed thread.

This work was done by M. Bruce Milam of **Goddard Space Flight Center**. *For further information, Circle 24 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 18]. Refer to GSC-13200.

Fabrication Technology

Hardware, Techniques, and Processes

Simple Method for Detection of Intergranular Attack

Replicating tape replaces test coupons and metallurgical inspection.

Marshall Space Flight Center, Alabama

Evidence of the intergranular attack that sometimes occurs on chemically milled and wire-electrical-discharge-machined metal parts can be detected by use of replicating tape. The use of replicating tape makes it unnecessary to manufacture and stock test coupons and to inspect them microscopically.

Heretofore, test coupons have accompanied the parts to be manufactured through the chemical-milling and wire-electrical-discharge-machining processes. Theoretically the postprocess conditions of the coupons represent the postprocess conditions of the parts. The coupons are destructively tested for intergranular attack instead of testing the manufactured parts. However, the coupon method is not always reliable; parts can pass the test while the coupons fail, and vice versa.

The replicating tape is simply pressed on a part to be inspected. The tape conforms to the surface of the part, to which it adheres. When the tape is removed, it presents visual evidence of intergranular attack.

This work was done by Amy A. Jackson of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available. MFS-29798*

Masks for Deposition of Aspherical Optical Surfaces

Relatively smooth, precise surfaces can be made at less cost.

NASA's Jet Propulsion Laboratory, Pasadena, California

Masks of improved design are being developed for use in the fabrication of aspherical, rotationally symmetrical surfaces of mirrors, lenses, and lens molds by evaporative deposition onto rotating substrates. The first published description of this method of fabrication appeared in 1936, but the use of the method has been limited because it has resulted in surfaces of unacceptably large roughness that increased with the depth of asphericity.

New impetus for the fabrication of deeply aspherical optical surfaces by this method is provided by modern coating chambers, which can deposit such materials as tantalum pentoxide, silicon dioxide, lithium fluoride, silicon, and germanium to useful depths with relatively smooth surfaces. The combination of the improved masks and modern coating chambers is expected to provide optical surfaces comparable or superior to those produced by conventional polishing, computer-controlled polishing, replication from polished molds, and diamond turning, and to do so at considerably less cost in material, labor, and capital expense.

In the deposition chamber, the source and mask are aligned with the axis of rotation of the substrate (see Figure 1). The chamber is evacuated, and the material to be deposited on the substrate is evaporated by bombarding the source with an electron beam. The relative thickness of deposition as a function of radius from the axis is nearly proportional to the rotationally smoothed azimuthal opening in the mask as a function of radius; the absolute thickness is proportional to the rate of deposition and the deposition time.

The mask is designed by an iterative procedure that involves computer modeling of the deposition process. One begins by prescribing a mask function $M(r)$ (where

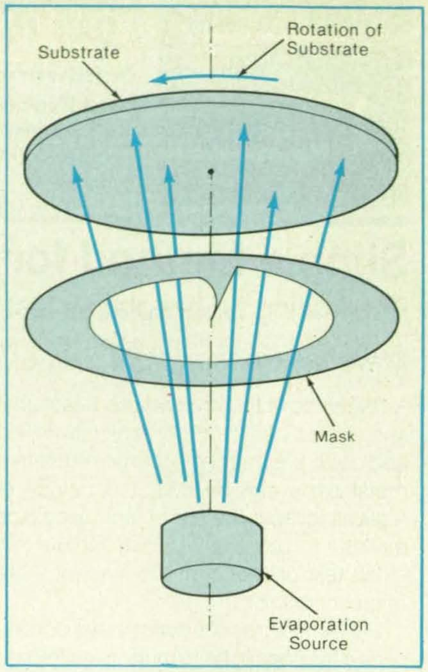


Figure 1. The **Mask Shadows the Source** on the rotating substrate. The azimuthal opening (as a function of radius) in the mask is approximately proportional to the desired thickness (as a function of radius) to which material is to be deposited on the substrate.

Figure 2. **Multiple Lobes** reduce the sensitivity of the deposited surface profile to decentration of the mask.

r = radius) that denotes an azimuthal mask opening (as a function of radius) proportional to the depth (as a function of radius) of the desired aspherical profile $I(r)$. The finite size of the source and the distance of the mask from the substrate give rise to a blur, which is included in the computer model. Also included in the model is the measured or theoretical directional distribution of the intensity of the source. The mathematically modeled deposited profile $S(r)$ that results from these combined effects is compared with the desired profile $I(r)$, and an error function $E(r) = I(r) - S(r)$ is computed. $E(r)$ multiplied by the applicable scale factor is added to $M(r)$ to obtain a new $M(r)$, other corrections to improve accuracy at the edges and center are made, and the process is repeated until $E(r)$ becomes tolerably small.

Multiple lobes (see Figure 2) are used to make the profile of the deposited surface less vulnerable to decentration of the mask. In addition, a small compensatory cusp error is deliberately incorporated to reduce and/or smooth out the more-severe cusp error that would otherwise occur. (Cusp error is the spike or hole that forms in the deposit because the azimuthal opening at the center of the mask is necessarily either 0° or 360°, regardless of the required opening, and the resulting error increases with decentration.) The compensatory cusp error is implemented by modifying $M(r)$ so that it becomes 0° or 360° anyway within a circle slightly larger than the circle of centration tolerance.

This work was done by John R. Rogers and John D. Martin of the University of Rochester for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 150 on the TSP Request Card. NPO-17995*

Reusable Cryogenic-Liquid Tank With Replaceable Liner

The tank could not only be reused but would also weigh less.

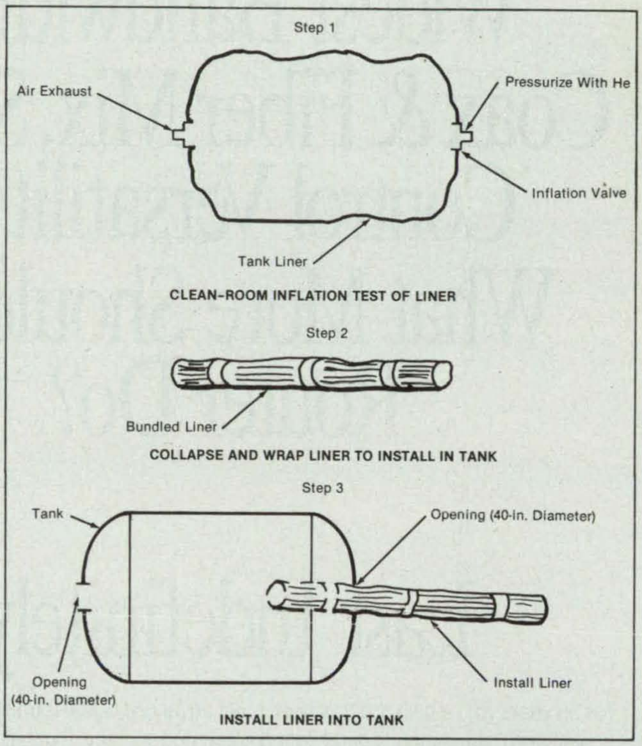
Langley Research Center, Hampton, Virginia

A conceptual main tank equipped with a replaceable liner would hold liquid propellant and would be suitable for reuse in such spacecraft propulsion systems as those of Earth-to-orbit transports. Current tanks for containment of cryogenic propellants are not reusable because of the tendency of the insulation in them to crack. All large tanks up to the present have been expended after one use apiece.

According to the new concept, a thin, lightweight metallic foil or organic film would be used as an impermeable barrier to leakage for the containment of a cryogenic or storable propellant within a composite pressure vessel lined with insulation. The main components of the reusable tank are (1) a composite outer shell for containment of pressure, (2) a replaceable membrane liner, and (3) a foam-filled honeycomb sandwich bonded to the inside of the tank to serve as an insulator and stabilizer to prevent buckling of the wall of the tank.

A new liner (see figure) would be inflated and leak-tested in a clean room. After leak-testing, the liner would be collapsed and bundled. The bundled liner would be fed into one of two access ports in the domes of the tank while the tank was oriented vertically. The preferred opening would be the forward or upper end, where the smaller pressurization and vent lines are located, and the weight of the liner would aid the extension of the liner.

Retaining rings would be installed to secure the two ends of the liner at each access port. A vacuum would then be drawn on the void between the outside of the liner and the wall of the tank by use of a multiplicity of small ports through the honeycomb sandwich and composite outer wall of the tank. A network of vacuum tubes could be used for this purpose. End plates for pressurization would be installed, and the liner would be tested in place. The end caps would then be reinstalled, and pressurization and feed lines reattached.



Replaceable Liner is tested, bundled, and installed in tank. It is vacuum-expanded through small ports in honeycomb sandwich and in tank wall, then retested in place.

Graphite composite materials exhibit the highest specific strengths of state-of-the-art materials that are candidates for propellant tankage. By use of this concept, it would be possible to maximize the potential of filament-wound composite pressure shells that conservatively have strength-to-density ratios five times those of comparable aluminum shells typically used for tankage in propulsion systems.

The concept is intended to solve the reusability problems for future Space Shuttles with internal tanks. However, the concept could be applied equally well to expendable tanks. The estimated reduction in weight below that of the current expendable tank or a tank with composite overwrap and thick metal liner could be as much as 50 percent. Custom-built, single-use liners could be inexpensively proof-tested for each flight, eliminating concern for inspection, maintenance, and repair associated with a metal liner or all-metal tank. By employing a new liner on each flight, the fracture-mechanics issues associated with reuse and concern for potential damage would be eliminated.

This work was done by William T. Freeman, Jr., and Charles F. Bryan, Jr., of **Langley Research Center** *and Ian O. MacConochie and Charles A. Breiner of PRC Kentron, Inc. For further information, Circle 151 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-14172.

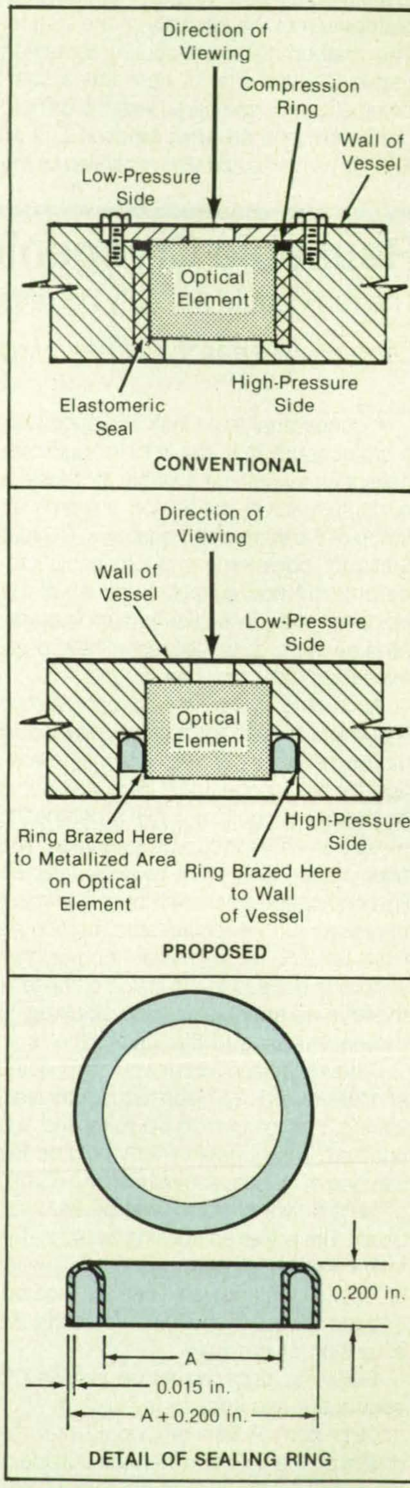
Hermetic Glass-to-Metal Seal for Instrumentation Window

A metal pressure-assisted seal would be brazed to metalized glass.

Marshall Space Flight Center, Alabama

A proposed mounting scheme for a glass, sapphire, or other optical element of an instrumentation window in a pressure vessel would ensure a truly hermetic seal while minimizing the transmission of stress to the optical element. The brazed metal seal would be superior to conventional gaskets of elastomer, carbon, asbestos, or other material compressed between the optical element and the wall of the vessel. Those seals are not hermetic. Furthermore, elastomeric seals have limited temperature ranges and are prone to deterioration with age.

The proposed seal around the edge of the optical element would include a metal ring of U-shaped cross section (see figure). The inner edge of the ring would be brazed to a metalized area on the cylindrical surface of the optical element. The inner edge



Concentric Brazed Joints in the proposed seal would bond the metal ring to the wall of the vessel and to the optical element. The U-shaped cross section would allow the ring to flex under pressure. The inner diameter of the gasket (dimension A) may range from as little as 0.05 in. (1.3 mm) to more than 0.5 in. (13 mm).

of the ring would be brazed to the metal wall of the vessel, in which the optical element would be mounted.

To minimize thermal stresses, the ring would be made of a sheet of an iron/nickel/cobalt alloy like Kovar (or equivalent) that has a low coefficient of thermal expansion. The thin sheet-metal ring would also act as a pressure-assisted seal; that is, it would seal itself more securely as the differential pressure across the window increased.

This work was done by Arthur J. Hill of Rockwell International Corp., for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29778

Algorithm for Simplified Robotic Tracking of Weld Seams

Small cross-seam corrections are computed from a few data.

