February 1999

Vol. 23 No. 2

TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING

National Design Engineering Show Preview

Test & Measurement

Computers & Peripherals

Electronics Tech Briefs

Motion Control Tech Briefs

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NASA TECH BRIEFS

February 1999 • Vol. 23 No. 2

Features

Briefs

Departments

A planned series of new VXI-based systems that provide foundations for functional test systems has been launched by Hewlett-Packard, Palo Alto, CA. The HP E8751A and HP E8754A systems, the first two systems in the series, are described in detail in the Special Coverage on Test & Measurement, beginning on page 36.

(Photo courtesy of Hewlett-Packard)

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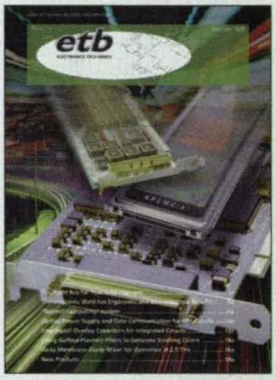
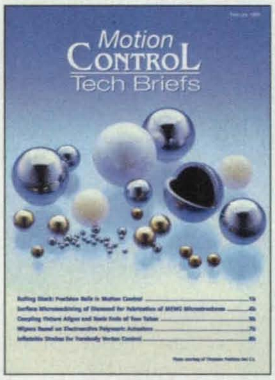
Special Supplements

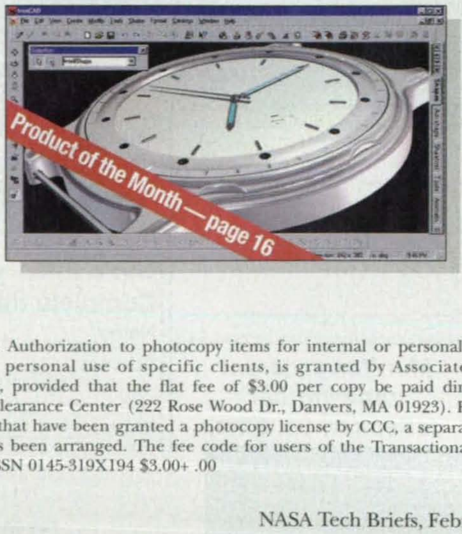




On the cover:

The National Design Engineering Show (NDES) is one of four shows that comprise National Manufacturing Week, which will be held March 15-18 in Chicago. More than 1,200 exhibitors will display everything from industrial design products, to rapid prototyping tools and CAD/CAE software. One of those software products is SolidWorks 98Plus 3D mechanical CAD software — which was used to model this snowmobile — from SolidWorks, Concord, MA. For more information on SolidWorks 98Plus, and other products on display at NDES, see the feature beginning on page 24.

(Image courtesy of SolidWorks)



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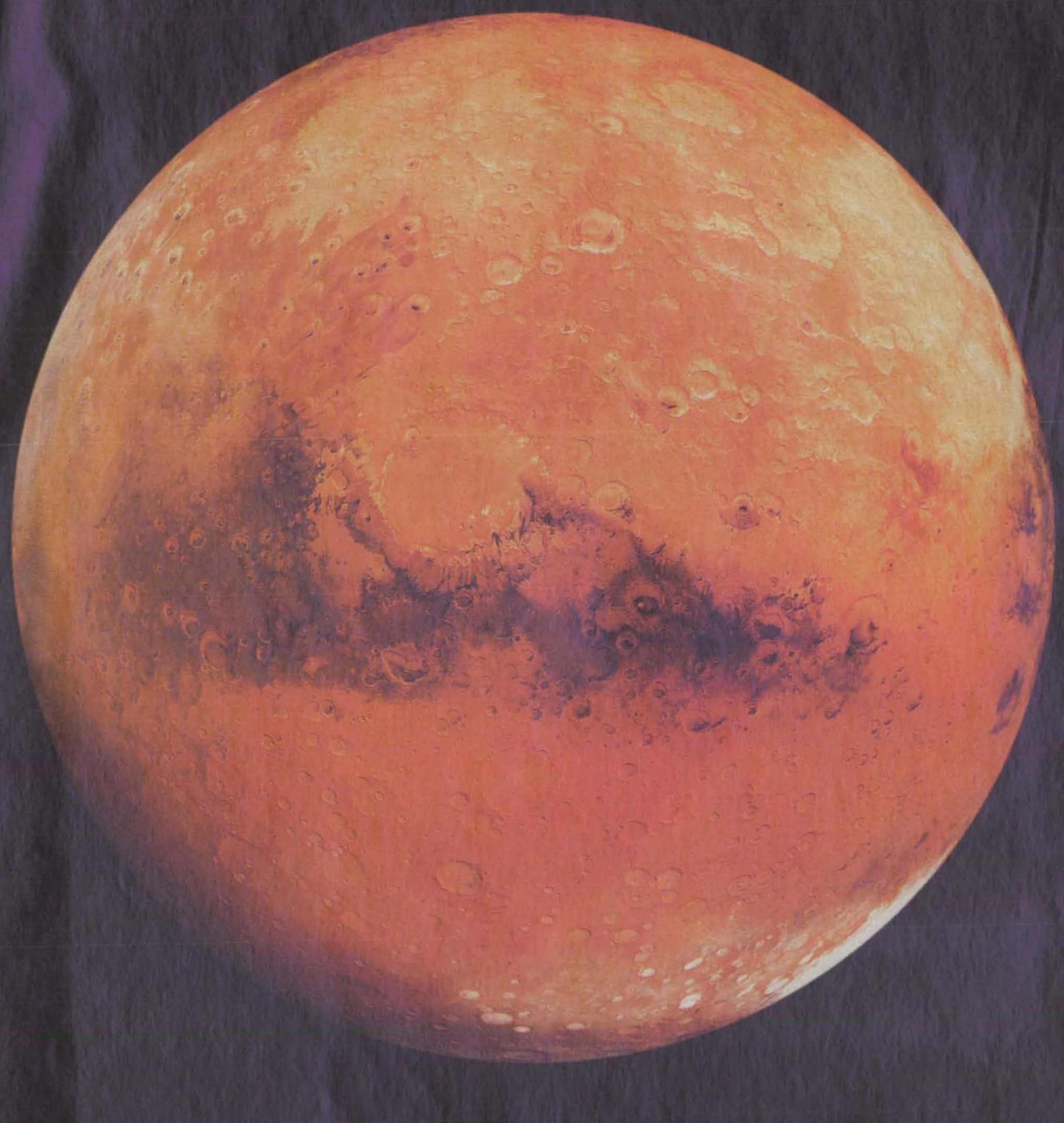

NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (206) 683-1005 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-0893
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
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galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(281) 483-0474
hdavis@gp101.jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
Gale Allen
(407) 867-6626
galeallen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6006
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Sally Little
(256) 544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(228) 688-1929
ksharp@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
Massachusetts Technology Park
(508) 870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
(904) 462-3913

Gary Sera
Mid-Continent Technology Transfer Center
Texas A&M University
(409) 845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(412) 383-2500

Chris Coburn
Great Lakes Industrial Technology Transfer Center
Battelle Memorial Institute
(216) 734-0094

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
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cray@mail.hq.nasa.gov

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rcrouch@hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

Dan Morrison
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

Joe Boeddeker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

Marty Kaszubowski
Hampton Roads Technology Incubator (Langley Research Center)
Hampton, VA
(757) 865-2140

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

PRODUCT OF THE MONTH

Visionary Design Systems, Santa Clara, CA, has introduced Version 2.0 of IronCAD™ mechanical engineering software. The new release offers drag-and-drop sheet metal part creation, new object manipulation functionality, improved 2D profile creation, and enhancements to its data translation and surface-to-solid capabilities. Handles, including SmartSnap® and a dynamic 3D constraint solver, allow users to perform sizing and positioning operations regardless of how the model originally was dimensioned. Sheet metal parts can be modeled by dragging and dropping intelligent bend, lip, hem, and offset features from a catalog. A customizable catalog of parameterized punch and stamp IntelliShapes® is available that conforms to industry-standard sizes. The Windows NT/95/98 software is priced at $3,995.

For More Information Circle No. 747

Green and Clean

A new NASA study reports that plants absorb more carbon dioxide in the Northern Hemisphere than previously believed — about one-third of the amount that comes from the burning of fossil fuels. According to Dr. Christopher Potter, a research scientist at NASA's Ames Research Center and co-author of the study, the amount of carbon dioxide in the atmosphere continues to increase, even though vegetation is absorbing more carbon than some scientists previously thought.

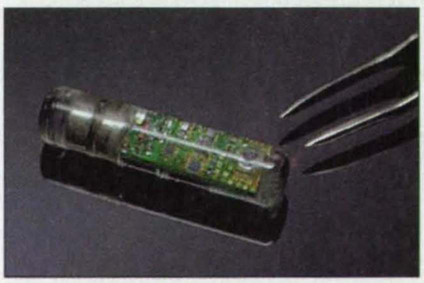
The NASA team studied solar irradiance data from the GOES satellite, and visible and near-infrared data from National Oceanic and Atmospheric Administration (NOAA) weather satellites. The data also revealed that the ecosystems of Africa and Eastern Brazil have recovered strongly from the stressful effects of the 1983 El Niño and the severe 1984 drought. "Our research suggests that there is a possibility that scientists in the future may be able to accurately predict which areas of the world will be positively or negatively affected by climate change," said Dr. Potter.

For more information, visit the authors' web site at: http://geo.arc.nasa.gov/sge/casa

Keeping an Eye on the Baby

NASA's Ames Research Center has developed a tiny transmitter that can be implanted in a mother's womb to monitor the health of an unborn child. Developed in cooperation with the Fetal Treatment Center at the University of California, San Francisco, the device is scheduled to be implanted in expectant mothers early this year.

The "pill" monitor is the size and shape of a large vitamin pill. Doctors at the University needed a tiny device that could monitor babies who have undergone a newly developed endoscopic surgery, which is performed on fetuses still in the womb. The surgery, which is performed with long, thin instruments inserted through a small incision in the mother's abdomen, replaced a more invasive surgery using large Cesarean-like cuts.



There were no commercially available sensors small enough for the job, so NASA developed a device that can fit through the endoscopic equipment. The resulting monitor measures the pressure and temperature of the amniotic fluid. The next generation of the monitor will also measure the pH of the fluid. Eventually, a smaller monitor will gauge the electrical activity of the fetal heart and transmit the data, along with measurements of the baby's body chemicals, including carbon dioxide, glucose, and ionic calcium.

The tiny monitors also can be used to measure core body temperature, monitor patients for shock, and check intestinal pressure changes or stomach acidity in ulcer patients. Patents are pending and the technology is open to licensing, according to Mike Skidmore, deputy program manager for NASA's Sensors 2000 program at Ames.

"We would like to use this technology to study what happens to astronauts during space travel," said Skidmore. "Not only could they swallow the smaller pill transmitters we plan to develop, but the small, flat monitor we have designed could be taped to their bodies like a small bandage."

For more information, visit the NASA Ames web site at: http://www.arc.nasa.gov

Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

I'm looking for a computer-based wing design program. I have been reading about how wing designs also can be tested using software. Any help would be appreciated in locating one of these programs.

Shawn McDaniel
DocMk@hotmail.com

*(**Editor's Note:** Shawn, you may want to contact DARcorporation of Lawrence, KS, which offers a number of aviation design software packages such as Aero-CADD and G.A.-CAD. You can reach the company at 785-832-0434; Fax: 785-832-0524; or visit them on the web at: www.darcorp.com.)*

I am searching for information on a new medical device that I believe NASA is responsible for creating. The device is a needle based on NASA's rocket boosters. It uses high pressure to push drugs through the skin at supersonic speeds. I would like to know the following: Will it inject insulin? What is the cost? Thanks for your assistance.

Warwick Lake
Warwick-lake@use.net

The other day, someone from NASA Tech Briefs *called to ask if I wanted to continue my subscription. I thought for a moment and decided that I didn't really get much out of the magazine, so I said, "No, thank you." What a mistake! This morning I received what is probably my last scheduled issue. By the time I reached the end of page 16, I had already cut out two advertisements and was raving about the two UpFront articles, sharing them with my co-workers. I now remember other valuable articles I have clipped out of* NASA Tech Briefs. *I admit I was wrong. I do get a lot out of* NASA Tech Briefs. *Please don't cancel my subscription! I can't imagine what I was thinking!*

Jon Penner
H R Textron
Valencia, CA

*(**Editor's Note:** Jon, we forgive you. I hope you continue to find valuable information in* NASA Tech Briefs.*)*

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Patents

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Tough, Soluble, Aromatic Thermoplastic Copolyimides

(U.S. Patent No. 5,741,883)

Inventor: Robert G. Bryant, Langley Research Center

Aromatic thermoplastic polyimides are a class of polymers used in a variety of high-performance, high-temperature applications. By the present invention, wholly aromatic, thermoplastic polyimide copolymers were prepared based on 4,4'-oxydiphthalic anhydride, 3,4,3',4'-biphenyltetracarboxylic dianhydride and 3,4'-oxydianiline. These were found to be tough thermoplastics that are soluble in common amide solvents, and thus can be applied as the fully imidized copolymer in addition to the amic acid solution. They may be used to prepare the following articles: a solvent cast film, an extrudable object, a fiber-reinforced composite, a neat resin molding, a coating, a hot-melt adhesive tape, a fiber, a filled resin molding, and a matrix composite.

Ho:LuLF and Ho:Tm:LuLF Laser Materials

(U.S. Patent No. 5,742,632)

Inventors: Norman P. Barnes, Clyde A. Morrison, Elizabeth D. Filer, Mahendra G. Jani, Keith E. Murray, and George E. Lockard, Langley Research Center

In the development of a laser emitting at 2 micrometers, it is desirable to provide a material that has a higher efficiency and lower threshold at room temperature than known laser materials such as Ho:Tm:YAG and Ho:Tm:YLF. Furthermore, it is desirable to provide a laser material that is compatible with laser diode pumping using currently available GaAlAs laser diodes. The present team achieved these ends with a material comprising Ho:Tm:$LuLiF_4$ (Ho:Tm:LuLF). Quantum mechanical modeling showed that in this material the lower laser level would have a low thermal occupation and that there would be a high effective stimulated emission cross section, thereby decreasing the threshold and increasing efficiency over such materials as YLF and YAG. The use of Tm allows for the ability to pump the laser with GaAlAs laser diodes. Efficiency is also increased as a result of a lower upconversion rate. In addition, doping with erbium may be employed to provide a laser material that may be pumped with a flashlamp. In this case the Er would be utilized in relatively high concentrations to achieve efficient absorption of flashlamp radiation.

Particle Velocity Measuring System

(U.S. Patent No. 5,741,979)

Inventors: G. Dickey Arndt and James R. Carl, Johnson Space Center

In the past, the aseptic method of cooking foods, in which the product typically flows through a flowline rather than being cooked within a retort, has not been used for foods such as stews, pastas, soups, and other multiple-component slurries of food because it has been too difficult to determine the cooking time of all food particles. The time the particle takes to flow through the holding tube determines whether it is adequately cooked and sterilized. Various methods have been attempted to measure the velocity of individual food components within a slurry. The present invention is a method and apparatus for measuring transit times of food elements in a flowline. It combines an upstream microwave transducer with an upstream transmitter and receiver spaced across the flowline for transmitting a microwave signal through the flowline. Likewise a downstream microwave transducer has a downstream transmitter and receiver for transmitting a similar signal. Particles of food are marked with a pellet of some light metal such as beryllium, magnesium, or aluminum that does not significantly alter the specific gravity of the food but does affect the transmission loss and/or reflection loss of the signal. Another marker can be a resonant half-wave dipole element preferably formed of a thin-diameter wire. The transit time of movement of the elements between the two signal transducers is measured.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 14 for a list of office contacts.

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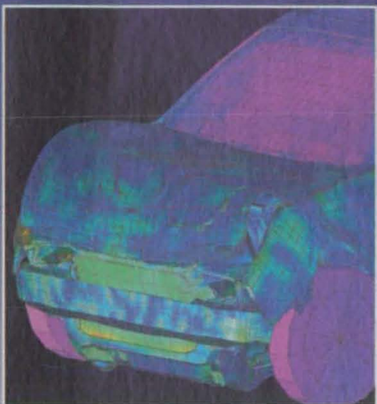

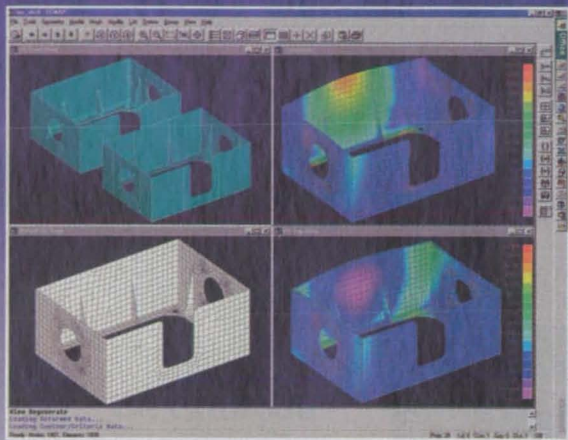

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National Manufacturing Week

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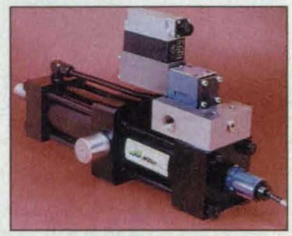
National Manufacturing Week, March 15-18 at Chicago's McCormick Place, will encompass four major events: the National Industrial Automation (NIA) Show; the National Industrial Enterprise IT Show; the National Plant Engineering MRO & Management Show; and the National Design Engineering Show (NDES). More than 2,200 exhibitors will display products and technologies to an expected attendance of more than 60,000 industry professionals. Following are some of the products that will be on display by NDES exhibitors. (For more information on the event, visit the web site at: www.manufacturingweek.com)

Booth 1606

Compaq Computer Corp., Houston, TX, will introduce the XP1000 Alpha-powered **workstations** for Windows NT or UNIX. Featuring the Alpha 21264 500-MHz/4 MB cache processor, the workstations are equipped with 100 MHz registered ECC SDRAM, 8 DIMM sockets, two 64-bit PCI slots, and 128, 256, or 512 MB memory (2 GB maximum). The units are available with 2D/3D ELSA GLoria Synergy graphics or Compaq PowerStorm 300 PCI or 350 PCI graphics. The expandable mini-tower chassis can support four 10,000 rpm drives, and features five slots (4 PCI and 1 shared PCI/ISA), six bays, and 4- or 9-MB storage capacity. Applications for the high-performance workstations include mechanical CAD, CAE, geographic information system (GIS) applications, 3D rendering and animation, and design synthesis and simulation.

Circle No. 750



Booth 2750

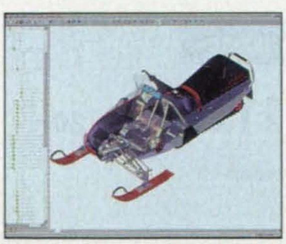
Miller Fluid Power, Bensenville, IL, will feature closed-loop proportional and servo solenoid **valves and cylinders**. The valves provide zero overlap at the mid-position area, instant response to rapid changes in signal, and reduced filtration requirements. The systems use analog, digital, or bus-based control for controlling acceleration, deceleration, velocity, position, and force in hydraulic and pneumatic cylinders. The controllers are available in bore sizes of 1-1/2" to 20", up to 3000 psi, and with maximum strokes to 120".

Circle No. 752

Booth 2315

A 200-page "B600" catalog of **bearings** will be available from Quality Bearings & Components, Garden City Park, NY. More than 18,800 bearings are featured in the catalog, including rod ends and spherical bearings, rolling contact bearings, sintered and metal bearings, and plastic and nonmetallic bearings. A 48-page technical section describes bearing design and selection, including load factors, sizing, and bearing mounting. Major product groups include ball, thrust, sleeve, needle, and linear ball bearings; and roller clutches, guide wheels, and rail systems.

Circle No. 753



Booth 201

SolidWorks Corp., Concord, MA, will demonstrate SolidWorks 98Plus **3D mechanical design software,** which features more than 200 enhancements. Improved detailing tools include the ability to embed custom properties in a drawing template, automating standard company practices by reusing custom symbols and notes, and Dynamic View Activation, which automatically activates a view sheet depending on cursor location. Other features include automatic updating of the relationships between parts in an assembly; the ability to drag models directly from web pages and drop them into SolidWorks parts or assemblies; new lofting, shaping, and surfacing functions; and sheet metal design capabilities for creating designs in 3D or in the flat.

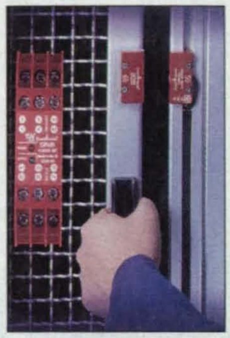
Circle No. 754

Booth 3528

Haydon Switch & Instrument, Waterbury, CT, will exhibit a new family of miniature stepper-driven **gearmotors** designed for applications in limited spaces that require the torque or output speeds of a gearmotor. The gearhead is coupled to a 1" or 3/4" diameter stepper. Gear ratios from 2.4:1 to 3600:1 are available. Composite gears are available for quiet operation, and metal gears are available for higher torque applications. Special mounting and output shaft configurations are available. Typical applications include medical equipment, chart recorders, and research instrumentation.

Circle No. 756

Booth 5518



The Sipha tamper-resistant, non-contact **safety interlock switch** is available from Scientific Technologies, Fremont, CA. As a fully monitored dual-channel system, a single Sipha switch and control unit combine to fulfill Category 3 safety requirements. The NEMA 6 enclosure allows operation in harsh environments. The control unit can monitor a large number of switches for applications with numerous doors. The control unit also provides motor contactor monitoring and/or a manual reset function, allowing it to replace a safety relay in some applications.

Circle No. 757

Booth 2657

Nylok Fastener Corp., Macomb, MI, will display the PRECOTE® chemical **adhesive system**, which uses a patented dual-encapsulation process on both the resin and hardener to ensure a longer shelf life. The epoxy resin and hardener components remain microencapsulated until tightening of the fastener breaks the capsules and causes the two agents to mix. The adhesive can be applied to internally or externally threaded fasteners, sizes M4 and higher, and comes in several grades, distinguished by color: PRECOTE 5 (white), PRECOTE 30 (yellow), PRECOTE 80 (pink), and PRECOTE 85 (turquoise).

Circle No. 761

Booth 5025

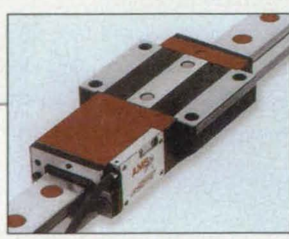
The Survivor-LightLink™ **flat-panel monitor** will be featured by Computer Dynamics, Greenville, SC. The Class I, Division 1 and 2-compliant monitor communicates via fiber-optic link with its host up to 20 kilometers away. The system's 15", 900-nit, XGA display and optional touchscreen are housed in a NEMA 4/4X enclosure. A transmitter/receiver unit, mounted at the host computer, transmits and receives all signals — including video, RS-232, PS2 mouse, and keyboard — over a single pair of eye-safe fiber-optic cables at 1.5 GB per second. It measures 18.3 x 13.5 x 4.2" and features an operating temperature range of 0 to 50°C.

Circle No. 762

Booth 431

Durobal® thermoplastic **ball bearings** will be on display by Busak+Shamban, Fort Wayne, IN. The injection-molded components are used in applications requiring long wear life, low friction, non-metallic bearings. They are available in a range of standard and custom thermoplastic compounds. Features include self-lubricating properties, temperature range from cryogenic to 287°C, chemical and corrosion resistance, low noise, and design options.