Marshall Space Flight Center, Alabama

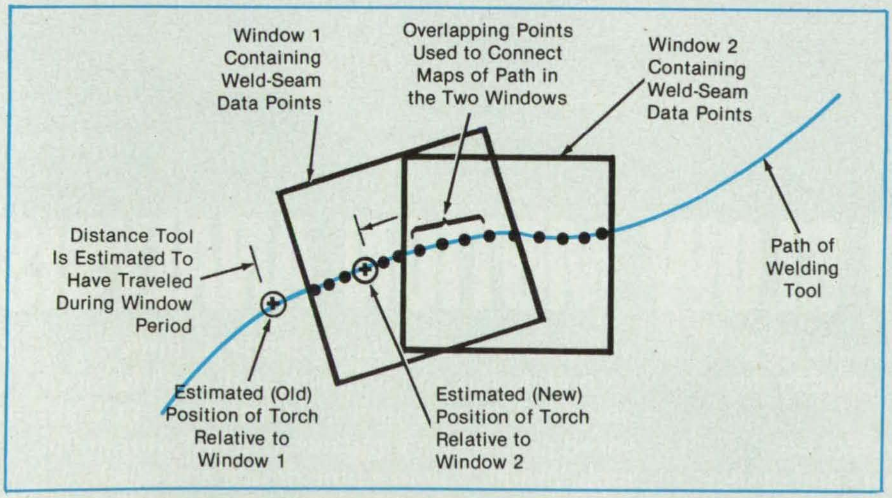
An algorithm computes small cross-seam corrections to the programmed path of a welding robot. The algorithm is intended for use in conjunction with an add-on vision system that is loosely coupled to the robot; more specifically, a vision system that transmits, along a slow communication channel, a small amount of information about part of the weld seam ahead of the welding torch. Unlike older control algorithms, this one does not need data on the position of the torch and does not transform the data on the seam to another reference frame. The robot instrumentation is therefore simpler, and the computational delay attributable to transformations of coordinates is eliminated.

The algorithm constructs a map of the seam in an arbitrary coordinate space. To provide data for the map, the vision system locates points along the seam within a "window" ahead of the torch (see figure). As the robot moves and new vision data are acquired, the window is advanced, the last point along the seam in the old window serving as an intermediate point in the new window. The lines that connect the points in the old and new windows are aligned by correlating those data points that are common to both windows. Then using the programmed speed of the torch at the current time and location (as supplied by the robot-control system a few times per second), the algorithm updates the position of the torch in the window coordinates by calculating the distance the torch should have traveled along the seam from its old estimated position during the window period. The robot-control system then uses the cross-seam error in the current estimated position of the torch to correct the movement of the torch.

With time, the map of the seam becomes less accurate because of errors in correlation and speed. The error is small, however, inasmuch as data are needed only for the span between the torch and the current window; previous data can be discarded.

The algorithm is equally effective if both the torch and the workpiece are moving. The motion of the workpiece simply causes the coordinate space to move.

This work was done by David A. Gutow and Vincent Y. Paternoster of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 20 on the TSP Request Card.*
MFS-29737



The **Position of the Welding Torch** in the reference frame of a moving window is estimated on the basis of data on the weld seam and on the speed of the welding torch.

Tool for Making Curved Holes

An electrical-discharge-machining electrode follows a curved path into the workpiece.

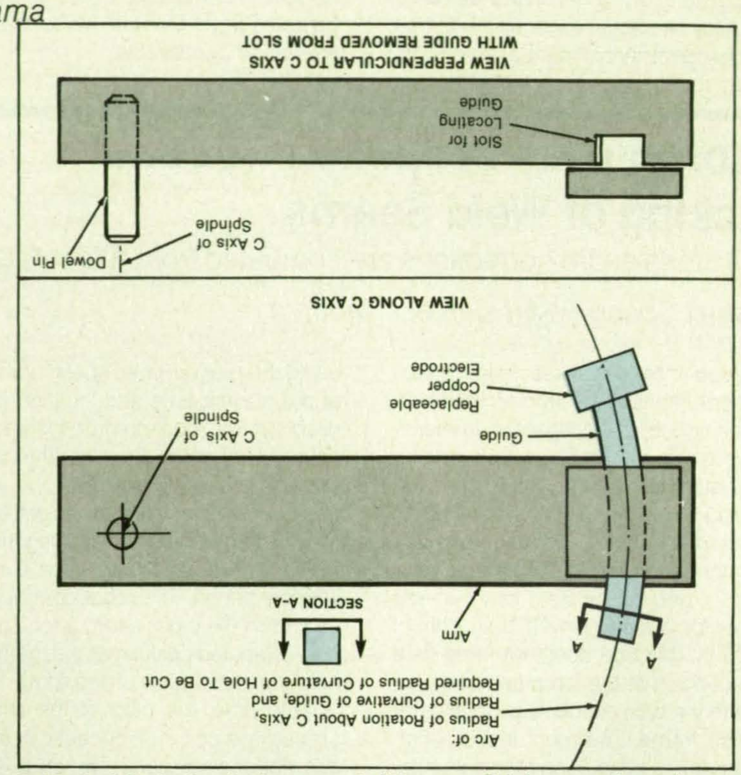
Marshall Space Flight Center, Alabama

A tool for use in electrical-discharge machining (EDM) guides an EDM electrode in making holes, the longitudinal axes of which are circular arcs. The tool is intended for use on a machine equipped with an additional "C" axis (rotation of a spindle). The tool includes an arm attached via a dowel at one end to the axis of rotation of the spindle. A curved guide rod is mounted in a slot at the other end of the arm (see figure). A replaceable copper electrode is attached to the tip of the guide rod.

The radius of curvature of the guide rod equals that of the hole to be made. When EDM is started, the electrode burns into the workpiece while the arm rotates on the spindle. The discharge thus cuts a hole of the same radius of curvature.

This work was done by Robert Allard, Andrew Calve, Edwin Pastreck, and Edward Padden of United Technologies Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-28601.

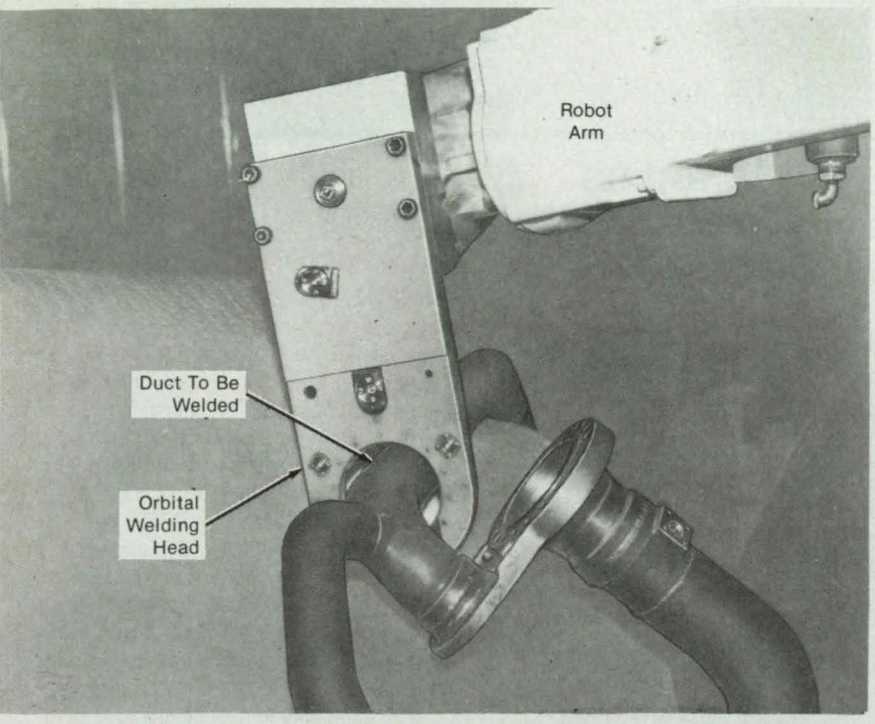


The **Guide Rod** fits in the slot in one end of the arm, which moves through an arc. The motion of the arm thus drives the electrode into the workpiece along the desired curved path.

Orbital Welding Head Held by Robot

Round parts in confined spaces can be welded robotically.

Marshall Space Flight Center, Alabama



The **Orbital Welding Head Encircles** a duct while a robot arm holds the head in position.

An orbital welding head is positioned by a robot, which also controls the motion and the voltage of an arc-welding torch mounted in the head. The orbital welding head is intended for welding pipes or similar round, stationary parts.

Previously, an orbital welding head had to be positioned manually by clamping it on a straight section of the part. Thus, short parts without an adequate mounting space could not be welded.

The new head encircles the part at its torch end and is held and manipulated by the robot arm at the opposite end (see figure). With it, the entire welding operation — including positioning of the head — can be automated. Thus, it is useful for operations in hazardous environments.

This work was done by Kenneth J. Gangl, Benny F. Graham, Malcolm F. Nesmith, and David C. McFerrin of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 53 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 18]. Refer to MFS-29832.

Mathematics and Information Sciences

Software for Allocation of Tolerances

Expertise on design and manufacturing would be reflected in a comprehensive program.

Marshall Space Flight Center, Alabama

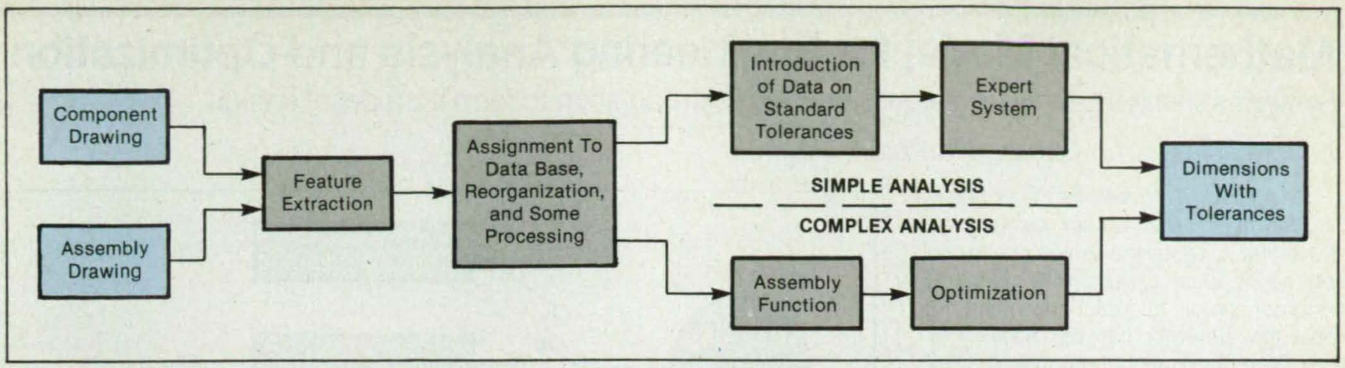
A collection of computer programs is being developed to assist engineers in allocating tolerances to dimensions of components and assemblies. When fully developed, the software system will reflect the tolerancing expertise of both design and manufacturing engineers; as such, it will help all engineers on a project to maintain the comprehensive tolerancing policy and overview that might otherwise get lost or be difficult to maintain when attending to the details of complicated and interdependent designs and manufacturing processes.

It is necessary to allocate tolerances for three main reasons:

1. No manufacturing process produces a component of exact dimensions. Tolerances allow for variations in the dimensions of components as manufactured.
2. To serve the purpose of an assembly of two or more components, the dimensions of both or all should lie between specified limits (e.g., to assure interference fits, clearance fits, or satisfaction of tolerances on overall dimensions of the assembly).
3. A part that wears out or is otherwise required to be replaced during the lifetime of an assembly must be made to satisfy tolerances to assure that it will fit in place.

The allocation of tolerances is a decision-making process. The developmental software is intended to provide an easy-to-use, menu-driven system that will aid this process (see figure). The system incorporates programs in several computing languages. The initial assembly and component drawings are prepared by use of AutoCAD, a computer-aided-design program. The drawings are modified by use of AutoLISP.

A procedure called "feature extraction" is an essential part of the tolerance-allocation process. This procedure is the computerized version of the manual process of reading and interpreting blueprints and identification of manufactured surfaces. In the developmental software system, feature extraction is done in AutoLISP with the help of data bases and codified expertise. The features extracted from a draw-



This **Flow Chart** illustrates the major functions of the developmental software. The output of the software would be the allocation of tolerances to the various dimensions in engineering drawings.

ing (e.g., data on straight and curved lines, circles, dimensions, attributes, and text) are stored in a data base along with such relevant information as coordinates of the features. By use of a program written in dBase III Plus, the data base is reorganized to facilitate programming and processed to indicate details of, and assembly relationships among, mating parts.

The system allocates tolerances by interaction with the user in either of two ways called "simple analysis" and "complex analysis." In simple analysis, the system (1) retrieves the record on the component and dimension in question from the data base prepared by feature extraction, (2) asks the user for information regarding the type of fit and/or intended use of the component, (3) taking account of the user's response, invokes a rule-based expert-system program that extracts the required information from a data base of standard tolerances, and (4) updates the part of the data base that contains the dimensions by adding the relevant tolerance to it.

Complex analysis has not yet been implemented. In complex analysis, the user could choose among several mathematical models of tolerance; e.g., the worst-case model or the statistical model. The worst-case model would result in no rejects but would dictate the tightest component tolerances and, consequently, the greatest manufacturing costs. The other models might allow a few rejects but could reduce the cost per component by relaxing tolerances. In complex analysis, the system would perform iterative calculations, using the chosen model, to obtain a solution that would optimize a specified objective function (e.g., minimize the overall cost).