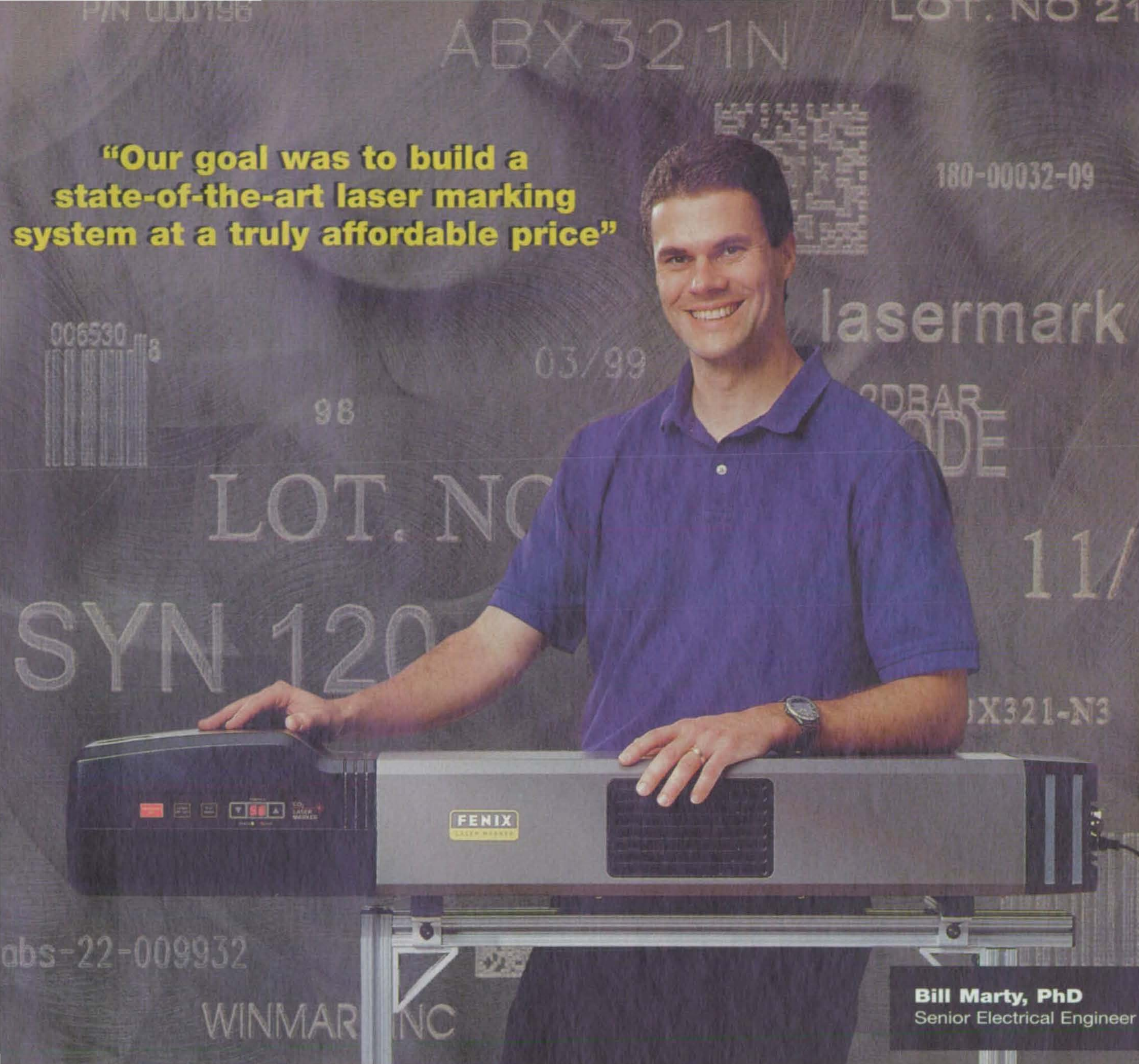
Circle No. 763



Booth 119

Schneeberger, Bedford, MA, will display the Monorail AMS **linear measuring system** that offers resolution of 1 μm. Standard accuracy grade is 5 μm per meter with typical repeatability of ±1 μm. The system features integrated measuring and guidance systems for reduced geometric and deformation errors. The system's scan head glides on a magnetic scale. Housed in a single piece of titanium, the solid-state scanning element generates two sinusoidal signals, phase shifted by 90°, plus a separate reference signal. The signals are available as 7-16 microamp current outputs or 1-volt p-p.

Circle No. 764



Lasers create crisp, permanent marks on plastics, wood, paper, metals, and countless other materials, so it's no wonder laser marking is the preferred method of product marking for many industries. Unlike other marking technologies, there are no messy inks to replace, no hazardous solvents to dispose of, and no tool wear. The only problem has been that, while lasers have always offered long-term cost savings, their initial price has often been too high for many companies' budgets.

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* US List price, add 10% for international shipments

The core of this compact, self-contained system is a 25 watt Synrad sealed CO_2 laser. Designed for rugged environments, a Synrad laser can be expected to operate for tens of thousands of hours with no maintenance requirements. Fenix operates from a standard, user-supplied PC. It couldn't be more simple to set up - just connect it to the computer, plug it into the wall, and start marking!

Synrad's own Windows®-based software, WinMark Lite, provides the user-interface to Fenix. This intuitive, easy-to-use software enables users to perform most marking functions. For advanced applications such as serialization, bar coding, and automation, upgrade to the feature-packed WinMark Pro™, and take full advantage of this flexible marking solution.

The first truly affordable laser solution to industrial marking, Fenix brings all the benefits of a state-of-the-art laser system at a lower cost than you ever imagined. For more information on Fenix, call us at **1-800-SYNRAD1**, or look us up on the world wide web at **www.synrad.com/fenix**

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For More Information Circle No. 552

Booth 4217

Boston Gear, Quincy, MA, will exhibit the modified 700 Series worm gear **speed reducers**, which are available with special keyways; reduced diameters; threaded, drilled, and tapped ends; machined flats; drilled cross holes; snap ring grooves; and non-standard projecting input and output shaft lengths. Hollow output shafts can be bored to size. Double projecting input shafts are available in quill, coupling, and projecting shaft styles.

Circle No. 768

Booth 409

The FDM2000 **rapid prototyping system** will be displayed by Stratasys, Minneapolis, MN. The system is based on the company's patented fused deposition modeling technology, and can build models up to 10 x 10 x 10" within ±0.005" accuracy. Available materials include ABS, medical-grade ABS, and investment casting wax. The system operates on Hewlett-Packard, Silicon Graphics, Sun Microsystems, and Windows NT workstations. The system uses QuickSlice 4.1, the company's proprietary operating software.

Circle No. 769

Booth 3534

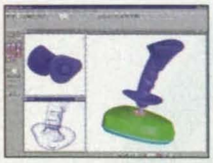
Balluff, Florence, KY, will display the BOD-26 **laser distance sensor**, which indicates object position to 80 µm resolution. Red laser light and dot size of 0.9 mm make the optical distance sensor suitable for non-contact dimensional measurement checks of small objects, level detection, tool condition checks, and surface checking, regardless of background conditions. The sensor uses triangulation to determine distance to objects. Powered by 18-28 VDC, the sensor has an operational sensing range of 45-85 mm. It is reverse-polarity and short-circuit protected.

Circle No. 770

Booth 160

The M Series miniature **air cylinders** will be displayed by Mead Fluid Dynamics, Chicago, IL. Available in bores from 1/4", the cylinders provide linear motion in limited or restricted space. The MA models feature a threaded body; the MF models offer a rectangular, flat body; and the MN models feature a flat body and a threaded nose mount. All cylinders are available in single- and double-acting models. They have bronze rod bearings and stainless steel piston rods. A non-rotating option is available on some models.

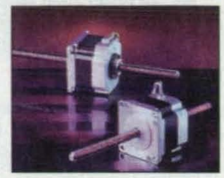
Circle No. 767



Booth 1625

Baystate Technologies, Marlborough, MA, will introduce CADKEY Design Suite **modeling software**, which integrates 3D automation tools — including advanced wireframe, surface, and solid modeling — with mechanical design features. The PC-CAD software incorporates solid modeling features of CADKEY 98, surface modeling features of FastSURF®, and mechanical features of DRAFT-PAK®. The package also includes ACIS® 4.2 solid modeling, photo-realistic rendering, multiple document interface, and the ability to generate 2D engineering drawings. Data translators allow transport of all data types to other CAD/CAM/CAE environments.

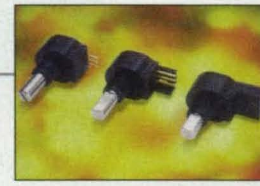
Circle No. 795



Booth 3628

A **linear actuator** based on high-torque stepping motor technology will be displayed by Eastern Air Devices, Dover, NH. The motor consists of a NEMA size 23 stepping motor and lead screw interface. It measures 1.8" in length and can deliver up to 180 pounds of linear force. A hollow shaft motor design accommodates leadscrews and ballscrews to 3/8" diameter. Special leadscrews are machined in a choice of materials and lengths for most applications.

Circle No. 796



Booth 4521

The Siebe SensorCube™ **position measurement sensors** will be displayed by Selco Products, Orange, CA. The plug-and-play position-sensing potentiometers have environmental seals that withstand rugged conditions and applications requiring long operational life. The sensors feature both quad-ring shaft and full-housing seals. The SA and SP versions offer integral Amp and Panduit mating connectors for both external and front-panel applications. All models offer rotational life of 10 million full cycles and 50 million dither cycles. The sensors feature an operating temperature range of -55°C to +125°C.

Circle No. 751

Booth 2536

The PF (PowerFlex) Series of **couplings** will be displayed by Helical Products, Santa Maria, CA. The key coupling component is the HELI-CAL Flexure, a flexible helix beam machined from one piece of material into a specific configuration that incorporates special design requirements, features, and characteristics. In addition to the HELI-CAL Flexure, the couplings feature removable tapered bushings, torque capacity up to 1800 lb/in., and misalignment capability of 4 degrees angular. Because shaft sizes are contained in the tapered bushings, the couplings can be assembled to suit customer specifications. The couplings are available in both inch and millimeter bore sizes, in aluminum or stainless steel.

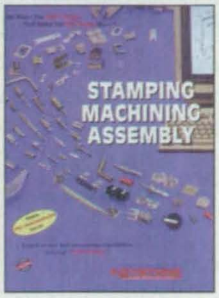
Circle No. 755

Booth 4520

The Model 605 DC angular **displacement transducer** will be displayed by Trans-Tek, Ellington, CT. The transducer offers accuracy to 0.03°, and eight measurement ranges for sensing angular position up to 300° of rotation. With a 3-kHz frequency response, the transducer is suited for use as a servo feedback sensor. Features include standardized DC outputs including 4-20 mA, two mounting options, connector termination, and a rugged housing. Accuracy is greater than 0.25% FS including nonlinearity, hysteresis, repeatability, and unit-to-unit variation. Extended temperature range versions and specially sealed units are available.

Circle No. 760

Booth 2716



The Stamping Division of Keystone Electronics Corp., Astoria, NY, will offer a catalog of custom and standard metallic and non-metallic **components and hardware**. The company offers CAD design and engineering services; and stamping, manufacturing, and assembly operations that incorporate in-die tapping, plating and assembly, and press capacities to 45 tons. Progressive, blanking, and forming dies are available.

Circle No. 797

Booth 4131

DieQua Corp., Bloomingdale, IL, will exhibit the Tandler line of servo **speed reducers**, which incorporate a motor mounting design that consists of a two-piece axial fit bellows coupling that isolates the internal gearing from the motor shaft. By eliminating shaft deflection, noise is reduced. Also on display will be the Tandler low backlash spiral bevel gearboxes, and other couplings, actuators, and power transmission components.

Circle No. 798

Commercialization Opportunities

Digital Approximation Premodulation Filter

Because this filter is synchronized with the bit-rate clock, it always produces the proper wave shape, regardless of the bit rate of the unfiltered data signal. The filter is designed for the transmission of serial digital data.
(See page 44.)

Snapshot CCD Camera With Microelectromechanical Shutter

The proposed camera is shuttered by a planar array of micromachined, electromechanically actuated shutters. The camera is part of a visible/near-infrared imaging spectrometer using commercial off-the-shelf CCDs.
(See page 51.)

Zb_4Sb_3: A High-Performance Thermoelectric Material

Zb_4Sb_3 offers a thermoelectric-performance advantage for generating electrical energy from heat sources in the temperature range from 200 to 350 °C. There are many potential applications for this material in thermoelectric generators, especially in recovering electrical energy from waste heat.
(See page 54.)

Cold Hibernated Elastic Memory (CHEM) Expandable Structures

The feasibility of a new class of lightweight, reliable, simple, low-cost expandable structures was experimentally confirmed. Parts made from this material can be compacted, stowed away, deployed, recompacted, etc., via heating and cooling.
(See page 56.)

Ceramic Hybrid Electromechanical Systems

These systems overcome disadvantages while retaining most of the advantages of microelectromechanical systems. Mature manufacturing techniques of ceramic hybrid structures practiced in the electronics industry will be used to produce these systems.
(See page 61.)

Optoelectronic Liquid-Level Gauges for Aircraft Fuel Tanks

Gauges that would measure liquid levels optically are proposed for aircraft fuel tanks. These gauges would have no moving parts and no wiring inside the tanks. Replacements can be accomplished in minutes instead of days.
(See page 63.)

Shape-Memory-Alloy Thermal-Conduction Switches

Use of these switches would be relatively cheap and reliable. The switches would be used to connect equipment to heat sinks to help maintain the required operating temperature.
(See page 64.)