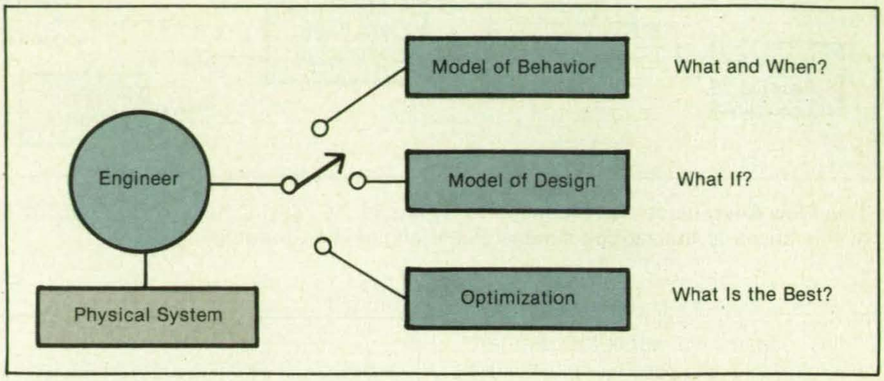
This work was done by Ken Fernandez of **Marshall Space Flight Center** *and Shivakumar Raman and Simin Pulat of the University of Oklahoma. For further information, Circle 134 on the TSP Request Card.*
MFS-27256

Mathematical Model for Engineering Analysis and Optimization

System-sensitivity analysis is combined with extrapolation to form a model of design.

Langley Research Center, Hampton, Virginia

Computational support for the engineering design process basically has two functions: first, to reveal the behavior of the designed physical system in response to external stimuli; and second, to find out how that behavior can be modified by changing physical attributes (design variables) of the system. For a large engineering system, the conventional evaluation of the effects of changes in design variables via repetitive simulations of behavior for perturbed variables is impractical because of excessive cost and inadequate accuracy. In an alternative method, recently developed system-sensitivity analysis is combined with extrapolation to form a model of design (see figure). This model of design is complementary to the model of behavior and is capable of direct simulation of the effects of changes in design variables.



The **Design Model Complements the Behavior Model** and extends the array of mathematical tools that assist the engineer in the design of an optimal physical system.

The first function of computational support calls for system analysis. The second function answers the "what if" types of questions and is performed by sensitivity analysis. The design model answers the "what if" questions concerning effects of the design variables on behavior — the questions that must be answered in the quest for an optimal design.

System-sensitivity analysis quantifies answers to such questions via computation of the derivatives of behavior with respect to design variables, without the costly finite differencing of system analysis. Sensitivity analysis yields derivatives of the first and higher orders that may be coupled with an extrapolation based on these derivatives to form a model of design. This model is capable of answering the designer's queries about the effects of design variables nearly instantaneously.

Complementing the model of behavior with the model of design affords the option of obtaining answers to three basic questions that occur in the design process. The "what now" question about the response of the system is answered by the model of behavior. The "what if" question about the effects of a design variable is answered by the model of design. Finally, the question, "What is the best?" in the search for an optimal setting of many design variables, under complex and possibly competing considerations, can be answered by a formal optimization that calls on both models.

The algorithms developed for this method should be applicable to the design of large engineering systems, especially those that consist of several subsystems that involve many disciplines. The array of mathematical modeling tools provided by these algorithms has potential for adding to the general body of knowledge in the engineering community.

This work was done by Jaroslaw Sobieski of **Langley Research Center**. *Further information may be found in NASA TM-101616 [N90-10308], "Approximate Simulation Model for Analysis and Optimization in Engineering System Design."*

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

LAR-14364

Rugged Video System for Inspecting Animal Burrows

A slim camera is used to find gopher tortoises in deep, dark holes.

John F. Kennedy Space Center, Florida

A video system is designed for use in examining the interiors of the burrows of gopher tortoises. The system, made largely of commercial components, is used to probe the tortoises' burrows which are 5 in. (13 cm) in diameter or greater, to a depth of 18 ft. (about 5.5 m).

The burrows are examined to survey the population of gopher tortoises. The species, *Gopherus polyphemus*, which is in decline because of building in their habitat, is a major benefactor to wildlife in the southeastern United States, especially Florida. Its burrows provide a refuge not only for the tortoises themselves but also for more than 80 other species. The bare soil exposed by tortoises' digging also provides open sand for vegetation and other animals. The survey is intended to help preserve the species by measuring population and population trends, as well as variations in the occupancy of burrows with seasons and weather.

The video system includes a video camera, video cassette recorder (VCR), television monitor, control unit, and a power supply, all carried in a backpack. The camera is enclosed in a waterproof aluminum housing of 3-in. (7.6-cm) diameter. The camera can be equipped with a built-in light source. The power supply was modified and separated mechanically from the camera while remaining electrically connected to the camera by a cable and waterproof connectors. Thus shortened, the camera can negotiate the sharp turns common in the burrows.

A pair of polyvinyl chloride (PVC) poles, 1/2 in. (1.3 cm) in diameter, is used to maneuver the camera into (and out of) burrows. The video scenes are observed on the television monitor and recorded on the VCR. The poles are stiff enough to push the camera into the burrow but flexible enough to bend around curves.

Adult tortoises and most other burrow inhabitants are readily observable, although young tortoises and such small animals as mice can be obscured by sand or debris. The camera, although it is waterproof, cannot focus in water and thus cannot be used in flooded tunnels. Plans call for the camera to be replaced by a newly developed camera that produces high-resolution underwater images in color.

The work was done by Dick Triandafils and Art Maples of **Kennedy Space Center** *and Dave Breininger of Bionetics Corp. For further information, Circle 160 on the TSP Request Card. KSC-11468*

New on the Market

Morton International's advanced materials facility, Woburn, MA, has developed a technology for mass production of bulk **CVD (chemical vapor deposited) beta silicon carbide.** The process is based on a reaction of gases that forms a polycrystalline solid, providing a highly-polishable, theoretically dense material with very high stiffness and thermal conductivity, as well as excellent thermal shock resistance at high temperatures (1500^{0}C).

For More Information Circle No. 800

The NP-600 color network **printer** from Codonics Inc., Middleburg Heights, OH, is designed to work with any homogeneous or heterogeneous TCP/IP-based network. Utilizing dye-sublimation technology with 16.7 million simultaneously printable colors, the NP-600 can produce continuous tone format prints. It recognizes most popular image file formats, including TIFF, GIF, PCX, Macintosh PICT, SUN raster, PPM, and X11 Bitmap.

For More Information Circle No. 794

A high-performance, portable **infrared camera** is available from Amber Engineering, Santa Barbara, CA. The RADIANCE 1, which measures 5.2" x 4.2" x 9.5" and weighs less than five pounds, acquires images at 60 frames per second with a 256 x 256 indium antimonide staring focal array. The camera features a self-contained, closed-cycle Stirling cooler and is designed for use in surveillance, predictive maintenance, process control, and materials evaluation.

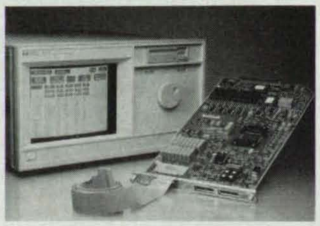
For More Information Circle No. 798

Synergistic Detector Designs, Fremont, CA, has announced a super-high-resolution **x-ray inspection camera** that produces the highest resolution 2D images available without microfocus sources and image magnification. The system, first used for rapid x-radiographic, production line characterization of NPR (new production reactor) target particles, provides a spatial resolution greater than 45 lp/mm 4096 intensity steps.

For More Information Circle No. 796

Sun Microsystems Computer Corp., San Francisco, CA, has introduced the industry's fastest **desktop workstation**, the SPARCstation™ 10. Built around the new superscalar SuperSPARC™ chip from Texas Instruments, the SPARCstation 10 features a modular design and achieves a multiprocessing performance rating of up to 218 and more than 400 MIPS in its four-microprocessor configuration.

For More Information Circle No. 792

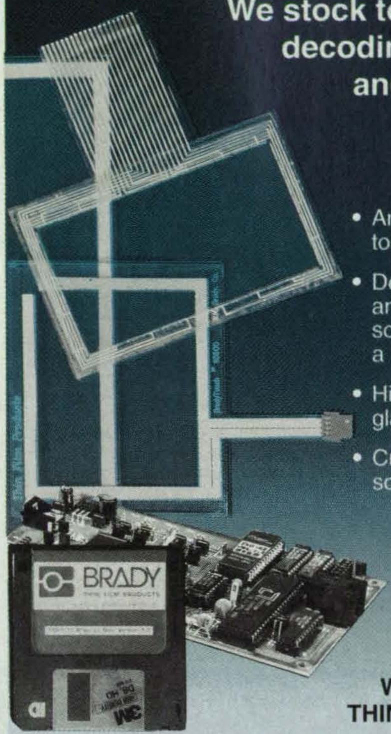


The Hewlett-Packard Co., Palo Alto, CA, has produced a new **data acquisition card** for the modular HP 16500 series logic-analysis system that provides five to ten times the memory depth of any available 100 MHz logic analyzer. Dubbed the HP 16542A, it provides 2 MB of memory with 100 MHz state/timing analysis across 16 channels, important for digital-data-stream and microprocessor designers who collect and analyze large data streams.

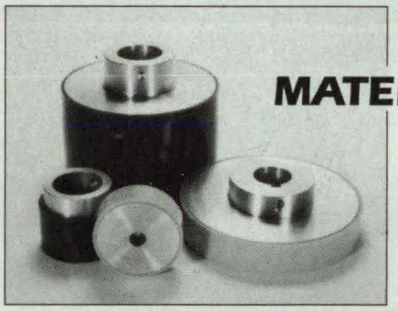
For More Information Circle No. 790

The PDDR-12 **portable radio modem** from Pacific Crest Instruments, Sunnyvale, CA, provides wireless data communication for field applications where hard-wired connection is impractical. Both asynchronous and synchronous modes of data communication are supported, enabling point-to-multipoint network applications. The RS-232 interface can be programmed for hardware or software handshake and communicates with the DTE at up to 9600 bps.

For More Information Circle No. 788



For More Information Circle No. 637



For More Information Circle No. 488

New on the Market

Industrial Perception Systems Inc., Allison Park, PA, has announced an advanced color-processing **machine vision system** called PHOTON that provides acquisition and processing operations in RGB or HSI parameters. Applications include spatial processing, edge finding, shade gradient inspection, color parts sorting, and color verification, as well as standard vision functions such as defect detection, gauging, sorting, and robot guidance.

For More Information Circle No. 772

A hand-held, clamp-on **power measurement** instrument that incorporates both multimeter and oscilloscope functions has been introduced by LEM USA, Milwaukee, WI. The portable ANALYST™ 2000-P Power Meter displays DC and AC current or voltage, true power, and apparent power in alphanumeric and bar graph notation, and can display voltage and current in oscilloscope-like waveforms.

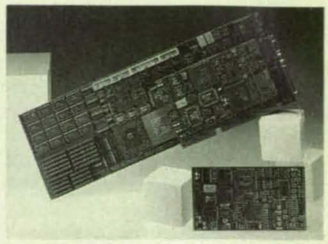
For More Information Circle No. 784

A **scientific workstation** providing 64 MegaFLOPS performance for **computer graphics visualization** is available from Lazerus, Oakland, CA. The new Visualization Solution features display resolution from NTSC/PAL to high resolution; true color or software selectability from 1 to 32 bits/pixel; real-time 3D graphics; and real-time, true-color image and motion compression/decompression with an image digitizer.

For More Information Circle No. 776

The HDB **gear sets** from Harmonic Drive Technologies, Peabody, MA, are compact, end-of-roll mounted 1:1 differential drives that provide dynamic registration of rotating elements. Integrating both driving and trimming capabilities at the end of the rolling element, the HDB is suited for web presses and other machines that require constant monitoring and adjustment of rotating cylinders, wheels, cams, cutoff knives, and indexing devices.

For More Information Circle No. 778



The VISIONplus-AT Modular Frame Grabber (MFG) from Imaging Technology Inc., Bedford, MA, is the first AT-based **image processor** to display a live video image within Microsoft Windows on a high-resolution PC display. The MFG combines plug-on camera interface modules, an on-board VGA adaptor, flexible memory architecture, and high-resolution, flicker-free display. It displays images from virtually any camera and can be configured for a range of monochrome, true color, or variable-scan applications.

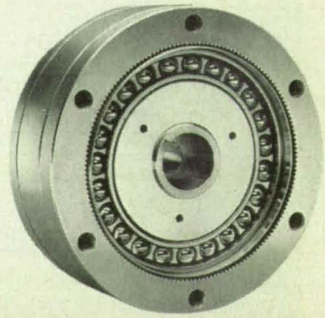
For More Information Circle No. 766

Banner Engineering Corp., Minneapolis, MN, has introduced a **photoelectric sensor** that connects directly to a distributed control network, eliminating the need for a PLC. The new OMNI-BEAM™ sensors are incorporated into a high-performance, distributed control system called Seriplex® that can control up to 510 digital I/O points using only a single four-wire cable. One Seriplex system can replace up to 1024 individual control wires, reducing sensor installation time and expense.