Surface-Plasmon Reflective Flat-Panel Color Displays

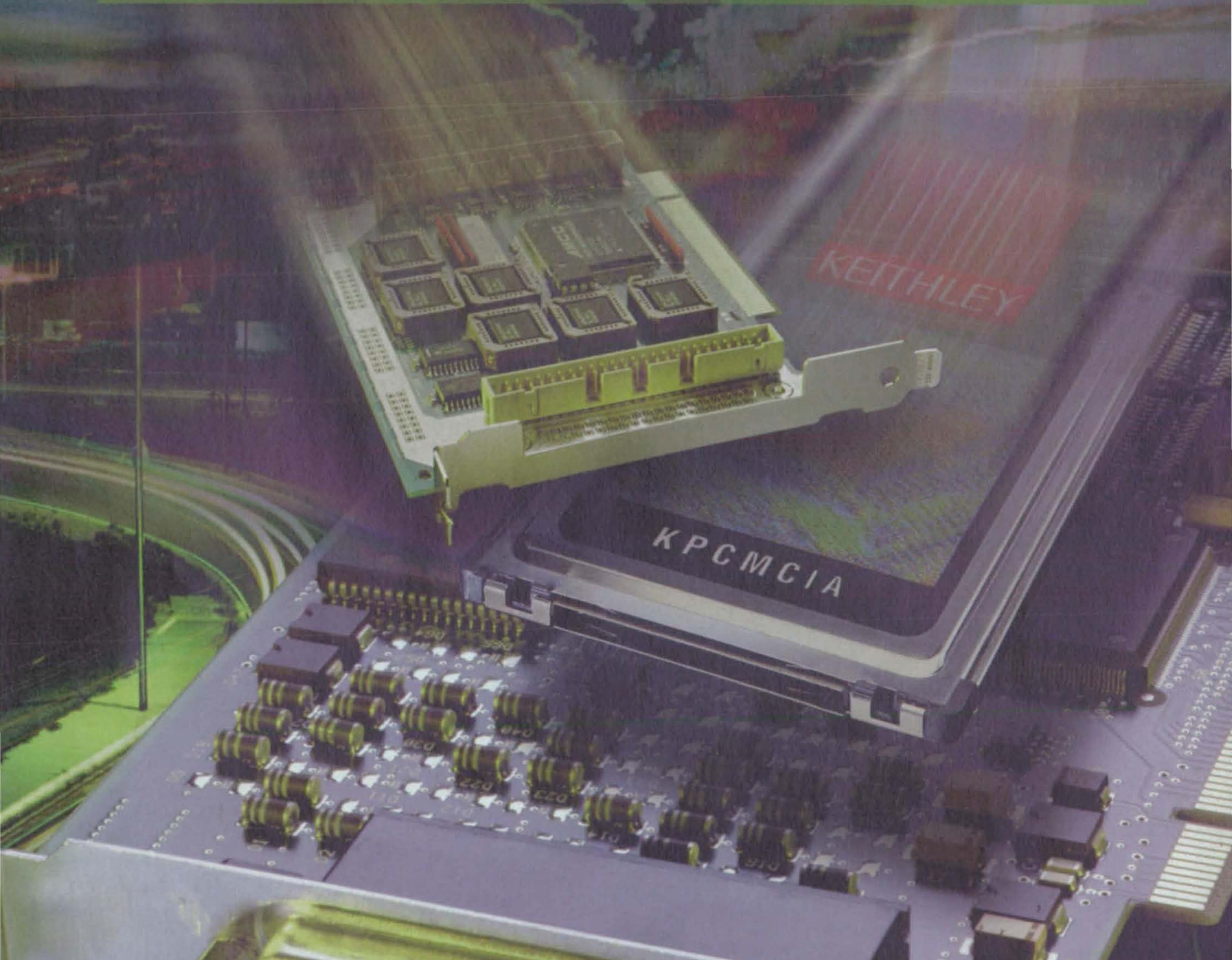
These display devices would be operated without internal lighting, would consume much less power than active-matrix displays, and would be readable in bright light.
(See page 68.)

Cover art courtesy Keithley Instruments Inc.

February 1999

etb

ELECTRONICS TECH BRIEFS



THE RIGHT BUS FOR YOUR DATA HIGHWAY

In integrating instruments and related devices in a PC-based test system, the choices are many.

Success in getting test data to where it's needed is analogous to using public transportation: you have to use a bus with the right number. Lately, users have a confusing array of data buses from which to choose. From the legacy serial buses to several new bus developments, the user's options have been greatly expanded: RS-232, RS-422/485, EPP, IEEE-488, USB, IEEE-1394 (FireWire), Ethernet and more. Several of these may do the job, but some make the trip a lot faster and more pleasant.

Which bus is best for a specific application? To help answer that question, this article surveys various communication buses a user might consider for integrating instruments and related devices in a PC-based test. Some of the issues discussed include:

- Inadequate speed/bandwidth of some of the buses;
- Inability of instruments equipped to use newer, easy-to-use high-speed buses;
- Methods for adapting present instruments to a wide-bandwidth bus; and
- Recognizing when the bus isn't the problem in limiting data transmission throughput.

Characteristics of Buses

Table 1 shows selected data communication buses and their salient features, as seen by Keithley Instruments engineers.

One of the most pronounced differences between the various communication buses is speed. As seen in the table, the speed ranges from 20 kbps for RS-232 to 100 Mbps for 100BaseT Ethernet. However, when choosing a bus for instrumentation purposes, users are usually constrained by the capabilities of the instrument, which means that they can't directly use some of the new high-speed buses, such as FireWire. This is most common in both legacy and new benchtop instruments, such as digital multimeters (DMMs), that are controlled over the IEEE-488 bus. Fortunately, however, interface controllers are available to enable these instruments to transmit over several of the other buses.

Serial Port Connections

The serial interface network connections—RS-232, RS-422, and RS-485—are one of the most popular ways to perform remote I/O between PCs and electronic instruments today. Because this networking methodology has been in existence longer than most, and is easy to use, it retains its popularity.

RS-232. All PCs shipped up to today are equipped with a serial port that can support RS-232 communications. RS-232, a serial asynchronous communications standard, is the simplest and the lowest-cost bus and operates at a relatively slow data speed of 20 kbps. It can only operate up to 50 feet, but its range can be expanded by using a modem. There is no standard protocol built-in to the serial interfaces, which means that software terminal programs must be used to provide control. Only one device can be controlled from a single RS-232 port, and there is no electrical isolation to protect the PC from hazardous voltages. In addition, the signals are referenced to ground, making them subject to line noise.

Although the new USB bus is poised to replace RS-232 on new PCs for consumer and business applications, the RS-232 serial port may be retained on PCs for industrial use for a longer period of time because of the large installed base of devices supporting this standard.

RS-422/485. The PC's serial port also supports RS-422 and RS-485 buses, which are an improvement over RS-232 because they support 10 and 32 devices, respectively, at speeds from the base 1.2 kbps up to 10 Mbps. In addition, these serial standards use differential transmission protocols for greater noise immunity and communicate beyond RS-232's 50-foot limit. Distance capability ranges from 4000 feet at 100 kbps to 50 feet at 10 Mbps. In addition, RS-422/485 ports are electrically isolated, deterministic, and robust, which makes them well suited for industrial applications. However, use of RS-422/485 requires installing an interface card in the PC, increasing the system cost over RS-232 solutions.

To enable a PC equipped with an RS-232 port to communicate with RS-485 devices, a RS-232-to-RS-485 converter module is available. The module, external to the PC, enables a single RS-232 port to communicate with up to 32 RS-485 devices over distances up to 4000 feet.

Parallel Port Connections (EPP/SPP)

The Enhanced Parallel Port (EPP) together with the Standard Parallel Port (SPP) are the most popular PC ports used to connect peripherals today. The parallel port is most commonly used to connect printers to a PC, but because of its universality is also used to connect to data acquisition hardware. EPP, compared to SPP, provides bidirectional capabilities over distances up to 50 feet and increased speed—up to 500 kbps burst, and 100 kbps for continuous operation. EPP operation can be configured on most PCs using the BIOS utility, so an interface card is not required. The parallel port's increased speed, compared to the serial port's, makes it more suitable for data acquisition applications requiring higher sampling rates at a low cost. The PC parallel ports are expected to be replaced by the new USB bus as peripherals supporting this bus come to market.

GPIB: IEEE-488 and HS488

The General Purpose Interface Bus (GPIB), officially designated IEEE-488, is the industry-standard bus used for controlling instruments from a PC. Compared to most serial and parallel port bus configurations, IEEE-488 operates at higher speeds of up to 1 Mbps over distances of up to 6.5 feet (2 m). However, this distance can be extended

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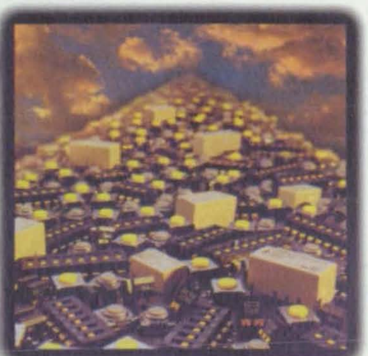

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Source: The World Electromechanical and Solid-State Relay Industry, 4th edition by Venture Development Corp.

Products	*Specifications*	*Applications*
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Relays 	**G6K (ControlFax #13310)** DPDT, 1 A @ 30 VDC, 0.3 A @ 125 VAC 37.5 VA, 30 W maximum switching capacity Gull wing and inside "L" terminals 4.5, 5, 12, 24 VDC coil voltages **G6S (Control Fax #13309)** DPDT, 2 A @ 30 VDC, 0.5 A @ 125 VAC 62.5 VA, 60 W maximum switching capacity Meets 2.5 kV Bellcore surge requirement Non-latching and latching versions Gull wing and inside "L" terminals 3, 4.5, 5, 6, 9, 12, 24 VDC coil voltages	**G6K:** Network interface cards/units Test equipment Home security, thermostats Medical monitoring **G6S:** Telephone central office switches Digital loop carrier SONET
DIP and Tactile switches 	**A6S DIP switches (ControlFax #16404)** Flat and raised actuator models, tape sealed washable version available 2, 3, 4, 5, 6, 7, 8, 9, 10 pole versions	Selector switches for modems, audio, HVAC and data communications control boards
	B3SN Tactile switches (ControlFax #16202) 160 ±50g operating force SPST contact, with or without ground terminal Sealed construction to IP62 for dust and humidity	Keypad switches for garage door openers, thermostats, home alarm systems, data communications

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	RS-232 Serial Bus	RS-422/ 485 Serial Bus	EPP Enhanced Parallel Port	GPIB IEEE-488/ HS488	USB Universal Serial Bus	FireWire IEEE-1394	Ethernet 10BaseT/ 100BaseT
Max Speed	20 kbps	1.2 kbps to 10 Mbps	100 kbps continuous, 500 kbps burst	1 Mbps/ 8 Mbps	12 Mbps	400 Mbps (1.6 Gbps planned)	10 Mbps/ 100 Mbps (1 Gbps planned)
Shared Bandwidth	No	No	No	Yes	Yes	Yes	Yes
Max Distance from PC	50 ft	4000 ft. @ 100 kbps, 50 ft @ 10 Mbps	30-50 ft	6.5 ft. (2m)/ cable. Can extend to 6562 ft. (2 km)	System bus 50 ft., or 16.5 ft. (5m)/ cable	15 ft. (4.5m)/ cable	Up to 3000 ft., unlimited with repeater. 328 ft. (100m) from hub
Max No. Devices.	1	10/32	1	15	127	63	255
Point-to-Point	Yes	Yes, with multidrop	Yes	No	No	No	No
PC Req'd Interface	No	Yes	No	Yes	No	No	Yes
All PCs Support	Yes	Yes	Yes	No	New PCs only	Few PCs (future std)	No
Cabling	4-wire	4-wire	25-wire	24-wire	4-wire	6-wire	4-wire
Cost	Low	Medium	Low	High	Low	Medium	Medium
Pro	Easy installation	Noise immunity, isolated electrically, deterministic	Easy installation, faster than most serial port configurations	Interrupt line, moderately high-speed with HS488	True plug-and-play, hot insertion, wiring, drivers built-in.	True plug-and-play, hot insertion, high speed acquisition	Access and share data from anywhere, great legacy high speed
Con	Wiring, not isolated electrically, slow	Wiring	Limited transfer rates	Proprietary drivers	Limited transfer rates, cell orientation	Low PC penetration	Non-deterministic

Table 1. Features of Selected Data Buses

up to 6562 feet (2 km). One advantage of IEEE-488 is its ability to share bandwidth with up to 15 devices, and another is its ability to provide interrupts to control the CPU's processing activities. A disadvantage of IEEE-488 is that a PC interface card is required, as well as a unique software driver for every instrument connected. While the bus itself is an open standard, all the software drivers are proprietary.

The controversial proposed enhanced IEEE-488 standard designated HS488 specifies that it can operate at speeds up to 8 Mbps. However, it is not clear whether or when this proposed new standard will be officially recognized. Some manufacturers envision compatibility between standard GPIB and HS488 instruments. Nevertheless, devices supporting this proposed standard are on the market today.

Because of the large installed base of standard GPIB instrumentation, notably benchtop instruments such as DMMs and counter/timers, it is expected that this bus will be around for a long time, even with migration to USB and FireWire. However, in order to enable these instruments to take advantage of the greater bandwidth of the newer buses, as well as to provide the flexibility to communicate over a PC's serial and parallel port, vendors have developed interface controllers. The controllers are modules supported by software drivers, located outside the PC, that transfer control of IEEE-488 instruments to another type of bus. These interface controllers include IEEE-488-to-Ethernet, USB, RS-232, RS-485, or the parallel port (EPP and SPP).

Universal Serial Bus (USB)

Universal Serial Bus is a newcomer that will become ubiquitous on PCs, because it is incorporated into every new PC shipped as of early 1998. Originally adopted as a standard by Intel and Microsoft for use in consumer applications, USB has found its way into the industrial arena. USB supports relatively high speeds—up to 12 Mbps, which is roughly 50 times faster than an RS-232 serial port and 10 times faster than EPP, and makes installation of peripherals hassle-free because it provides true plug-and-play, hot swapping, and 5-V power-up for low-draw (500-mA) devices. Because PCs equipped for USB have software support built into their operating systems for many types of common devices, device drivers and interface cards are not required for these devices. In fact, connecting peripherals is as simple as plugging in a toaster. (For newer peripherals not supported by current software operating systems, drivers must be developed, which requires an expertise in Windows NT driver development.) USB devices are controlled by the host PC, which manages latency and can support up to 127 devices (compared to GPIB's 15) using a hubbing arrangement. An advantage of USB is that it can guarantee a device a certain percent of bandwidth and provide a high overall bandwidth utilization as well.

USB's industrial use is expected to be concentrated in the area of data acquisition, with migration to USB expected to be strong for those applications now using the serial and parallel ports. This is because the invested base of instrumentation using serial and parallel ports is not as large as the IEEE-488 instrument


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base. However, currently only a very limited number of vendors have produced instrumentation supporting USB.

FireWire (IEEE-1394)

Similar to USB, IEEE-1394, also commonly known as FireWire (a trademark of Apple Computer, Inc.), is a serial bus geared to high-speed applications. Because its data rate is 400 Mbps, with developments planned to extend it to as high as 1.6 Gbps and even higher, FireWire can handle virtually all continuous high-speed data acquisition applications, including video and high-speed printing. Currently, specifications call for bandwidth to be shared with up to 63 devices, with the use of bridges to expand the number of devices into the hundreds. Cable length is limited to 15 feet (4.5 m), but is expected to increase to 82 feet (25 m) or farther using extenders.

Like USB, FireWire provides true plug-and-play and hot swapping. Desktop and laptop PCs are starting to appear that have FireWire connectors as standard equipment, and Microsoft has included native driver support in its Windows 98 and NT 5.0 operating systems. A special work group has been formed within the 1394 Trade Association to develop standard protocols and command sets, much like GPIB, which will allow instrumentation and industrial control devices to work together and communicate in a system environment using FireWire technology. As the number of FireWire devices increases, and this new standard proliferates among the PC world, high-speed data acquisition will be tremendously simplified.

Ethernet

Ethernet is an open network standard for communications networks that was standardized in the '80s by IEEE and has now become the enterprise network de facto standard. While it has traditionally been used as an office data network, many engineers are now discovering that it is well suited for industrial remote I/O applications. It provides high-speed, multidrop transmission capabilities at low to moderate cost.

While Ethernet can use several protocols, the protocol of choice is TCP/IP, which is compatible with Windows® 95, 98 and NT operating systems, UNIX, and the Internet. This means that the user will not run into interoperability problems. Ethernet operates at data speeds of 10 Mbps (10BaseT) or 100 Mbps (100BaseT), with development of a 1-Gbps capability expected shortly. Wide bandwidth means that fast response to events can take place as well as allowing up to 255 devices to share the bandwidth and communicate on the network. Ethernet's transmission distance is one of its high points. While individual cable lengths from a hub to a device are limited to 328 feet (100 m), by using repeaters and/or the Internet, data can be transmitted worldwide.

Ethernet's network components are priced low compared to competitive networks, primarily due to the large volume of products being manufactured. Interface cards are required, but are priced under $50. Adding to a network is accomplished by adding hubs, priced under $100, that can add as many as eight more devices to a network. Devices are added to the network by simply plugging them into a hub. (USB's hot-swapping feature is not available on Ethernet systems.) A software driver is required to enable the PC to communicate with the Ethernet interface card.

As with all systems, there are certain limitations that must be addressed. Ethernet is an asynchronous nondeterministic system. This means that hard real-time events, such as those in process control applications requiring interrupts in the low-microsecond range, can't be adequately controlled over an Ethernet network. Because Ethernet delivers data packets over the network in a random fashion, with only one transmission taking place at a time, delivery time can't be guaranteed.

Data acquisition from sensors over Ethernet is a common application for those companies that need to have access to the data at several sites within the enterprise. For example, an engineer can access the data from his desktop PC, or a quality engineer can monitor the product from a centralized location in another city over the Internet. This great flexibility can result in a considerable savings in personnel time and travel costs. While most instrumentation applications are still using IEEE-488 for networking, several vendors have introduced instrumentation products with an Ethernet communication interface.

In addition, for IEEE-488 instrumentation without a built-in Ethernet interface, vendors have developed separate interface controllers to provide the required compatibility to Ethernet. In fact, it has emerged as a viable field bus. Keithley 's 1997 survey of in-plant system engineers found that about 37 percent were using an Ethernet network to capture measurement data, and this same group forecast that 43 percent of measurement applications would use Ethernet in the near future.

Making the Right Choice

When it comes time to select the correct bus for a particular application, do not be deceived by the advertised maximum speed. Few systems operate at the maximum speed, because of factors such as the communication protocol, application software, and the PC's operating system, as well as other latencies common to the PC. Other parameters affecting actual speed are the distance between the sensor and PC as well as the number of devices sharing the bandwidth. Oftentimes the data throughput will be only a small fraction of the bus's maximum speed. For example, for USB with maximum speed of 12 Mbps, the actual throughput is only about 100 kbps due to the various latencies.

To make the correct bus choice the user must first calculate the sampling speed that the application requires. For example, for users measuring temperature using a thermocouple, the speed of a serial or parallel port connection would be very adequate. However, for applications requiring the collection and sharing of data from a remote location miles away, an Ethernet connection would be most appropriate.

Systems built around IEEE-488, of course, dictate the use of that bus, or if the user wants to use another bus, the purchase of an IEEE-488 converter is required. For high-speed data acquisition applications today not requiring hard real-time response, the answer is Ethernet. However, as software protocols evolve and FireWire is available on all PCs and widely supported by instrumentation manufacturers, that would most likely be the best choice for high-speed applications. USB would be the choice for lower-speed applications when supporting instrumentation is available.

Picking the right bus for your data highway involves knowing the characteristics of all the buses available, determining specific needs, and balancing those against your budget. With all the new developments taking place in instrument and bus architectures, the decisions you made yesterday and today very likely will be different from those you make tomorrow.

For more information, contact the author of this article, Gary Sakmar, staff engineer for Keithley Instruments, 28775 Aurora Rd., Cleveland, OH 44139-1891; (440) 248-0400; fax: (440) 248-6168; http://www.keithley.com.

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For More Information Circle No. 464

Thermoplastic Weld Has Ergonomic and Environmental Benefits

etb CONNECTORS

A technique available for license is a simple, cost-effective plastic welding process.

Lucent Technologies, Murray Hill, New Jersey

Thermoplastic coupling is a patented welding process that is used to join thermoplastic parts. At the drill press, during a connector design brainstorming session, an engineer at Lucent Technologies' Bell Laboratories inserted a plastic rod into a cavity that was slightly too small in its cross section. He hit it with a hammer once to make it fit, and found when he tried to strike it a second time, it wouldn't budge. The explanation was simple: a single stroke converts kinetic energy into thermal energy when a shaft is rammed into a cavity slightly smaller in diameter than the shaft. Trapped frictional heat causes the two to weld permanently together.

Thermoplastic coupling has been used since 1994 to weld more than 15 million handsets for telephones. This welding process has resulted in cost savings of five to eight cents per handset, because thermoplastic coupling eliminates the cost of two screws, and the labor to apply those screws.

Other benefits of thermoplastic coupling range from the sheer strength of the weld to ergonomic and environmental safety. Because there are no harsh solvents or glues used with this type of welding, it is environmentally friendly. Thermoplastic coupling also avoids repetitive-motion injuries, common to assembly workers, by eliminating the torque motion necessary to apply screws.

The thermoplastic weld is very strong, since plastic is literally fused with plastic. This opens the door to a myriad of uses for large-volume assembly of injection-molded products, such as toys, computer and other permanent electronic equipment housings, auto parts, and disposable medical products.

The technology is easy to transfer and to implement. Process steps can be eliminated on the assembly line, such as applying screws, glue, and a drying process, all typically used for a redundant assembly process. Thermoplastic coupling saves money and time, and is striking in its utter simplicity.

This work was done by Robert J. O'Connor and Jaime R. Arnett at **Lucent Technologies' Bell Laboratories**. *This technology is available for licensing. Lucent has available an entire package, including a patent, press-weld machinery specifications, and other technical information necessary to implement the process. For more information, contact John Simon, District Manager, Lucent Technologies GRL Corp., Miami Lakes, FL; (305) 817-8143; fax (305) 817-8180; e-mail: jfsimon@lucent.com.*

"Natural Computing" System

etb SOFTWARE

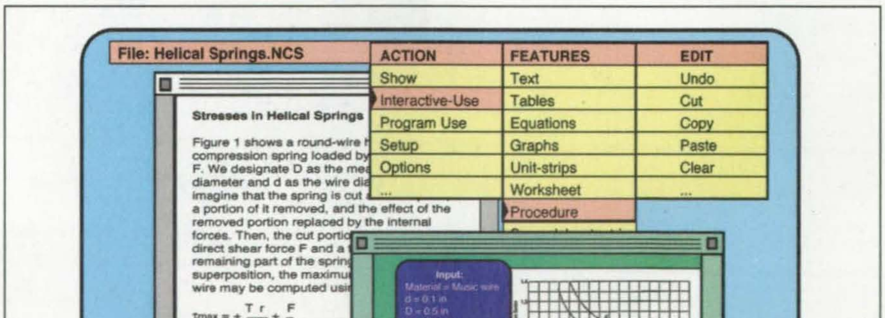
A novel system would allow computational capability in electronic books.

U.S. Army Research Laboratory, Adelphi, Maryland

A patent (U.S. Patent No. 5,680,557, "Natural Computing System and Environment") describes an invention that allows people to do computations by using time-tested and trusted ways of representing data and information. This method relies on equations, tables, graphs, worksheets, unit strips, text, and so forth in computers as if these objects were on paper. In the "Natural Computing" environment, these natural features (equations, tables, etc.) are preprogrammed in object-oriented programming languages. Electronic documents based on the "Natural Computing" format allow people to use text and concurrently carry out computations. For the end user or the developer of a solution to a computational problem, no further programming is required, other than the manipulation of features in an obvious and instinctive way.

The figure shows an example of a "Natural Computing" screen depicting a procedure object containing three other object types, namely a table, a graph, and a number of equations. Once the procedure object is highlighted and input values are provided by the user, result values are output. The procedure object and other objects are embedded along with the text in the electronic document.

The invention attacks the common software development problem in computation-intensive domains. Despite the enormous achievements in computation capa-



An example of a **"Natural Computing"** system screen.

bilities seen in the nineties, software development in calculation-intensive applications is still slow, costly, and unreliable.

This situation arises in large part because traditional software development methods require that subject-matter specialists explain their computational procedures to programmers before the data, knowledge, and procedures can be encoded for computer systems. The inherent complexity of current computer language schemes has led to the development of an army of professional programmers, analogous to the scribes who transcribed hieroglyphic symbols for use by ancient end users before the invention of widely accessible alphabets and Arabic numerals. The need for these intermediaries between the user and the task introduces inefficiency, incessant programming, and considerable lag between the availability of knowledge and its use.

The invention relies on the natural way people do computations. They read information from journals, textbooks, handbooks, encyclopedic references, brochures, and catalogs, then transfer that data, information, and methods onto paper; do the computation; and record the information resulting from the new computations. This invention consists of building classes that represent computational features such as equations, tables, graphs, worksheets, unit strips, text, and so forth in computers as if these objects were on paper.

The classes contain operations and methods to manipulate data in the objects that are instances of these classes. In a typical domain application, equations, tables, and so forth are represented as objects, and domain data and information are entered. For example, procedure objects are developed by connecting the necessary objects in the required sequence. The "Natural Computing" environment is intended to present a menu of objects for domain specialists to choose objects from as necessary for a given application.

The system presents numerous benefits. Authors of electronic textbooks, papers, and handbooks will be able to embed computational features and procedures in text for easy computation. Since users of these electronic documents will be able to use calculation procedures directly from these sources, the need for applications programming professionals will be eliminated. Avoiding these intermediaries increases efficiency and economy and decreases the gap between the generation of knowledge and its availability in electronic books. The impact of the "Natural Computing" system could be comparable to that of

word processing, desktop publishing, CAD, spreadsheets, and database systems development.