For More Information Circle No. 764

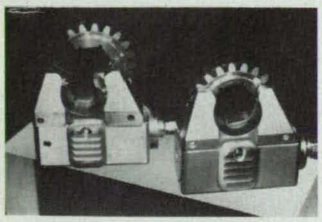
Two ultra-compact, portable **GPS receivers** have been introduced by GARMIN International, Lenexa, KS. The GPS 55 and GPS 55 AVD use GARMIN's MultiTrac™ technology, which tracks up to eight satellites from horizon to horizon for improved coverage and precision, and provides updates every second. Capable of speeds up to 695 knots, the hand-held units feature reversible ten-route storage capacity and AutoStore™ for instantaneous waypoint storage.

For More Information Circle No. 774



New on the Market

D.A.T.A. Business Publishing, Englewood, CO, has released an easy-to-use **International Semiconductor Directory (ISD) database** that includes over 400,000 devices from over 500 manufacturers. The cost-effective ISD database—priced at $249—describes the components, provides part numbers and availability data, and identifies manufacturers, sales offices, and distributors.
For More Information Circle No. 762



Swearless Tools Corp., Boulder, CO, has designed a **tool for turning line-fitting nuts** that consists of a drive head and a set of geared sockets that open to fit around a hydraulic line and then lock shut for operation. The heads attach to a range of commercial electric drive tools to provide a fast and efficient means of removing hydraulic lines, installing line fitting, and adjusting torque. The tool comes with flexible drive shafts that permit access to lines blocked by other lines or obstructions.
For More Information Circle No. 760

Imaging Services, Santa Barbara, CA, offers **atomic force and scanning tunneling microscope services** using state-of-the-art equipment for images with true 3D resolution at the nanometer scale. Scan sizes range from the atomic scale to 125 mm x 125 mm, and samples can be imaged in air or a variety of fluids.
For More Information Circle No. 780

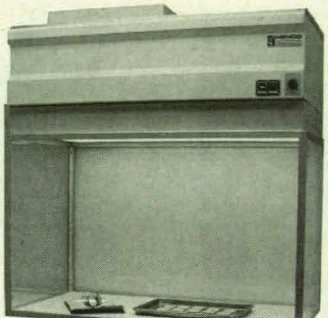
Festo Corp., Hauppauge, NY, has introduced **photoelectric sensors** designed to close the gap between diffuse sensors and fiber-optic cables. Only 8 mm in diameter and 56 mm long, the optical reflex sensors operate on 10 to 30 VDC and feature non-contact sensing distances up to 50 mm at 1 kHz switching frequency with 100 ma output.
For More Information Circle No. 768

IN[3] Voice Command, developed by Command Corp. Inc., Atlanta, GA, integrates **speech recognition** with Sun SPARCstations to permit voice control of Sun's OpenWindows user interface and voice command input to applications running on SPARCstations. The manufacturer cites studies that indicate voice command input can speed up command-intensive applications such as CAD by 35 to 40 percent.
For More Information Circle No. 782

The industry's first eight-channel **serial communications controller**, called the Enhanced Serial Communications Controller-8 (ESCC-8), is available from Siemens Corp., Santa Clara, CA. The ESCC-8, which reduces board space requirements by 15 cm^2 and system energy needs by 40 mW, can replace up to four two-channel controllers. It supports multi-master BUS configurations, plus international protocols including X.25, LAPB, ISDN, LAPD, HDLC, SDLC, ASYNC, and BYSYNC.
For More Information Circle No. 770

Chessell, Newtown, PA, has unveiled a 250 mm, 56-channel, hybrid strip chart **data processing recorder** that features an unique alphanumeric-symbolic touch-screen keyboard, visible only when desired, for front-panel configuration of all software-based attributes. The new model 4200 has a three-color vacuum fluorescent display that presents data clearly as digital readout and on analog scales. The recorder can process data to derive other parameters, display results on a color operator panel, trace or log inputs and calculated values in six colors, scan all points for alarms, and update up to 45 trended points in one second.
For More Information Circle No. 786

New on the Market

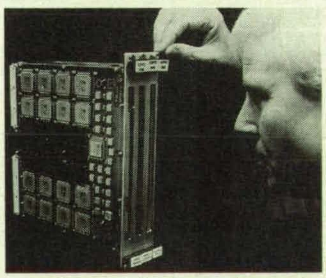


The Clean **Work Station** was designed by HEMCO Corp., Independence, MO, to provide individual users with a contamination-free work area for medical, pharmaceutical, food and dairy, and electronics manufacturing applications. Available in two- and four-foot widths, it maintains a Class 100 environment with HEPA filtration that is 99.99% efficient on .3-micron particles. A molded fiberglass body contains the filter and clear plexiglass side panels with aluminum framework allow viewing from all sides.

For More Information Circle No. 756

Arizona Packaging Software Inc., Tucson, AZ, has introduced the AZtec™ system for **modeling and simulation of advanced electronic packaging designs**. The unique system provides rigorous solutions for prediction of pulse shape, delay, and crosstalk. It features package parasitics modeling for interconnect capacitance, inductance, and skin-effect resistance; and rapid digital pulse simulation for multiple coupled transmission lines.

For More Information Circle No. 754

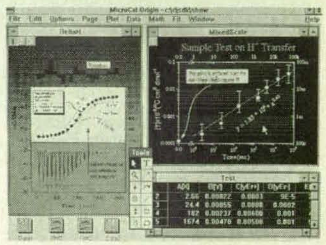


An advanced high-speed **associative/parallel processing computer** built by Loral Defense Systems, Akron, OH, is dramatically smaller and faster than other computers in its class. Loral's ASPRO-VME is a modular, open architecture computer programmable in Ada. In its basic configuration, it consists of three 6U VME modules and can perform 150 million FLOPS and five billion operations per second of integer arithmetic.

For More Information Circle No. 750

An **analytical video camera** for computerized imaging systems was designed by Image Technology Methods Corp., Waltham, MA, to provide exceptionally clean images for a wide range of low-light-level applications without resorting to camera cooling or intensification imaging. The ITM Model 250-I SOFCAM™ provides image sensitivity on the order of 10^{-3} lux, achieved with 98% preservation of the dynamic camera range response.

For More Information Circle No. 752



The latest version of Origin™ **scientific graphics and data analysis software** from MicroCal Inc., Northampton, MA, features an enhancement called Active Graphic Objects™ (AGOs) that allows the user to associate a LabTalk™ script with a graphical object—moving, drawing, or clicking on the object executes the associated script. AGOs can be copied and pasted, stored, and reused in other analyses.

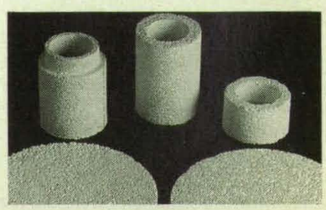
For More Information Circle No. 748

Integrated Systems Inc., Santa Clara, CA, has released the Xmath™ Signal Analysis Module (SAM), a CAE environment for **signal processing and communications systems analysis**. The Xmath SAM combines the flexibility of custom user design with a comprehensive library of system and signal models. It also supports complex envelope analysis to improve CAE efficiency.

For More Information Circle No. 746

Zircar Products Inc., Florida, NY, has introduced a rigid, low-density insulating **refractory material** that comprises Zircar Insulating Bubble and a refractory cement. The new Bubble Alumina is prefired, contains no organics, and is well-suited to high-temperature applications where high strength and low thermal conductivity are required.

For More Information Circle No. 758



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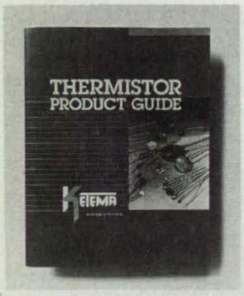
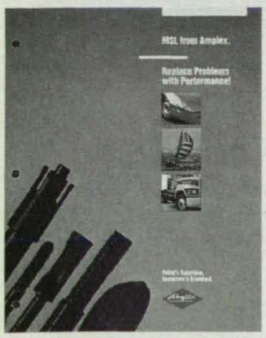
New Literature

The Rodan Division of Ketema Inc., Anaheim, CA, has released a product guide for its advanced industrial **thermistors**. The 24-page publication highlights the company's NTC (negative temperature coefficient) and silicon PTC (positive temperature coefficient) thermistors. Dimensional drawings, conversion tables, curves, and flow charts illustrate the products for easy determination of applications. A glossary is also included.
For More Information Circle No. 702

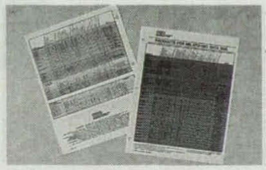


Metal single-layer (MSL) superabrasive products are described in a four-page brochure from Amplex Corp., Bloomfield, CT. MSL products feature a crystal attachment that ensures high performance at low grinding speeds and with soft or temperature-sensitive materials. In comparison to plating, they offer stronger particle retention and bond uniformity, greater particle exposure, longer tool life, and sufficient chip clearance. Amplex produces products in both diamond and cubic boron nitride abrasives, mesh sizes from 20/30 through 270/325, and three abrasive densities.
For More Information Circle No. 704



Recent advancements in **timer/counter technology** are described in five new application notes from John Fluke Mfg. Co., Everett, WA. Topics include the growing importance of modulation domain measurements in such applications as frequency-agile radios and oscillator testing; sources of error in time interval measurements; characterizing rapidly changing frequencies and frequency bursts; and using arming delay.
For More Information Circle No. 724

Portescap US Inc., Hauppauge, NY, has published a 116-page catalog of escap® **motion systems**. Featured products include ironless DC motors with precious metal commutation and with "Rotafente" graphite for high-current commutation, DC motor drive circuits, brushless DC motors, sensorless drivers, DC tachometers, and optical encoders. Sample motor calculations and a comprehensive list of technical definitions is provided.
For More Information Circle No. 706

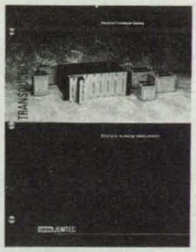


A product selection chart to aid **MIL-STD-1553 data bus** design engineers is available from ILC Data Device Corp., Bohemia, NY. It provides quick reference for monolithic chip, McAir compliance, monitor, dual redundant, VME-VXI, Unibus, Multibus, IBM PC bus, Flat Pack, and SEAFAC testing. The two-sided chart lists over 60 data bus products, including single and dual transceivers, bit processors, RTUs, interfaces, card assemblies, and testers.
For More Information Circle No. 708

Matrix Information Services, Lathrup Village, MI, has introduced *VR Monitor*, a newsletter for the field of **virtual reality**. Each issue provides news and analysis of industry activity worldwide, expert technical tips for hardware and software, calls for bids and proposals, application stories, and new product announcements. The newsletter focuses on immersive VR, including head-mounted displays, position sensing, 3D sound, and tactile/force feedback.
For More Information Circle No. 722

Emerson & Cuming Inc., Woburn, MA, is offering a selector guide for its UNICOAT® line of one-component, solventless, low viscosity, and low-stress urethane, silicone, and acrylate **conformal coatings**. The coatings provide environmental protection for printed circuit boards and electronic components and can be applied by dip, spray, flood, brush, or screen methods.
For More Information Circle No. 710

Level control products, including new microwave sensors for solids flow and point level detection, are featured in a four-color brochure from Monitor Manufacturing, Elburn, IL. Featured products include the non-contacting SFD-1 solids flow detector with nonintrusive flush mounting for use in material handling lines and feeders; the BBD broken bag detector which signals when unacceptably high volumes of particulate matter pass through baghouse filter outlets; and the MBB-3 microwave beam breaker, a noninvasive point level detector for use with bulk material or in peak level detection.
For More Information Circle No. 712



Jemtec Electronics Co., Columbus, OH, has announced an 88-page **electrical transducer** catalog and engineering guide that provides detailed specifications, photographs, wiring diagrams, and application information. The guide describes Jemtec's signal conditioners, alarms, DC isolation amplifiers, analog-to-pulse and pulse-to-analog converters, watt transducers, watt/watthour meters, and transducer calibrators. A reference section provides calibration formulas, application notes, and a glossary.
For More Information Circle No. 714

A new design handbook for **fixed frequency filters** is available from Telonic Berkeley Inc., Laguna Beach, CA. The 32-page publication contains a filter selection guide, frequency and bandwidth tolerance curves, and passband relationship curves. It also describes Telonic's low pass and bandpass tubular filters; highpass filters; and cavity, interdigital, combline, and miniature bandpass filters.
For More Information Circle No. 716

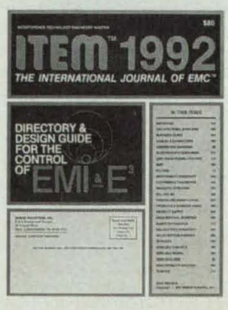
A 200-page technical manual and catalog from Environmental Container Systems Inc., Grants Pass, OR, details over 300 standard transportable **electronic enclosures for 19-inch equipment**. The catalog provides design information for enclosures, cases, and reusable containers; an overview of the company's extensive plastic and composite molding capabilities; and a complete color chart. The technical section features line drawings of components, dimensions, EMI/RFI/ESD shielding data for conductive composites, and shock- and vibration-protection characteristics.
For More Information Circle No. 726

A **test and measurement** handbook and buyer's guide from EIL Instruments Inc., Hunt Valley, MD, details more than 2500 electronic systems from over 100 manufacturers. The guide compares features and lists specifications, prices, and applications. Products include multimeters, recorders, printers, data/telecommunications testers, power supplies, function generators, frequency counters, and logic testers.
For More Information Circle No. 718

Litton Systems' Electron Devices Division, Williamsport, PA, has released a full-color brochure spotlighting **microwave power devices**. In addition to describing the company's research facilities, it provides selection charts for medium-power klystron amplifiers and oscillators; magnetrons in S-band through Ku-band frequencies including coaxial, vane and strap, and injection-locked models; and crossed-field amplifier tubes.
For More Information Circle No. 728

Magnavox Electro-Optical Systems, Mahwah, NJ, is offering a catalog highlighting its **infrared components**, including a range of dual-opposed piston split Stirling cryogenic coolers. The catalog describes the new MX7045L linear-resonant split Stirling cooler, which utilizes clearance seal technology, needs no lubricants, and operates on a 17-32 VDC bus.
For More Information Circle No. 730

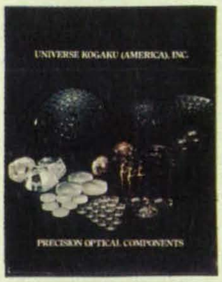
R&B Enterprises, West Conshohocken, PA, has announced the 1992 edition of *ITEM, The International Journal of EMC*. The 384-page design guide and directory addresses measurement, reduction, and control of electromagnetic interference and electromagnetic environmental effects. Featured sections cover architectural shielding, filters, TEMPEST, EMP, lightning, ESD, shielded cabinetry, and susceptibility sources.
For More Information Circle No. 720



NASA Tech Briefs

LITERATURE SPOTLIGHT

Free catalogs and literature for NASA Tech Briefs' readers. To order, circle the corresponding number on the Reader Action Request Form (page 97).