This work was done by Som Karamchetty of the **U.S. Army Research Laboratory**. *Inquiries concerning rights for the commercial use of this invention should be addressed to Ms. Norma Cammaratta, Office of Research and Technology Applications, Army Research Laboratory, AMSRL-CS-TT, 2800 Powder Mill Rd., Adelphi, MD 20783-1197; (301) 394-2952; fax: (301) 394-5818.*

Optical Power Supply and Data Communication for APS Circuits

etb POWER SOURCES

There would be no electrical connections with external circuits.

NASA's Jet Propulsion Laboratory, Pasadena, California

Active-pixel-sensor (APS) circuits and perhaps other dense complementary metal oxide/semiconductor (CMOS) very-large-scale integrated (VLSI) circuits would be powered by infrared beams transmitted by laser diodes and received by photodetectors, according to a proposal. Clock signals for synchronizing the operations of such a circuit would be transmitted as modulation on the infrared power-supply beam. Command data signals could be received via other, low-power infrared beams. Digital APS output signals would likewise be sent to external circuits via modulation of infrared beams transmitted by low-power laser diodes incorporated into the VLSI APS chips.

The power-supply part of the proposal has been made feasible by advances that have reduced the power demands of CMOS VLSI circuits. The power demand of a typical CMOS VLSI APS chip is now low enough that a single, sufficiently illuminated infrared photodetector could serve as the source of a galvanically isolated power supply on the chip. With a sufficiently high duty factor, the clock modulation on the infrared power-supply beam should exert little effect on power-coupling efficiency.

The data-communication part of the proposal has been made feasible by the evolution of sensitive infrared detectors and low-power, frequency-tunable laser diodes. The infrared beams for input and output of data would have wavelengths different from that of the power-input beam. By use of tuned laser diodes in the transmitters and narrow-band dielectric filters in the receivers, it would be possible to communicate simultaneously over multiple infrared bands; thus, it would be possible to use a wavelength-multiplexing scheme to achieve a high data rate.

Multiple CMOS VLSI APS chips could be operated under common control and readout by use of a combination of wavelength and time multiplexing. The multiplexing scheme could be simplified, at the cost of some increase in structural complexity, by using a dedicated optical fiber for data communication between

each APS and the common readout and control circuitry.

As APS and other VLSI circuits become denser and more complex, design problems pertaining to reliability of, and power dissipation in, electrical interconnections, become increasingly difficult. The problems are further intensified in cases in which VLSI circuits are required to be connected together in many-to-one networks. In general, the complexity of, and power dissipation in, electrical interconnections increase approximately exponentially with the number of nodes, while reliability decreases approximately exponentially with the number of nodes. The use of all-optical input and output connections according to the proposal described above could reduce overall complexity and increase reliability. In particular, if full-duplex communication with frequency multiplexing of data signals were used, then the complexity of a network with all optical interconnections would increase only linearly with the number of nodes.

This work was done by Frank Hartley and Bedabrata Pain of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category. NPO-20438*

Interdigital Overlay Capacitors for Integrated Circuits

A given amount of capacitance can be accommodated on less chip area.

etb PASSIVE COMPONENTS

NASA's Jet Propulsion Laboratory, Pasadena, California

Interdigital overlay capacitors have been invented to decrease the amount of integrated-circuit chip area needed to accommodate a given amount of capacitance. In most very-large-scale integrated (VLSI) circuits and monolithic microwave integrated circuits (MMIC), the integrated capacitors are the largest circuit elements. By making it possible to fit the capacitors within smaller chip areas, this invention offers the potential to reduce the overall chip sizes, increase

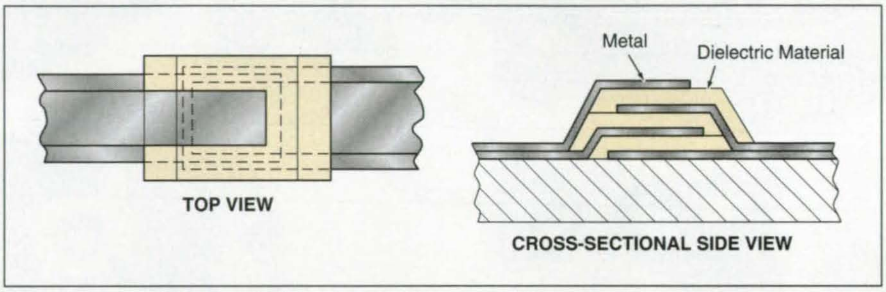


Figure 1. **Layers of Metal and Dielectric Material** are stacked in alternation, and the metal electrodes are connected alternately to two terminals to form a multilayer capacitor.

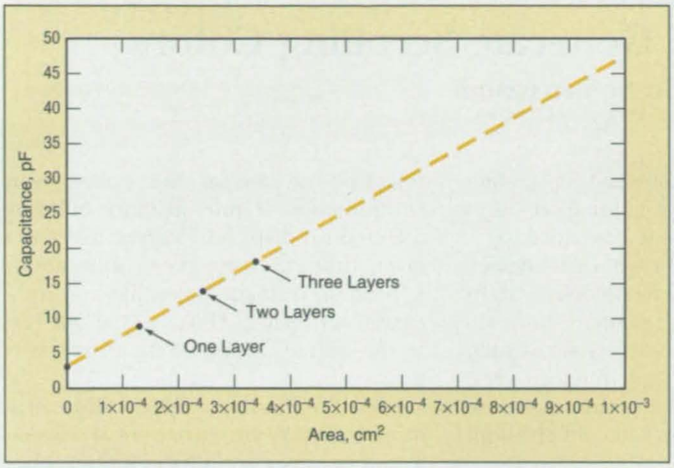


Figure 2. **Measurements of Capacitance (*C*) vs. Overlapping Electrode Area (*A*)** have been fitted with a straight line represented by the equation $C = 4.4 \times 10^4 A + 3.35$. The 3.35 pF is a fringing capacitance.

the numbers of circuit elements that can be accommodated on given chip areas, and/or satisfy increasingly stringent design constraints on the dimensions of circuit elements.

An interdigital overlay capacitor is a multilayer parallel-plate capacitor with thin layers of dielectric material between the electrodes. It is so named because its electrodes appear interdigitated in a cross-sectional view (see Figure 1) and because its layers are stacked or overlaid on an integrated-circuit chip. The chip area occupied by an interdigital overlay capacitor is the same as that of a conventional dielectric-overlay capacitor, which contains only one dielectric layer and thus has less capacitance.

Prototype interdigitated overlay capacitors have been made by use of established integrated-circuit fabrication techniques: The metal electrode layers were made by evaporative deposition of Ti sublayers to a thickness of 300 Å and Au sublayers to a thickness of 2,000 Å. The dielectric layers were made by deposition of a nitride material deposited from a room-temperature electron-cyclotron-resonance plasma, with patterning by a lift-off photolithographic process. The relative permittivity of the dielectric layers was ≈6, and the thickness of each dielectric layer was about 1,200 Å. To provide a taper needed to ensure a high yield of the fabrication process, each metal layer in a stack was recessed from the one below it by a margin of 5 µm.

Figure 2 is a plot of measured capacitances of prototype one-, two-, and three-layer interdigitated overlay capacitors versus overlapping electrode area. These measurements show that the capacitance was doubled from 9 pF (for one layer) to 18 pF (for three layers) without increasing the capacitor base area.

This work was done by Trong-Huang Lee, Jeff Hong, and Imran Mehdi of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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Refer to NPO-20383, volume and number of this NASA Tech Briefs *issue, and the page number.*

Using Surface-Plasmon Filters To Generate Scrolling Colors

Efficiencies of liquid-crystal display devices would be increased.

NASA's Jet Propulsion Laboratory, Pasadena, California

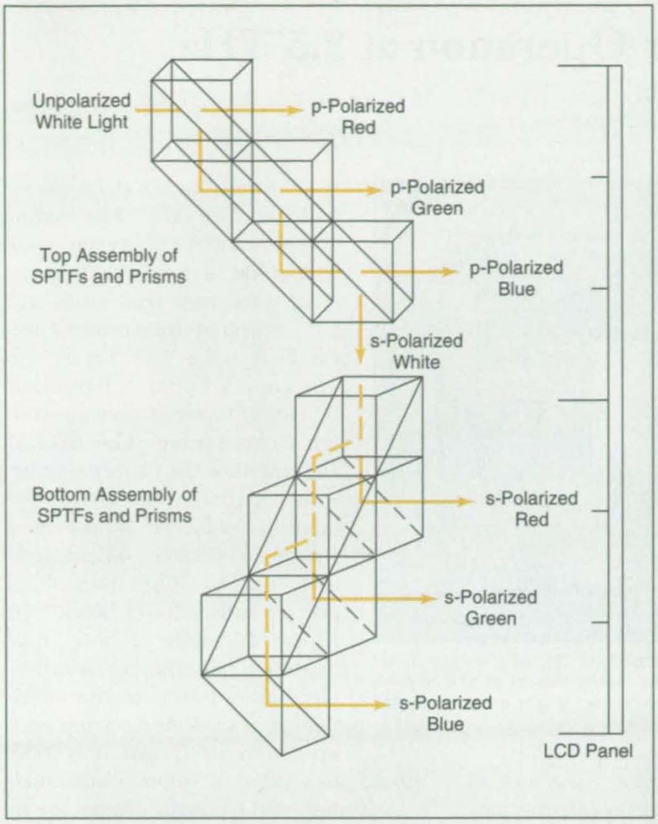
Surface-plasmon tunable filters (SPTFs) have been proposed for use in generating scrolling colors on the faces of liquid-crystal display (LCD) devices. In comparison with a conventional color LCD device equipped with primary-color filters, a LCD device equipped with SPTFs according to the proposal would utilize a greater proportion of the available luminous flux, generating a display about six times as bright, eliminate the in-pixel dye color filters, and cut number of pixels to one third.

A conventional color LCD device operates with linearly polarized light and is equipped with primary-color filters, there being a complete set of such filters (red, green, and blue) in each pixel. Therefore half the available white illumination is rejected through rejection of one of the polarization components. If one primary color is selected for display in a given pixel at a given time, then no more than about 1/3 of the remaining available illumination is utilized. Thus, only about 1/6 of the initially available illumination is utilized.

According to the proposal, white illumination for an entire LCD device would be processed through assemblies of SPTFs and prisms. The SPTFs would serve as polarization-sensitive band-pass filters to generate the primary colors, while the prisms would serve as total internal reflectors to change the direction of the light.

Incident unpolarized white light would enter the top assembly which contains three SPTFs. It would allow only p-polarized light to generate scrolling RGB (red, green, blue) colors and would reflect the remainder of the incident light downward to the bottom of the assembly. For example, the very top SPTF would allow red-color pass-through only; the downward-reflected remainder of the incident light would be totally internally reflected toward the middle SPTF of the top assembly, which would only pass p-polarized green light. In a similar manner, the bottom SPTF of the top assembly would be made to pass only the p-polarized blue light and reflect the remaining light downward. At this point, the remaining downward-reflected light would comprise the s-polarized portion of the incident white light.

Using scrolling color, the frame should change three times faster, *i.e.*, a 180-Hz frame rate is needed. For example, at the first 1/3 of the 1/60 second, the image on a black-and-white LCD screen would look like this : the sixth and the third sections are red, the fifth and the second sections are green, and the fourth and the first sections are blue. At the next moment, the second 1/3 of the 1/60 second, the colors scrolling downward, the image on the black-and-white LCD screen would look like this: the sixth and the third sections are blue, the fifth and the second sections are red, and the fourth and the first sections are green. At the last 1/3 of the 1/60 second, the image on the black-and-white LCD screen would look like this: the sixth and the third sections are green, the fifth and the second sections are blue, and the fourth



All Three Primary-Color and Both Polarization Components of the incident unpolarized white light would be utilized in this scheme. In contrast, a conventional color LCD device wastes about 5/6 of incident unpolarized light because it rejects one polarization component and two of the three color components.

and the first sections are red. Therefore, one sees a full color image at 60 Hz.

The bottom assembly would function similarly to the top assembly, except that it would be configured to receive the remaining downward-reflected light, and its SPTFs would be made perpendicular to those of the top assembly so as to exploit the s polarization of this light. Unlike in a conventional color LCD, the two assemblies would utilize both polarization components and all three color components of the white illumination. Thus, the display would be about 6 times as bright as is a conventional LCD.