UKA OPTICAL PRODUCTS PLUS

Complete engineering, design and manufacturing of optical lenses and optical components. Custom design and off-the-shelf lenses with superior precision of computer design. Full sales and customer service support. Brochure available at your request.

Universe Kogaku (America), Inc.

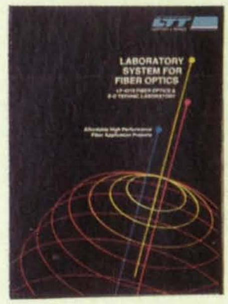
For More Information Circle Action No. 301

FREE ENGINEERING FINDINGS CATALOG

Featuring 272 pages of components, materials and select tools in this new 1992/1993 catalog. Among the hard-to-find items are small gauge 304 & 316 type stainless steel hypodermic tubing, shrink Teflon tubing, stainless steel guide wire, Torx, and metric machine screws. Will furnish small quantities for R&D, or large quantities for economical pilot production.

Small Parts, Inc.

For More Information Circle Action No. 302



FIBER OPTICS EDUCATION KIT

Laser Tools and Technics LF-4310 system is an integrated FO-communications and electro-optics instruction kit. System integration provides higher performance and more experiments at a lower price. The 20 labs cover basic to advanced fiber principles, from cutting fiber to use of lock-in amplifiers and fiber interferometers.

Saguaro Scientific Corporation

For More Information Circle Action No. 303

ADVANCED COMPOSITE WORKSHOPS

The brochure describes six different "hands-on" workshops in advanced composite materials technology covering fabrication, tooling, repair, engineering design for specialized repairs, and ultrasonic inspection of composites. Emphasis is on prepreg carbon and aramid fiber material and processes, utilizing vacuum bagging and high-temperature curing methods. Workshops vary from 3 to 8 days in length.

Abaris Training Resources, Inc.

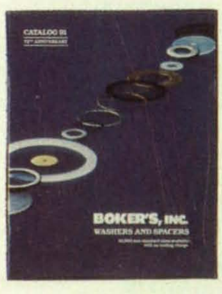
For More Information Circle Action No. 304

NEW LASER OPTICS CATALOG

This new, 300-page catalog contains many special laser optics—femtosecond mirrors, anamorphic prisms, ultra-broadband polarizers—as well as extensive listings of such other high damage threshold optics as lenses, prisms, mirrors, and wave- plates.

CVI Laser

For More Information Circle Action No. 305



WASHERS AND SPACERS

Boker's 28-page catalog '92 offers 10,000 nonstandard sizes with no tooling charges. Outside diameters are 0.080 to 2.631, with numerous inside diameters and thicknesses. 2,000 material variations, including plastics, create millions of possibilities.

Boker's, Inc.

For More Information Circle Action No. 306

FREE DATA ACQUISITION SOFTWARE TOOL

DAQ Designer is a free software tool that helps determine the best hardware and software combinations for a PC-based data acquisition system. It will (1) ask questions about application, (2) analyze answers to determine a system's needs, (3) describe what hardware and software is needed to develop the system.

National Instruments

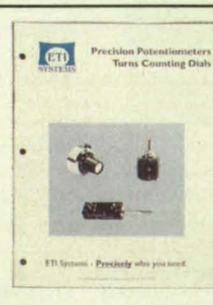
For More Information Circle Action No. 307

NEW SPECIFICATION CHART FOR ALUMINUM GAS CYLINDERS

Aluminum cylinders are used for the safe storage and transportation of compressed gases. Corrosion resistant, light weight, and preferred for specialty gases. Specification chart and pricing for 23 sizes of cylinders—from 3½ ounces to 20 pounds CO_2 capacity—pressures up to 3000 psi service pressure.

Cliff Impact Div.

For More Information Circle Action No. 308



POTENTIOMETERS AND DIALS

Catalog describes full line of potentiometers; linear motion, multi-turns and single turns, as well as concentric and digital turns counting dials. Engineering drawings and schematics for each unit included. Appendix describes mounting techniques and limit switches. Information vignettes explain topics such as linearity, hybrid elements and resolution.

ETI Systems

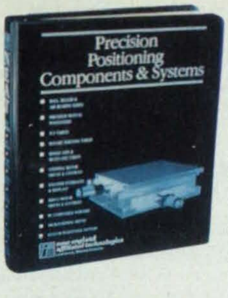
For More Information Circle Action No. 309

FAST 950 V PULSE/DELAY GENERATOR

The programmable 6040/310H generates pulses to ±950 V at rates to 1 MHz with 5 ns risetime. Peak current is 19 A into 50 ohms. The instrument also functions as a synchronous digital delay generator and double pulse or variable gate-width source with 1 ns-step resolution and 50 ps jitter.

Berkeley Nucleonics Corp.

For More Information Circle Action No. 310



PRECISION POSITIONING & MOTION CONTROL

155-page catalog includes single/multi-axis tables, rotary & high vacuum stages, air bearings, RS 232 indexers, stepper/servo drive modules, programmable controllers, custom systems, system integration, speeds to 18"/sec., stage travels: 2" - 30", and repeatability of 1 micron.

New England Affiliated Technologies (N.E.A.T.)

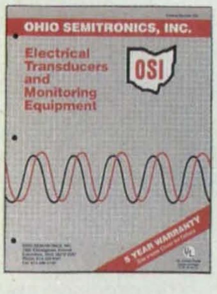
For More Information Circle Action No. 311

ELECTRIC LINEAR ACTUATORS

Three series of electric rodless and standard cylinders and controls are covered in this 136-page catalog. It provides performance data, comparisons, dimensions, and accessories. Additional sections provide sizing and selection design considerations and applications.

Industrial Devices Corp.

For More Information Circle Action No. 312

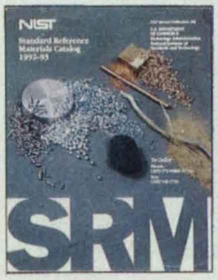


ELECTRICAL TRANSDUCERS

OSI's 80-page catalog features their line of UL-listed products. This line of electrical measurement transducers and instrumentation includes transducers to monitor voltage, current, watts, VAR, watt hour, power factor, phase angle, and test consoles for use on ac, dc, or variable frequency power systems. Also includes complete line of current relays, signal converters, and current transformers.

Ohio Semitronics, Inc.

For More Information Circle Action No. 313



STANDARD REFERENCE MATERIALS CATALOG

The New Standard Reference Materials catalog from NIST lists some 1300 SRMs in 70 major categories. SRMs are well-characterized materials produced to improve measurement science and serve industry.

National Institute of Standards and Technology

For More Information Circle Action No. 314

COMPACT MeV MATERIALS ANALYSIS

This brochure describes the MAS1000 analysis instrument, which performs elemental analysis, depth profiling and channeling in crystals. In most cases the analysis is non-destructive and quantitative. The brochure describes the capabilities of standard RBS analysis as well as other analytical techniques capable with the MAS1000.

National Electrostatics Corp.

For More Information Circle Action No. 315

REAL-TIME NETWORK

The SCRAMNet™ network combines the real-time speed of replicated shared memory with the flexibility of a fiber optic LAN to get microsecond response from multi-vendor computers. It offers distinct advantages in critical simulations. Brochure highlights system's features.

Systran Corp.

For More Information Circle Action No. 316

TEMPERATURE SENSORS

Bulletin TS-102 features resistance temperature detectors (RTD's), thermocouples, and transmitters for precision temperature sensing. Shown are sensor probes and accessories, stator and bearing detectors, and flexible Thermal-Ribbon™ sensors. The 104-page bulletin includes a list of stock models, technical data, and a custom design guide.

Minco Products, Inc.

For More Information Circle Action No. 317

COATING ADHESION TESTERS

Measures the strength of paints, coatings, and adhesives. Surface can be smooth, rough, or porous. True tensile strength is measured with a pneumatic piston, up to 10,000 psi. Analog and digital models meet ASTM D4541.

SEMicro Corp.

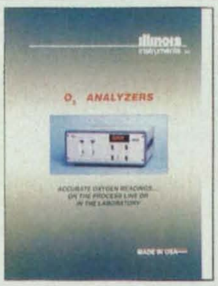
For More Information Circle Action No. 318

1992 DATA ACQUISITION CATALOG

From Keithley MetraByte—new free 288-page catalog describing Data Acquisition hardware and software. The catalog provides facts on all plug-in boards, Data Acquisition Software, IEEE-488.2 interfaces and PC instrumentation for IBM PC and Micro Channel.

Keithley MetraByte

For More Information Circle Action No. 319

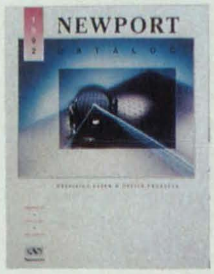


REVIEW OXYGEN ANALYZERS

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

Illinois Instruments, Inc.

For More Information Circle Action No. 320



1992 NEWPORT CATALOG

It's here! The new 1992 Newport Catalog! Our 560-page catalog features a complete line of optics, instruments, mechanical positioners for optics and fiber optics, optical tables, motion control products and bio-instrumentation.

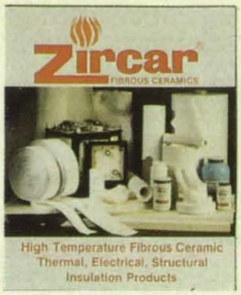
Newport Corp.

For More Information Circle Action No. 321

AIR FORCE INDUSTRIAL BASE TECHNOLOGY TRANSFER BULLETIN

Recurring publication highlights applications of industrial technologies with proven or probable worth to industry and the Air Force. Also airs initiatives within the Air Force Industrial Base Program, and provides an awareness of technologies and initiatives to foster an interaction between industry and the government to benefit the defense industrial base.

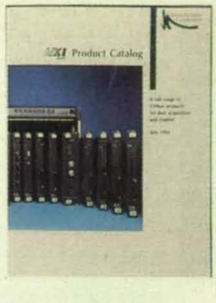
For More Information Circle Action No. 322



FIBROUS CERAMICS

Manufacturers & fabricators of high-performance, high-temperature fibrous ceramic thermal, electrical, and structural insulation products. Fiber types offered include: zirconia, alumina silica, and other refractory oxide compositions. Product forms include: bulk fiber, powders, cements, hardeners, felts, cloths, papers, boards, cylinders, ceramic composite shapes, and engineered insulation assemblies in standard and custom shapes. Heating elements and accessories are also available.

For More Information Circle Action No. 323



VXIbus PRODUCTS CATALOG

Free catalog details KineticSystems' extensive VXIbus (VMEbus Extensions for Instrumentation) product line, including new analog and digital I/O, counters, pulse generators, signal conditioners, transient recorders, and ARINC-429 and MIL-STD 1553 interfaces.

KineticSystems Corporation

For More Information Circle Action No. 324

LASER PUMP CHAMBER GUIDE

Designing your own laser, or have specific requirements? KENTEK has high efficient state-of-the-art single, dual, four flashlamp pumped water cooled units, for rods from 2mm to 10mm diameter. Custom and OEM requirements.

KENTEK Corporation

For More Information Circle Action No. 325

WORK STATIONS, LAB FURNITURE

20-page illustrated guide covers the Teclab line of technical work stations and laboratory systems furniture. Included are versatile work stations of different lengths, combined with a choice of cabinets, shelves, parts drawers, partitions, and accessories. Typical arrangements and dimensions are shown. The catalog describes work surfaces, and has a convenient color selection guide.

Teclab

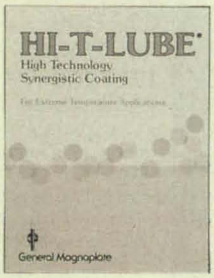
For More Information Circle Action No. 326

NEW HIGH PERFORMANCE DMM

Keithley offers a new high performance DMM with 18 functions and 7½ digit resolution. The Model 2001 has 18 ppm DCV accuracy, 0.03% ACV accuracy, and 2000 readings/sec. It also measures 1 Hz - 2 MHz ACV bandwidth, peak spikes, AC crest factor, and frequency from 1 Hz - 15 MHz.

Keithley Instruments, Inc.

For More Information Circle Action No. 327



DRY LUBRICANT PREVENTS WEAR

Literature delineates the HI-T-LUBE™ dry-film lubricant coating for gears, bearings and other metal parts solves wear, galling and fretting problems at high and low operating temperatures. Works under high compression loads, in a vacuum, and in high radiation environments. Consists of a matrix of metallic layers and becomes a permanent, integral part of the base metal.

General Magnaplate Corp.

For More Information Circle Action No. 328

PROGRAMMABLE MOTION CONTROLLERS

16-page catalog describes full line of servo motion controllers. Includes box-level industrial controllers; multi-axis plug-in boards; and low-cost, single-axis motion cards. PC/XT/AT, STD, VME and RS 232 interfaces available. Linear and circular interpolation, gearing, programmable I/O, and memory. Also power amplifiers, servo motors and support software.

Galil Motion Control, Inc.

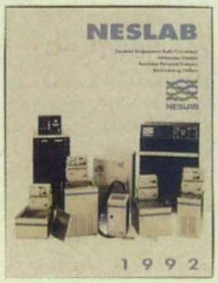
For More Information Circle Action No. 329

FREE DESIGN AID

Save layout time and eliminate detailing with this 16-page template catalog. This catalog shows full size drawings of many tooling components used in designing jigs and fixtures. It includes spring & ball plungers, nuts, bolts, washers, knobs and many other items all with sizes and part numbers. Also included will be a copy of the current catalog listing prices of all items.

Northwestern Tools, Inc.

For More Information Circle Action No. 330



CONSTANT TEMPERATURE BATH/CIRCULATORS

NESLAB Instruments offers an entire line of constant temperature bath/circulators for life science applications such as cell culture, electrophoresis, incubation, diffusion, amino acid analysis, etc.

NESLAB Instruments, Inc.

For More Information Circle Action No. 331

DATA ACQUISITION SYSTEMS CATALOG

Both general and specialized data acquisition systems are set forth in this new catalog from Hi-Techniques. Modular in design, these products contain all the software for acquisition of signal data, calculation of data parameters, and output of finished documentation for both research and routine test applications.

Hi-Techniques, Inc.

For More Information Circle Action No. 332

DESIGN & CIRCUIT BOARD MANUFACTURE

Douglas CAD/CAM Professional System for circuit board design on the Macintosh computer includes schematic capture, digital simulation, parts placement, manual and autorouting. Designs can be printed, plotted, or translated to Gerber or Excellon files. Manufacturing and photoplotting also available directly.

Douglas Electronics

For More Information Circle Action No. 333

CLAMPING AND WORKHOLDING DEVICES

Featuring 80 pages of clamping and workholding devices, this new De-Sta-Co catalog covers the company's full line of manually and power-operated toggle clamps. Also portrayed is their Hydra-Dyne line of air/hydraulic clamping systems and a number of unique workholding devices.

De-Sta-Co

For More Information Circle Action No. 334

LISTS FEDERAL CONTRACT ACTIVITY

Get federal prime contracts on CD-ROM to identify new sales leads, subcontracting opportunities and teaming partners. CD-ROM lists all activity on 90,000 annual federal contracts; 45,000 vendors; 2,500 product categories; 900 purchase offices; 200 federal agencies. Requires IBM-compatible desktop with 512K RAM.

Eagle Eye Publishers

For More Information Circle Action No. 335

TURBO-MACHINERY ENGINEERING

Free brochure shows how companies that produce or operate compressors, pumps, or turbines can benefit from NREC's advanced engineering consulting expertise, specialized CAE/CAM software, and precision manufacturing services.

Northern Research and Engineering Corp.

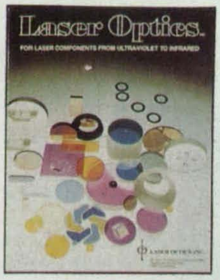
For More Information Circle Action No. 336

DATA ACQUISITION AND COMMUNICATION HANDBOOK

Quatech's 1991-1992 handbook features 86 pages of the latest information on our complete line of communication, data acquisition, and waveform synthesizers. Most products are available for PC XT, AT, and MicroChannel buses. Software available.

Quatech, Inc.

For More Information Circle Action No. 337



LASER COMPONENTS -UV TO IR

A 32-page catalog of optical components and coatings for ultraviolet, visible and infrared applications, including lenses, windows, prisms, beamsplitters, mirrors, and filters. Broad range of zinc selenide, germanium and silicon optics for CO_2 lasers. Specialists in optical coatings for high-power applications.

Laser Optics, Inc.

For More Information Circle Action No. 338

CALORIMETER OFFERS CALIBRATION STANDARD

Bird Electronic Model 6091 is a high-accuracy, broadband RF power calorimeter. Major application benefits include accuracy, repeatability and traceability. The Model 6091 is a calibration standard with +/-1.25% measurement uncertainty. The unit's measurements are repeatable over time and the model 6091 is traceable to NIST standards.

BIRD Electronic Corp.

For More Information Circle Action No. 339

PROGRAMMABLE POSITION CONTROL

A complete 416-page engineer's guide with specifications, dimensions, and performance data presents brushless servos, microstepping motor systems, indexers, linear motors and absolute encoders.

Compumotor Div., Parker Hannifin Corp.

For More Information Circle Action No. 340

POSITIONING SYSTEMS AND COMPONENTS

Daedal's 200-page catalog provides specifications for cross roller and ball slides; center and side drive cross roller tables; closed and open frame motorized tables; rail tables; manual and motorized rotary tables; digital micrometer stages; single- and multi-axis motion controllers; half step, microstepping and servo motor drives; and optical positioners and hardware.

Daedal Div.,Parker Hannifin Corp.

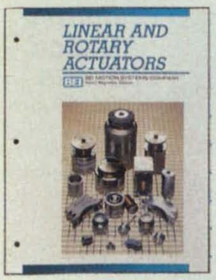
For More Information Circle Action No. 341

INDUSTRIAL WORKSTATION GUIDE

Pro-Log's new 300 Series line of workstations includes four models. The top-of-the-line model is based on a 25 MHz 80486 processor running MS-DOS 5.0. Other models feature a 25 MHz 386SX/AT, a 20 MHz 80C286, or an integrated PLC (IPLC) configuration. Designed for use in all industrial environments.

Pro-Log Corp.

For More Information Circle Action No. 342



ACTUATOR BROCHURE

This guide makes linear and rotary voice coil selection easy. Features motor and winding constants for BEI's comprehensive, high-performance actuator line. Detailed dimensional information includes size, mounting, configuration and lead termination. Available in standard, modified or custom designs.

BEI Motion Systems Co., Kimco Magnetics Div.

For More Information Circle Action No. 343

LAB/TEST OVENS BULLETIN

A 20-page catalog (Bulletin 3610) describes lab/test ovens manufactured by Applied Test Systems. Ovens available in box and split-box types, and standards plus custom ovens. Features include: stainless steel shell, uniform temperature, fast heat-up, low power consumption, low shell temperature, rigid construction, and temperatures from -300° F to + 1150° F.

Applied Test Systems, Inc.

For More Information Circle Action No. 344

ELECTRONIC HARDWARE CATALOG

Broadest selection of hardware for electronic assemblies. 300-page free catalog includes a full range of standoffs, captive screws and nuts, chassis fasteners, handles, ferrules, spacers and washers. Special sections—new/unusual products, metric information, and Mil-plating specifications. Full inventory, fast turnaround, samples.

Accurate Screw Machine Co.

For More Information Circle Action No. 345

INSTANT CONNECTOR/ POTTING KIT

Quickly make durable, inexpensive copies of countless connector configurations for test, prototype and R&D applications. Using connector contacts and polyethylene cartridges, a connector mate can be injection molded on the spot. Adhesive cartridges can also be used for encapsulation or spot bonding.

Wiring Analyzers, Inc.

For More Information Circle Action No. 346

TOOLING COMPONENTS & EQUIPMENT

New 346-page catalog offers full range of tooling components and equipment. Items include handwheels, handles, knobs, spring & ball plungers, leveling pads, clamps, set-up accessories, locating devices, cutting tools, rivets, thread inserts, hard-to-find tools, and metric items. Contains specifications and pricing. Items are stocked for same day shipment.

Reid Tool Supply Company

For More Information Circle Action No. 347

201,000 Reasons Why Your Ad Belongs Here

NASA Tech Briefs' Literature Spotlight section offers a low-cost way to reach over 201,000 industry and government LEADERS with your advertising message. These are technology managers, design engineers, and scientists with tremendous buying power. The **October 1992** issue is your next opportunity to use this high-impact sales tool. For more information or to reserve space in Literature Spotlight, contact your *NASA Tech Briefs* sales representative (listed on page 10 in this issue) or call Joseph Pramberger at (800) 944-NASA.

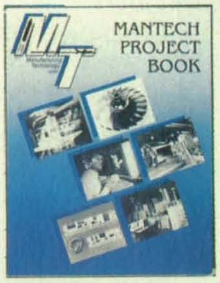
For More Information Circle Action No. 348

3kW HV GENERATOR FOR X-RAY DIFFRACTION

New XRD power supply is for x-ray diffraction and similar applications. The supply is capable of 0-60 kV, 0-80 mA at 3 kW max and contains the filament supply and emission loop. This unit incorporates adjustment for both high voltage and emission current, fail safe interlock, fail safe x-ray on lamp circuit, water flow, and extensive remote interface capabilities.

Spellman High Voltage Electronics Corp.

For More Information Circle Action No. 349



AIR FORCE MANUFACTURING TECHNOLOGY PROJECT BOOK

Brief descriptions of over 200 upcoming, active, and completed Air Force MANTECH programs. Areas covered include: metals, nonmetals, electronics, CIM, concurrent engineering, repair technology, and manufacturing science. Learn more about technologies available for transfer to the industrial base.

Lawrence Associates, Inc.

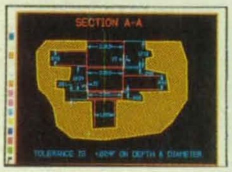
For More Information Circle Action No. 350

4kW HIGH VOLTAGE POWER SUPPLY

Extremely compact and rugged power supply in voltages from 1 kV to 60 kV at 4 kW. The SA4 is housed in a 5¼" H x 19" W x 22" D rack mountable chassis. The supply provides 0.1% ripple, 0.005% voltage regulation, 0.05% current regulation and low EMI and RFI due to sine wave conversion. Flexible remote interface is standard. Floating filament supplies are available.

Spellman High Voltage Electronics Corp.

For More Information Circle Action No. 351



FastCAD-POWERPACKED WORKHORSE FOR CAD

FastCAD works for you! Save time and money with FastCAD's blazing speed and dynamic user interface. If you are serious about generating fast, detailed CAD drawings, then request our free information.

Evolution Computing

For More Information Circle Action No. 352

PORTABLE CABLE, SLEEVING & WIRE MARKER

The Hotmarker is a high quality low cost foil marking system. Dial thousands of different character combinations or change imprint color in moments in production or on the job. Mark almost any material from AWG#20 to 5/8" O.D. cable and shrink sleeving.

Wiring Analyzers, Inc.

For More Information Circle Action No. 353

MOTION CONTROL HANDBOOK

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

Delta Tau Data Systems, Inc.

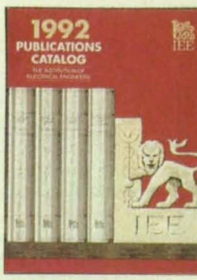
For More Information Circle Action No. 354

WORKMANSHIP STANDARDS MANUALS

Workmanship Standards were developed by Martin Marietta to use as guidelines in manufacturing electromechanical and electronic systems that perform to exacting government/defense requirements. Photographs and clear instructions provide the individual with a clear definition of what is required on the production line and in training programs.

Martin Marietta Information Systems

For More Information Circle Action No. 355



LISTS BOOKS, PROCEEDINGS, JOURNALS

Free 1992 publications catalog lists books, conference proceedings, and journals available direct from the publisher. Subject categories include: telecommunications, control engineering, electronic devices, electromagnetic waves, electrical power systems, computing and signal processing, and much more.

The Institution of Electrical Engineers

For More Information Circle Action No. 356

COMPUTER GRAPHICS SERVICES

Brochure shows how to communicate ideas, sell proposals, evaluate designs, and display finished products. Working with your concepts and CAD files, we use IGRAP™ and Wavefront, as well as custom graphics applications, to create 3-D photorealistic animations on broadcast quality or VHS videotape.

Graphics Simulation Group, ATR

For More Information Circle Action No. 357

PTFE IMPREGNATED HARD ANODIZE

An electrochemical process for building a lubricative aluminum oxide coating on aluminum for better wear and mold release qualities. HARD-TUF hard anodizes with aluminum and then impregnates the surface with our PTFE lubricants. The surface becomes resistant to abrasion and corrosion, exhibits high dielectric strength and resistance to chemical attack in addition to superior release.

Tiodize Co., Inc.