During each third of a frame period, the voltage applied to each SPTF could be changed so as to change its pass wavelength band to that of a different primary color. The temporal sequence of voltages applied to the six SPTFs could be chosen to make the colors on the corresponding six subdivisions of the display area scroll downward or upward.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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GaAs-Membrane-Diode Mixer for Operation at 2.5 THz

The design is readily scalable to other frequencies.

NASA's Jet Propulsion Laboratory, Pasadena, California

etb SEMICONDUCTORS

A prototype mixer designed for operation at input frequencies near 2.5 THz incorporates a planar Schottky-barrier diode and a radio-frequency (RF) filter that are parts of an integrated circuit on a GaAs membrane strip, plus several other unique features for which there are numerous potential applications. This mixer is intended to provide a less expensive, more reliable alternative to older whisker-contact-diode mixers. The components of the mixer are integrated into a robust package with an overall volume <1 in.^{3} (<16 cm^3). The design can readily be scaled to higher and lower frequencies.

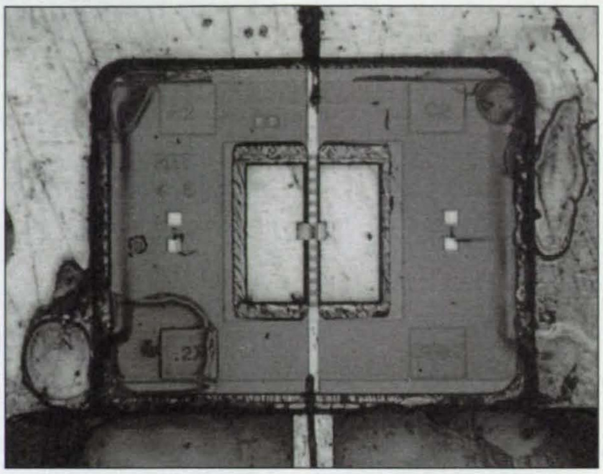

Figure 1. **Integrated Circuitry** is formed on top of the monolithic GaAs structure. The planar Schottky diode, shown at the highest magnification, includes an air-bridge contact finger and stress-relief air bridges at both ends.

The GaAs structure is monolithic and is patterned to form circuit elements by use of photolithographic techniques. The GaAs structure includes the membrane strip suspended over a rectangular hole in a rectangular frame (see Figure 1). The membrane strip serves as part of a low-loss transmission line and RF-coupling structure as well as a support and as an integral part of the diode and other circuit elements. The strip is 3 µm thick by 40 µm wide by 600 µm long; other dimensions could be chosen according to the intended operating frequency and requirement for mechanical rigidity. Beam leads for electrical contact with external circuitry are formed on the GaAs structure.

The GaAs structure is glued into a copper button with a diameter of 0.175 in. (4.4 mm) and a thickness of 0.075 in. (1.9 mm). The button contains a 2.5-THz rectangular waveguide, a rectangular-to-circular waveguide transition, and an integrated dual-mode conical feed horn (see Figure 2.) The copper button is fabricated by electroforming plus conventional machining. The desired alignment of the GaAs structure with respect to other circuit elements is enforced by use of a reference surface milled into the button. The button is pressed into a larger block (see Figure 2), made of brass, that holds a fixed (but replaceable) waveguide tuner section containing a backshort, a separate intermediate-frequency (IF) quartz suspended stripline impedance transformer, and a coaxial connector to couple with such external circuitry as an IF amplifier or a splitter.

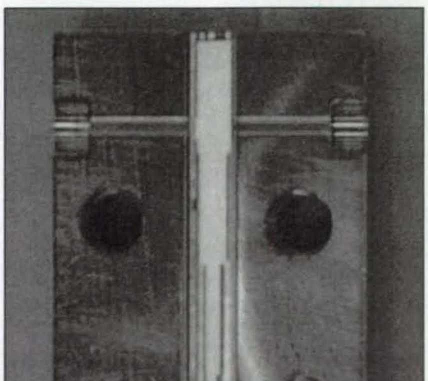

Figure 2. The **Mixer Is Packaged** in two half blocks of brass. Shown here is the lower half block containing the button and the transformer.

In operation, the local oscillator and the RF signal of interest enter the mixer via the feed horn. The input signals are combined at the diode and the beat-frequency output signal (that is, the IF signal) is removed via the RF filter on the membrane, the quartz impedance transformer, and the coaxial connector. There is no tuning during operation except what can be achieved by adjustment of the dc bias on the diode. The optimal backshort setting is determined in a trial-and-error procedure in which the mixer is operated with tuner sections of various waveguide lengths inserted in the block.

This work was done by Peter H. Siegel, R. Peter Smith, Suzanne Martin, Peter Bruneau, and Michael Gaidis of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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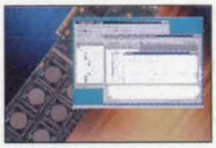
NEW PRODUCTS

PRODUCT OF THE MONTH

Ten-Bit A/D Converter

National Semiconductor Corp., Santa Clara, CA, introduces the ADC10321, an analog-to-digital converter (ADC) with 10-bit resolution, high speed of 20 MSPS, and single-supply operation. National says the device improves image quality in most digital video applications, with high linearity (DNL) of 0.3 LSB and exceptional dynamic performance of 9.2 effective number of bits at Nyquist sampling rates. The ADC10321 is suitable for battery-operated portable equipment because of its low power consumption of 100 mW typical from a single 5-V supply. The device uses error correction to maintain accuracy and performance over the industrial temperature range of -40 to 85 °C. Output formatting is straight binary coding with interface to either 3-V or 5-V logic.

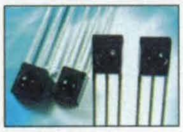
For More Information Circle No. 771



Software for SHARC-Based DSPs

Blue Wave Systems, Carrollton, TX, announces that it has bundled Analog Devices' new VisualDSP development tools with its own IDE6000 development environment. Blue Wave says that this will constitute the industry's most powerful integrated software development environment for SHARC-based digital signal processing (DSP) systems. The company says the new VisualDSP toolkit has three main parts: a much improved C compiler tool chain, a simulator, and a project manager. The compiler allows the user to include assembly language statements in-line, so he can program in C and still use assembly for time-critical loops.

For More Information Circle No. 772



Remote Control Receiver Module

Vishay Telefunken Optoelectronics, Malvern, PA, releases the TSOP28XX, a small photomodule for pulse-code-modulation (PCM) IR remote control systems with the photodetector and preamplifier in one package. Available with seven different carrier frequencies (30 kHz-56 kHz), it provides enhanced immunity against interfering light sources by applying an AGC preamplifier and internal metal shielding. The device's sensitivity is up to 30 m in dark ambient, and this can be improved with Vishay's TSAL62XX IR emitter family.

For More Information Circle No. 776

Reduced-Footprint Programmable Filters

The 424 and 428 series of 4-bit digitally programmable 4- and 8-pole filters from Frequency Devices, Haverhill, MA, use surface-mount technology to duplicate specifications of the 824 and 828 products, which provide -100-dB attenuation, noise and distortion floors sufficient for 16-bit A/Ds, and a package that occupies 60 percent less board space. The 0.08" × 1.8" (2.03 × 4.57 cm) package with a 28-pin DIP footprint make these the smallest off-the-shelf analog-programmable filters available, according to the company.

For More Information Circle No. 777

Matrix Tray Feeders

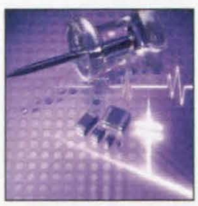
Envision Technologies, Palm Bay, FL, says that its feeder systems are designed to interface easily with a wide range of placement platforms and other host systems for micro-BGA, flip chip, and bare die. Utilizing an embedded control board, each feeder can provide real-time status information, including tray in position, fault detection, low materials, and output full signals to the host platform. Two standard versions accommodate either 2 × 2" or 4 × 4" matrix trays in regular or inverted format. Tray replenishment is less than 4 seconds, and tray positional accuracy when presented to the host is less than 0.005".

For More Information Circle No. 774

Wafer Flatness Inspection System

Veeco Metrology Group, Tucson, AZ, is offering the WYKO® SFT4500™ wafer substrate flatness inspection system, which it calls the first noncontact tool to improve process characterization of thin-film head wafer substrates by providing single- or double-sided measurement of global and site flatness across 4.5"-square wafer substrates. Based on Fizeau plano interferometry and operating at wavelengths of 633 nm or 1.06 microns, the system is gauge-capable for peak-to-valley tolerances as low as 2 microns. The fully automated instrument determines flatness such as Rz, Rt, slope, and radius of curvature in a single measurement.

For More Information Circle No. 778



Nickel-Based Ceramic Capacitors

Taiyo Yuden, San Jose, CA, calls its CE series of nickel-based high-capacitance multilayer ceramic chips (MLCCs) a lower-cost higher-capacitance chip than aluminum electrolytic and tantalum capacitors. The company says the MLCCs have a lower equivalent series resistance (ESR), no polarity for more efficient mounting, and a smaller case size and lower profile than those varieties. Available from 0.1 μF to 100 μF, the MLCC has lower power loss and heat generation because of the lower ESR, and its impedance is lower at higher frequencies than the alternatives named above.

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Embedded Machine Vision System

The MVS-8200 series from Cognex, Natick, MA, sets a new performance standard for dedicated machine vision processing while representing the most comprehensive line of embedded vision systems currently available, according to the company. Each MVS-8200 is equipped with a 200-MHz on-board Intel MMX processor. Users can run Cognex's vision software tools, including PatMax for high-accuracy part location and inspection, directly on board at speeds Cognex says are up to 15 times faster than previous embedded systems, and can choose PCI, CompactPCI, or VME form factors.

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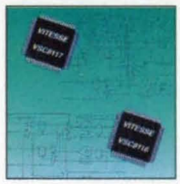

Transceivers for ATM and SONET/SDH

The VSC8116 and VSC8117 PHY transceivers from Vitesse Semiconductor Corp., Camarillo, CA, have 8-bit serial-to-parallel and parallel-to-serial data conversion. They are ANSI, Bellcore, and ITU-T compliant physical layer devices that provide designers with ICs that are fully compatible with today's leading User Network Interface (UNI) ICs. The VSC8117 integrates an on-chip clock multiplication unit (CMU) selectable for 622 Mb/s or 155 Mb/s operation for high-speed clock generation and a clock and data recovery unit. The VSC8116 delivers the same functions as the VSC8117 without the on-chip CRU and costs less.

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Silicon-on-Sapphire Pressure Transducers

The KA21 series pressure transducer from Patriot Sensors & Controls Corp., Simi Valley, CA, features the company's silicon-on-sapphire pressure sensor paired with a resistance temperature detector (RTD), to provide system temperature information in addition to the standard pressure sensor output. Available in gauge, absolute, or sealed versions, the KA21 series is offered with a variety of pressure ports and electrical connector outputs, and monitors pressure ranging from 25 to 30,000 psi. Accuracy is ±0.1 percent, and the unit's all-titanium construction yields a weight of just 5 oz. maximum.

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Vol. 23, No. 2 February 1999 This form expires: May 31, 1999

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Software Validates Space Station "Lifeboat"

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Engineers at NASA's Johnson Space Center in Houston, TX, are performing research, manufacturing, and testing for the X-38 Project, a series of four prototype Crew Return Vehicles (CRVs) for the International Space Station. The final CRV prototype will be a small shuttle attached to the Space Station that will serve as a "lifeboat" for the station crew to return to Earth in case of emergencies, and may also carry cargo or people back and forth to the Space Station.

Engineers at NASA apply LabVIEW graphical instrumentation software in the research, testing, and manufacturing of the Crew Return Vehicle, a small shuttle that will be attached to the International Space Station.

The first of the X-38 Project prototypes, Vehicle 131 (V131) is a scaled-down version of the shell of the CRV designed to test the flight parameters, which are recorded and analyzed. During testing, V131 is attached under the wing of a B-52 aircraft and flown to approximately 50,000 feet. An engineer in the B-52 uses LabVIEW software to listen and communicate with the V131 via a laptop and Ethernet connection. After the V131 separates from the B-52 and begins to descend, engineers in the X-38 control rooms use LabVIEW to monitor the vehicle's status.

V131, V132, V133, and the final prototype, V201, continue to undergo testing. The testing of the final prototype is expected to take place in 2000, when it will be released from the Shuttle Orbiter. It will orbit Earth a few times, enter the atmosphere, and land.

Created with LabVIEW, the Portable Diagnostic Terminal (PDT) is the software that monitors vehicle health onboard the prototypes. Engineers use the PDT, running on IBM Thinkpads, as their interface into the vehicle and testbeds. The PDT is connected directly into the prototypes' patch panels, where engineers can test software and hardware systems in the vehicles.

"The LabVIEW application gives us insight into the status of the vehicle systems," said Frank Delgado, software engineer at the Automation Robotics & Simulations Division of Johnson Space Center, and lead engineer for the PDT. "It gives us commanding capability over many different control devices and allows us to determine if we are 'go' or 'no go' for final vehicle separation from the B-52 during flight testing."