For More Information Circle Action No. 358

MICROFOCUS X-RAY SOURCES

The KM series microfocus x-ray tubes and power supplies offer focal spots of 10 microns covering a range of operating voltages up to 160 KV. Ideal for inspection of printed circuit boards and mechanical parts, the PXS series feature self-contained tube and high voltage supply with spot sizes of 10 microns and a range of voltages up to 70 KV. They are suitable for portable use operating from a 12VDC source.

Kevex X-Ray

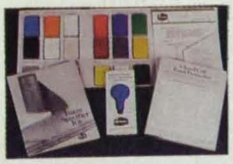
For More Information Circle Action No. 359

SOFTWARE FOR ELECTROMAGNETIC DESIGN

The legendary vector fields suite of software combines classical finite element techniques with user friendly interactive graphics in 2D and 3D for high accuracy simulation and design of all type of electromagnetic equipment.

Vector Fields, Inc.

For More Information Circle Action No. 394

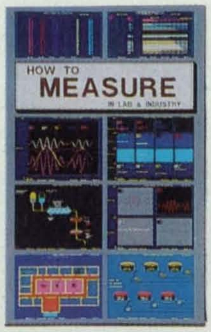


FREE FOAM SAMPLE MATERIALS

Included are separate specification sheets, as well as a standard-grade property comparison chart listing sizes, densities, strengths, and other properties for the usage and selection of foams. Sample pieces feature: Volara—irradiation crosslinked polyolefin, Volara S-types—second-generation cross-linked foams, Volextra—a composite that has been enhanced, and Minicel.

Voltek, Div. of Sekisui America Co.

For More Information Circle Action No. 361



HIGH-RESOLUTION DATA ACQUISITION

FREE booklet shows many ways to automate data collection using your personal computer. It comes with a FREE Instatrend Real-Time Graphics Demo Disk.

Dianachart, Inc.

For More Information Circle Action No. 362

STANDARD PLASTIC FASTENERS & COMPONENTS

High technology plastic fasteners and components for the electronics, computer, aerospace, communications, chemical, and commercial markets. New catalog No. 2004 describes our standard products: screws, washers, nuts, spacers, bushings, pipe fittings, caps, snap fasteners, clamps, manufactured in state-of-the-art plastics.

Craftech Industries, Inc.

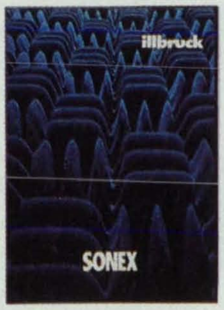
For More Information Circle Action No. 363

8.5" & 10" SUPER-VGA COLOR MONITORS

These Super-VGA monitors offer 800x600 resolution 8.5" SONY Trinitron or 10" Hitachi CRTs. Available in tilt and swivel enclosures, industrial metal enclosures, or open frame chassis. Also come in standard industrial 19" rack assemblies with single monitor mount or dual side-by-side monitor mount. Touch screens and 12/24 VDC power optional.

Modgraph, Inc.

For More Information Circle Action No. 364



NOISE CONTROL PRODUCTS

New color brochure describes SONEX and SONEX 1 sound-absorbing materials with patented shapes that control noise better than standard acoustical treatments. Brochure explains basic noise control techniques and presents many forms, sizes, and colors of SONEX products for industrial, office and OEM noise control. Brochure shows applications and includes information on acoustical performance.

Illbruck, Inc.

For More Information Circle Action No. 395

LVDT TRANSDUCER DESIGNER'S HANDBOOK

Sourcebook for LVDT gauging and displacement transducers as well as conditioning electronics. This 74-page, spiral-bound guide highlights product features, benefits and specifications of LVDT transducers. Includes electronics features and compatibility charts, product technology overview, applications diagram and glossary to help provide design solutions.

Schlumberger Industries

For More Information Circle Action No. 396

INCREASE VACUUM PROCESS PRODUCTIVITY

This free brochure features productivity enhancing vacuum gauges, controllers and valves used to measure and control pressure from atmosphere to ultra-high vacuum. The instrumentation can be configured to your specific application needs.

Granville-Phillips

For More Information Circle Action No. 367

HIGH RESOLUTION FLOW VISUALIZATION

The Laserstrobe™ offers ultra short pulse width, high intensity visible light at high framing rates (32kHz). Applications include: ballistics, wind tunnel studies, spray analysis, particle image velocimetry, flow visualization, and engine and combustion analysis. For immediate response call 1-800-222-3632.

Oxford Lasers, Inc.

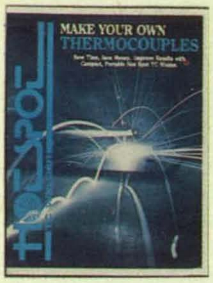
For More Information Circle Action No. 368

SOFTWARE SOLUTIONS CATALOG

New catalog features 38 innovative software packages developed and tested within AT&T. Applications include communications, operations and network management software, development and performance tools, math/stat packages, and more, for various platforms/systems. Ideal source for remarketers and end users.

AT&T Software Solutions Group

For More Information Circle Action No. 369

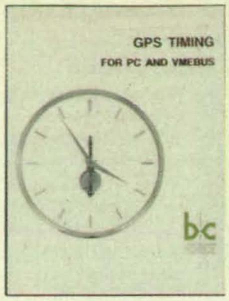


THERMOCOUPLES, MAKE YOUR OWN

The HOTSPOT allows thermocouple wire to be formed into freestanding junctions, or welded to metal surfaces. It provides a simple means of fabricating thermocouples "when needed and where needed". Brochure and specification sheet available.

DCC Corp.

For More Information Circle Action No. 397

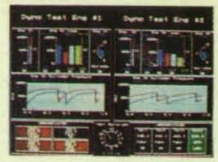


GPS TIMING FOR PC AND VMEBUS

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

Bancomm

For More Information Circle Action No. 371

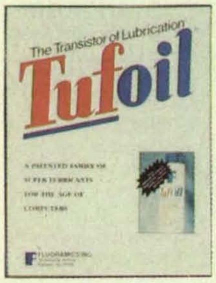


SCIENTIFIC AND ENGINEERING SOFTWARE TOOLS

A demo-disk and catalog is available for the Quinn Curtis line of scientific and engineering software tools for C and Pascal programmers. Scientific charting, numerical methods, real-time graphics, measurement and control, and huge virtual array libraries are discussed in detailed data sheets.

Quinn-Curtis

For More Information Circle Action No. 372

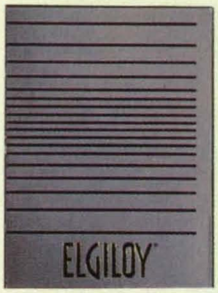


TUFOIL OIL ADDITIVE—SLIPPERIER THAN TEFLON

So unique, it's patented. Spectacular low friction and wear confirmed by U.S. Government lab. Next time you change your oil, change it into a patented engine treatment. Enjoy fast starts, smooth operation, better acceleration, and longer engine life. Lubrication is our business!

Fluoramics, Inc.

For More Information Circle Action No. 398

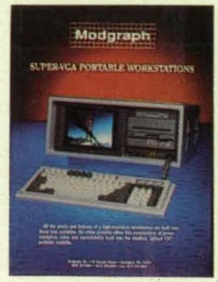


HIGH-PERFORMANCE ALLOY

Elgiloy® is a high-performance nickel-cobalt alloy. This brochure describes its characteristics and properties as well as processing information. Elgiloy® is offered in strip and wire and is used in a variety of specialized applications.

Elgiloy® Limited Partnership

For More Information Circle Action No. 374

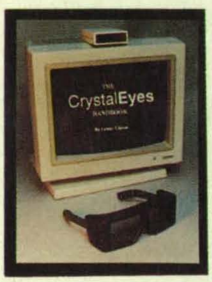


SUPER-VGA PORTABLE WORKSTATIONS

The Modegraph portable workstations are 800x600 resolution, 256 color Super-VGA portables. Powered by 386 or 486 processors, all equipped with 2-4 16-bit expansion slots, hard drives to 540 MBytes, and built-in 5.25" and 3.5" diskette drives. Included are an external VGA monitor port supporting resolutions up to 1024x768 , and one parallel and two serial ports.

Modgraph, Inc.

For More Information Circle Action No. 375

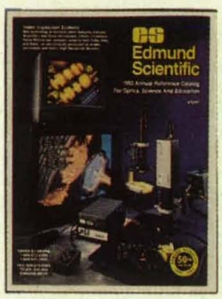


STEREOVIEWING HANDBOOK

77-page CrystalEYES Handbook shows how engineers and scientists use proprietary stereoviewing hardware for scientific visualization, molecular modeling, mapping, CAD/CAM/CAE, remote video. Users increase design productivity, reduce time to market, improve design implementations, understand complex images on all workstations.

StereoGraphics Corp.

For More Information Circle Action No. 376



OPTICAL REFERENCE CATALOG

Edmund Scientific's free 204-page, full-color annual reference catalog features one of the largest selections of precision optics, and optical instruments, plus a complete line of components and accessories for both large volume OEM users as well as smaller research facilities and optical laboratories. It contains over 8,000 hard-to-find items.

Edmund Scientific

For More Information Circle Action No. 377

SPACE PRODUCTS AND CAPABILITIES

Descriptions and specifications of Motorola's space products and capabilities, for both space and ground support equipment. Opens into a colorful wall chart showing the history of Motorola and electronic products.

Motorola Strategic Electronics Division

For More Information Circle Action No. 378

INTERNATIONAL SEMICONDUCTOR DIRECTORY DATABASE

The ISD database provides part numbers, manufacturers, and distributor listings in a logical computer database. Featured are 400,000 semiconductors from over 500 manufacturers and is designed for IBM®PC®/ATs-286/386/486 or compatible and can be installed on a Novell® network. Order before August 31, 1992 at the introductory price of $249.

D.A.T.A. Business Publishing

For More Information Circle Action No. 379

CATALOG COMBINES ESQ AND EMCOR I ENCLOSURE LINES

Emcor Products describes its ESQ and Emcor I modular enclosure systems in this free, color catalog. This inclusive, 72-page catalog summarizes new options, features metric conversions, dimensional diagrams, and contains an easy ordering guide.

Emcor Products

For More Information Circle Action No. 380

LABORATORY CORROSION TESTING

Corrosion laboratory provides testing of metals, alloys, composites, coatings. Capabilities include: bench-top, electrochemical, autoclave, stress corrosion cracking, erosion-corrosion, corrosion fatigue, salt spray evaluations. Standardized or custom-designed testing is available.

LaQue Center For Corrosion Technology, Inc.

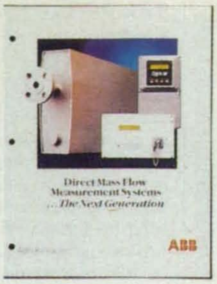
For More Information Circle Action No. 381

FREE DEMO DIGITAL SINE VIBRATION CONTROLLER

First in a series of low-cost Expansion Card & Software Packages from VTS converting 386 DX personal computer to a Digital Sine-Servo Vibration Controller. The DSC-I offers easy set-up, simple operation and low-cost. It has a full-color screen. A DRC-I Random Controller conversion will be available in October '92. VTS produces Vibration Test Systems from 25 to 600 pounds force.

Vibration Test Systems

For More Information Circle Action No. 382



MEASURING MASS FLOW

ABB K-Flow® Coriolis meters measure mass flow at 0.25% accuracy; plus they also measure density, temperature, multi-phase constituency (% solids/liquids/mass), specific gravity, net flow and concentration. For flows from a few cc's to 2,500 lbs/min., for hundreds of fluids, ABB K-Flow® meters are economical and unmatched in capability. Engineering data package available.

ABB K-Flow, Inc.

For More Information Circle Action No. 383

TEFLON SEAL DESIGN MANUAL

Describes seals made from PTFE AND PTFE based compounds for rotating, reciprocating, and static applications. Lists seals in inch, metric, and custom sizes. Coverage explains seal types, unique spring loading operation, material compositions, correct selection, and typical applications. Sections detail surface finishes and installation procedures.

Bal Seal Engineering Co., Inc.

For More Information Circle Action No. 384

IR CALCULATOR AND CATALOG

EG&G Judson's IR calculator is an easy to use slide rule with instructions for calculating spectral characteristics of blackbody sources without complex analysis. Together with Judson's IR catalog, it can be used to determine the ideal detector type for difficult applications. Judson's 49-page catalog features a full range of detectors and accessories for the 0.8µm to40µm wavelength region.

EG&G Judson

For More Information Circle Action No. 385

INVESTMENT CASTINGS

PMI brochure describes our ferrous & nonferrous investment castings. Near-net-shape, internal complexity, great surface finish designed in for parts 10 pounds or less. 200 alloys, with expanded capacity for aluminum & ductile iron. Engineering & prototype services.

Precision Metalsmiths, Inc.

For More Information Circle Action No. 386

MULTILOOP PID CONTROLLERS

Reports show ANAFAZE offers multi-loop PID controllers from 4 up to 512 PID loops. All take T/C, RTD, Infrared, mA and mV sensor inputs, and offer all the popular control features, including Autotune. Special strengths are communications I/O, with controllers networked with ANASOFT™ PC-software as well as most other control s/w packages.

Anafaze Measurement & Control

For More Information Circle Action No. 387

B92 CATALOG

This new catalog coincides with Berg's silver anniversary. Founded in 1967, Berg is a leading manufacturer and supplier of miniature precision mechanical components. B92 includes expanded product lines as well as new items. Featuring 60,000 standard components, 80% of which are shipped from stock. The new metric version of catalog M92 follows in September.

W. M. Berg, Inc.

For More Information Circle Action No. 388

COSMOS/M FEA TOOLS

Full function modular finite element analysis system offers mainframe capabilities on the desktop for design, analysis and optimization. Performs statics, dynamics, nonlinear, heat transfer, fluid flow, electromagnetics and design optimization. FREE 50 note working version.

Structural Research and Analysis Corp.

For More Information Circle Action No. 389

FREE CATALOG AND APPLICATION NOTES

VXIbus is the solution to automatic instrumentation needs. Learn about the latest instrumentation standard. Racal-Dana is a designer, manufacturer and integrator of VXIbus products and systems. They include: mainframes, switching, digital, time and frequency, RF products, breadboard prototyping, and integration services.

Racal-Dana Instruments, Inc.

For More Information Circle Action No. 390

ABRASIVE BLAST SYSTEM

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

Hunter Products, Inc.

For More Information Circle Action No. 391

SR620 TIME INTERVAL COUNTER

A reciprocal interpolating counter-timer with 25 ps rms, 4 ps LSD single shot resolution for time intervals and 11 digits of resolution for one second measurements of frequency. It can measure time interval, period, phase, pulse width, risetime, and falltime, and frequency to 1.3 GHz. Statistical functions programmed into the instrument include mean, min., max., standard deviation, and Allan variance for up to 1 million samples. U.S. list price of the SR620 is $4500.

Stanford Research Systems

For More Information Circle Action No. 392

PC SYSTEMS HANDBOOK

Designed for scientists and engineers, this handbook combines tutorial information and catalog of hard-to-find products for PC-based data acquisition, motion control, signal conditioning, and instrumentation. This new 1992 edition includes 196 pages of detailed technical and product information.

Cyber Research

For More Information Circle Action No. 393

Subject Index

When you bring your questions to America's leading event on sensing technology, what kind of information can you expect?

SENSORS EXPO

THE CONFERENCE AND EXPOSITION OF SENSORS AND SYSTEMS

O'HARE EXPOSITION CENTER, CHICAGO, ILLINOIS
SEPTEMBER 29 - OCTOBER 1, 1992

Whether you're trying to design a product, control a process, or automate a factory, integrating the right sensors and sensor-based systems can significantly increase your productivity and control costs.

And when the application calls for sensor-based systems, only one event meets all your requirements ... SENSORS EXPO, the only national event exclusively devoted to sensing technology for every type of industrial, commercial and consumer product application.

At SENSORS EXPO, you can discuss your sensing technology needs with over 275 leading suppliers. Evaluate and compare thousands of sensing products hands-on. And discover innovative, cost-effective solutions to your most difficult application requirements.

Explore the full range of related equipment for sensor-based systems

More than just sensors and transducers, SENSORS EXPO offers the full range of related equipment necessary to create a complete sensor-based system. This year, you'll find more control and motion products, data acquisition systems, instrumentation and other equipment you need to satisfy the most complex applications.

And to keep you on top of the latest developments in sensor technology, SENSORS EXPO features a **Technical Conference** offering seminars and full-day short courses geared to helping end-users and OEMs select the right sensors and sensor-based systems for their specific needs.

This year's event will also feature a special **Robotics Pavilion** sponsored by the Robotics Industry Association (RIA) to showcase the role of sensor technology in the emerging robotics and machine vision industries.

Whether you're a product and systems design engineer, control engineer, corporate manager, QC/test professional or R&D scientist, when the application calls for sensors or sensor-based systems, only one event meets all your requirements — SENSORS EXPO.

Mail coupon today for FREE Exhibit Hall Admission!

Sponsored by *Sensors* magazine and produced by Expocon Management Associates, Inc,.

YES! I want to attend SENSORS EXPO —the one event that meets all my applications requirements for sensors and sensor-based systems.

Please send me:

- ❑ FREE Conference Brochure as soon as it is available.
- ❑ Application for FREE admission to the Exhibit Hall.
- ❑ Information on how I can exhibit at SENSORS EXPO.

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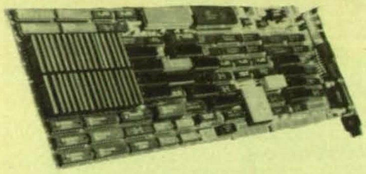
FAX: 203/374-9667. Phone: 203/374-1411, Ext. 127

For More Information Circle No. 529



4 MEG VIDEO Model 10

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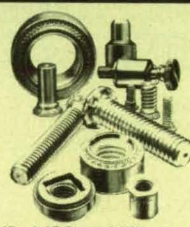

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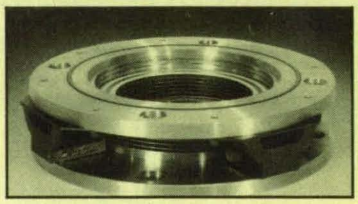
Vacuum Pump Vibration Isolator



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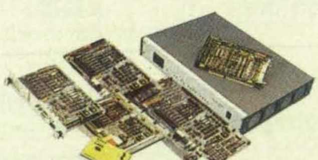

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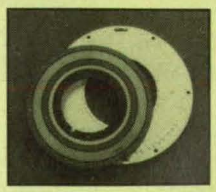

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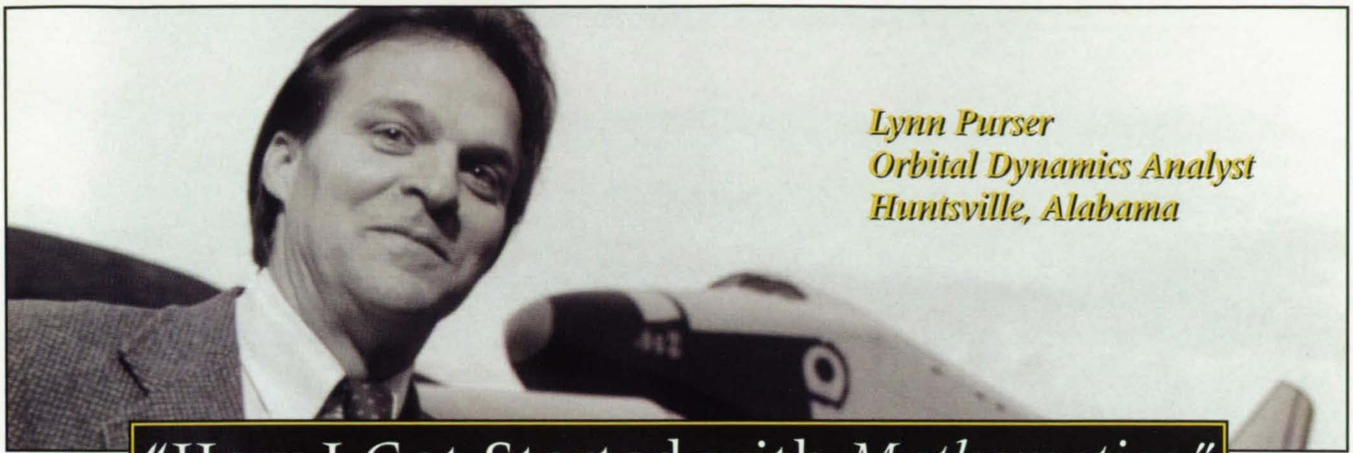

"How I Got Started with *Mathematica*®"

I admit, when I first read about *Mathematica*, I was a little skeptical. I guess mathematicians are like anybody else. Sort of like auto workers being replaced by robots—some mathematicians were skeptical of something that might replace them. So when my firm offered an in-house training seminar on *Mathematica*, I decided to see what all the talk was about.

Photo Courtesy of NASA

That class was fun. I tried to do things beyond what the teacher was covering—the rudimentary stuff about *Mathematica* syntax. I wanted to do animation and play with the graphics. I was taken with the visual dimension of it.

Working on NASA projects, I have to solve problems and present my solutions in a way others can understand. People respond to a visualization better than abstract equations, hand-waving, or scribbling on a blackboard. With *Mathematica*'s graphical capability, especially animation, I can make a dynamic presentation that gives a concrete idea of what I'm talking about.

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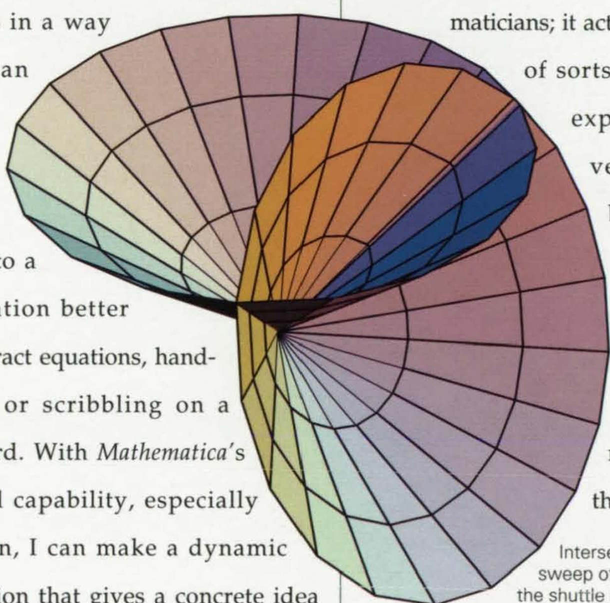

Intersection of fields of sweep of two sensors in the shuttle payload bay.

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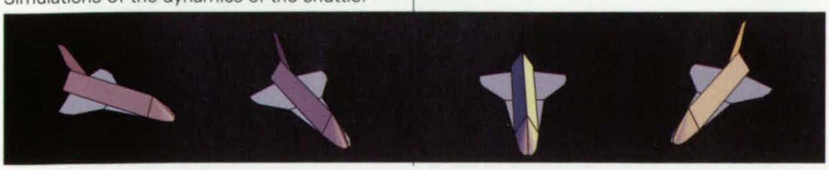
Simulations of the dynamics of the shuttle.



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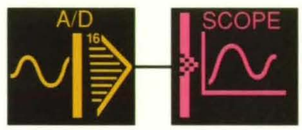
WHICH WOULD YOU RATHER WRITE?

```
/*
 C_EXAMPLE.C
   This program reads 100 values from channel 2 of the AXV11-C then
   displays the data in a graph on the screen.

   This is a simple application using the DECRTI libraries.

   This program can be compiled, linked, and run as follows:
        $CC C_EXAMPLE
        $LINK C_EXAMPLE, SYS$INPUT/OPT
        Sys$library:VAXCRTL.EXE/share
        <CTRL-Z>
        $RUN C_EXAMPLE
*/

#include <lioset.h>              /* LIO set parameter definitions */
#include <decrti.h>              /* DECRTI routine definitions */
#include descrip                 /* string descriptor definitions */
#include stsdef                  /* STATUS value bit definitions */

main()
{
/* Declare local variables */
       int STATUS           /* STATUS returned by LIO routine calls */
           ,axv_id          /* LIO-assigned device ID */
           ,data_length     /* number of data bytes to read */
           ;

/* Declare the string descriptors for the string constants */
       $DESCRIPTOR (dev_type, "AXA0:");      /* AXV11-C device type */
       $DESCRIPTOR (mode_string, "IXSY");    /* LGP$PLOT mode string value */
       $DESCRIPTOR (xlabel, "Time");         /* LGP$PLOT x-axis label */
       $DESCRIPTOR (ylabel, "Voltage");      /* LGP$PLOT y-axis label */
       $DESCRIPTOR (title, "C_EXAMPLE");     /* LGP$PLOT graph title */

/*
Declare data buffer for raw data in LSP$FORMAT_TRANSLATE_ADC. This
is a word (16-bit) array containing 100 elements.
*/
   short int raw_data[100];
/*
Declare data buffer for voltages in LSP$FORMAT_TRANSLATE_ADC and
LGP$PLOT routines. This is a single-precision, floating-point
array containing 100 elements.
*/
    float voltages[100];

/* Program execution */

/* Set up the AXV11-C */

     printf("C_EXAMPLE, Read data, convert it, plot it\n\n");

/*
Attach the AXV11-C and set up for mapped (polled) I/O. This routine
call returns an LIO-assigned device ID for the device.
*/
        STATUS = LIO$ATTACH (&axv_id, &dev_type, &LIO$K_MAP);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);

/* Set up the AXV11-C to use the synchronous I/O interface. */

        STATUS = LIO$SET_I (&axv_id, &LIO$K SYNCH, &0);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);

/* Set up AXV11-C channel 2 for input. */

        STATUS = LIO$SET_I (&axv_id, &LIO$K_AD_CHAN, &1, &2);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);

/* Set up a channel gain of 1. */

        STATUS = LIO$SET_I (&axv_id, &LIO$K_AD_GAIN, &1, &1);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);

/* Trigger on LIO$READ and fill buffer as fast as possible. */
        STATUS = LIO$SET_I (&axv_id, &LIO$K_TRIG, &1, &LIO$K_IMM_BURST);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);
```



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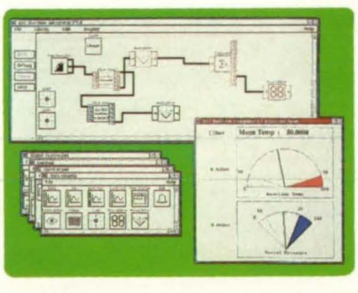

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