As the prototypes evolve into more sophisticated spacecraft, the PDT will develop into another human-to-machine interface (HMI) that will be used on the flight deck of the Shuttle Orbiter. The Orbiter will deploy the prototype V201 from space. LabVIEW and BridgeVIEW, a version of LabVIEW used in industrial automation environments, will be used in portable devices derived from the PDT and in the control centers to support the final prototype and the CRV craft.

The X-38 control rooms in Houston and at NASA's Dryden Flight Research Center in California use LabVIEW in the ground system communications and monitoring devices for the prototypes. LabVIEW or BridgeVIEW is expected to monitor the final "lifeboat." Both control centers include a network of computers, specialized servers, and display machines, all programmed with LabVIEW.

"This is the first human-rated vehicle that we've built at NASA in well over 25 years," said Mike Stagnaro, systems engineer in the Avionic Systems Division at Johnson, and head of the X-38 ground systems and LabVIEW programming. "We're doing the bulk of the work in-house with our own engineers and technicians. This is the kind of operation that gets the agency back to its R&D roots, while addressing the very real issues of lowering costs and accelerating delivery schedules."

According to Brian Anderson, NASA's X-38 project manager, "We can train our co-ops [interns] to use the [LabVIEW] program in just a couple of weeks. They and our programmers were able to write interface and test code in a fraction of the time it would have taken us to write it in C++ or another language. Saving time means saving a lot of money."

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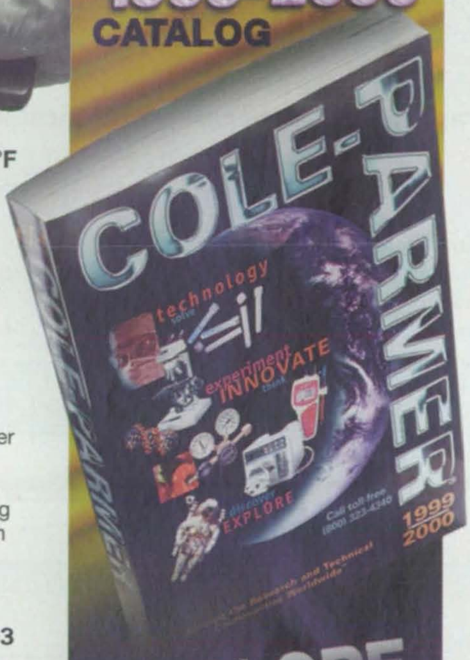

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A Technique for Axial/Torsional Thermomechanical Fatigue Testing

Test conditions can be selected to approximate thermomechanical-loading conditions in engines.

Lewis Research Center, Cleveland, Ohio

A technique for thermomechanical fatigue testing of thin-walled tubular specimens involves the application of cyclic axial (tension/compression) and torsional (shear) strains, along with thermal cycling. In this technique, the phase relationships among the two strain waveforms and the temperature waveform are prescribed and are maintained constant throughout a test.

Heretofore, axial/torsional fatigue testing has commonly been limited to

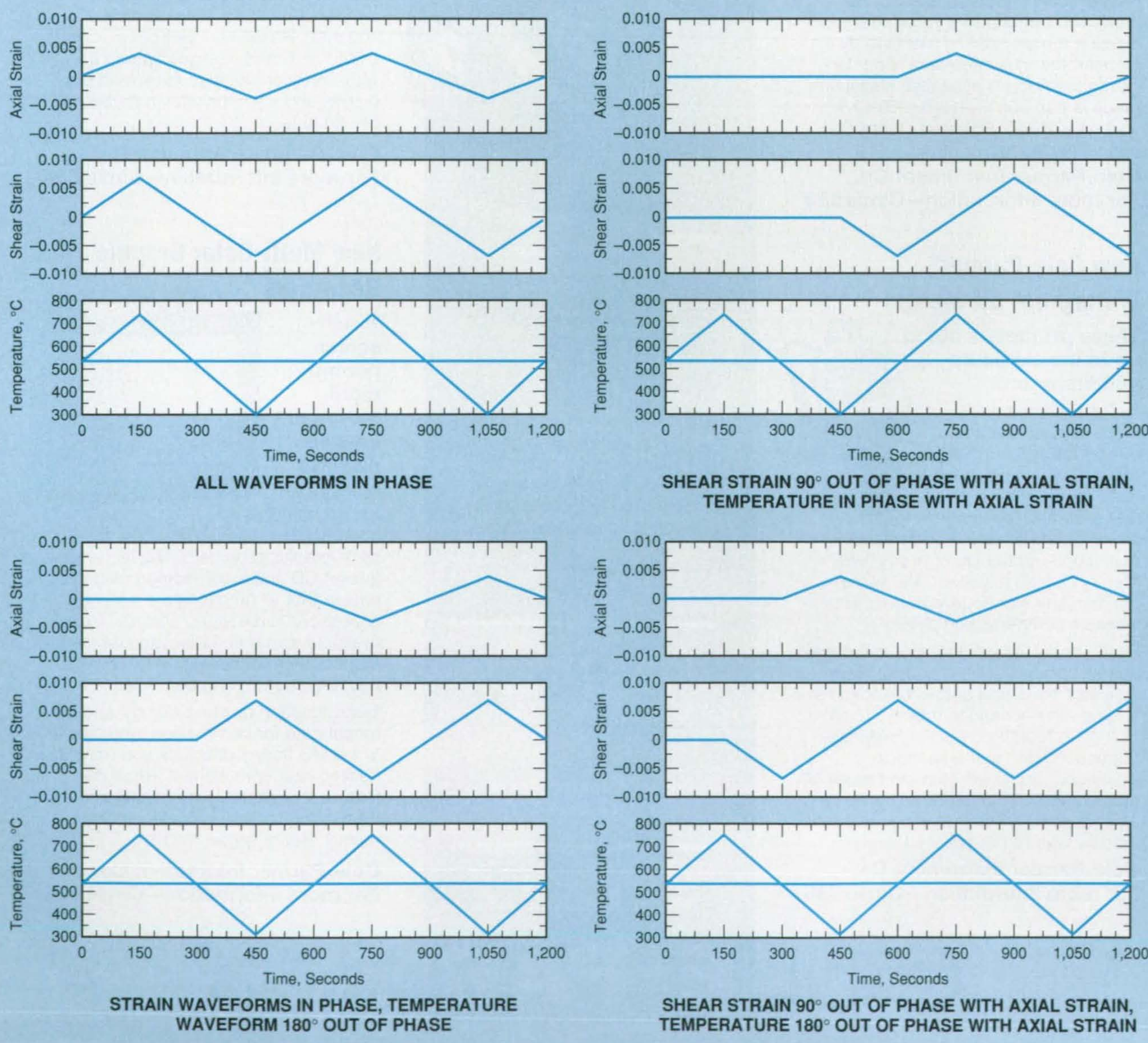


Figure 1. **Axial Strain, Shear Strain, and Temperature** are cycled with prescribed phase relationships.

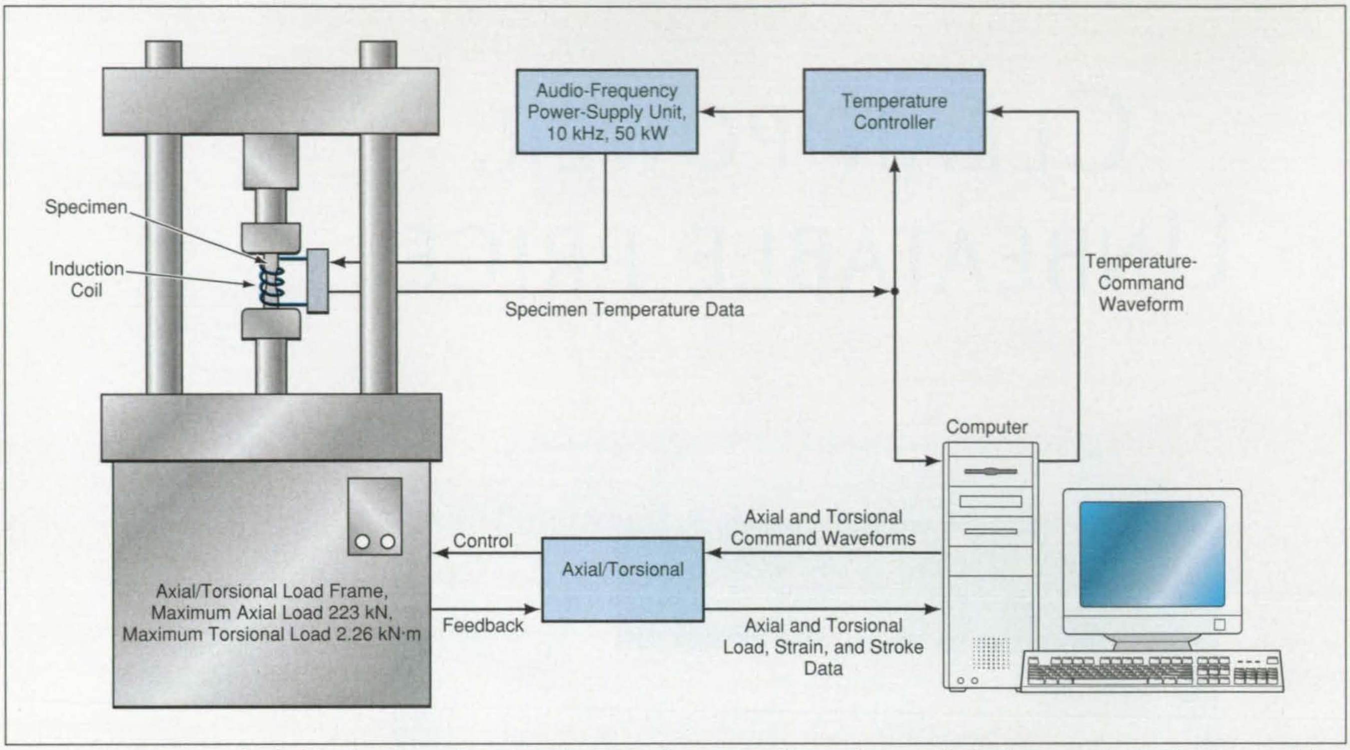


Figure 2. This **Thermomechanical-Testing Apparatus** was used to test tubular superalloy specimens with the thermomechanical loading conditions depicted in Figure 1.

isothermal conditions, while thermomechanical fatigue testing has commonly been limited to axial (only) or torsional (only) strain. The present technique for axial/torsional thermomechanical fatigue (AT-TMF) testing makes it possible to acquire materials data on effects of time-varying thermal and multiaxial mechanical loads similar to those experienced by tubular components of engines during cyclic and/or transient operation. The data can be used, along with mathematical models of thermomechanical behavior, to predict the deformations and fatigue lives of such components.

In principle, one could choose among an infinite number of combinations of mechanical-strain and temperature waveforms; in practice, one must limit to the choice to a representative few. Four different combinations of triangular waveforms were chosen for the present AT-TMF testing technique. The waveforms in these combinations are required to be synchronized, variously, with 0°, 90°, and/or 180° phase differences. Figure 1 presents examples of the four combinations of waveforms. The cycle time and the temperature and strain limits in these examples are specific to tubular specimens (22 mm inner diameter, 26 mm outer diameter) of a cobalt-based superalloy; other limits and cycle times could be chosen to suit different specimens.

Figure 2 schematically depicts the apparatus that was used to implement the present AT-TMF testing technique on the specimens mentioned above. An axial/torsional load frame was controlled with two servocontrollers: one for the axial and one for the torsional actuator. The axial and shear strains were measured by a commercially available, water-cooled, axial/torsional extensometer. The specimen was heated by use of induction coils connected to a controllable audio-frequency power-supply unit rated at 50 kW.

The axial and torsional strains and temperature were controlled and test data were acquired by a computer system (equipped with digital-to-analog and analog-to-digital converters) connected to the servocontrollers, a temperature controller, and temperature sensors. The computer generated command waveforms that corresponded to the specified axial-strain, torsional-strain, and temperature waveforms. For each of 1,000 points during a test cycle, the computer acquired data on axial and torsional loads, strains, and strokes and on temperatures at five locations on the specimen. The computer operated with a C-language program that provided a keyboard interruption capability plus a graphical display of axial and shear stresses versus time, temperatures, and test status.

This work was done by Sreeramesh Kalluri and Christopher S. Burke of NYMA, Inc., and Peter J. Bonacuse of the Vehicle Propulsion Directorate of the U. S. Army Research Laboratory for **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16663.

FT-IR Measurement of Hydraulic Fluids in Perchloroethylene

Very low concentrations can be measured to verify cleanliness of hardware.

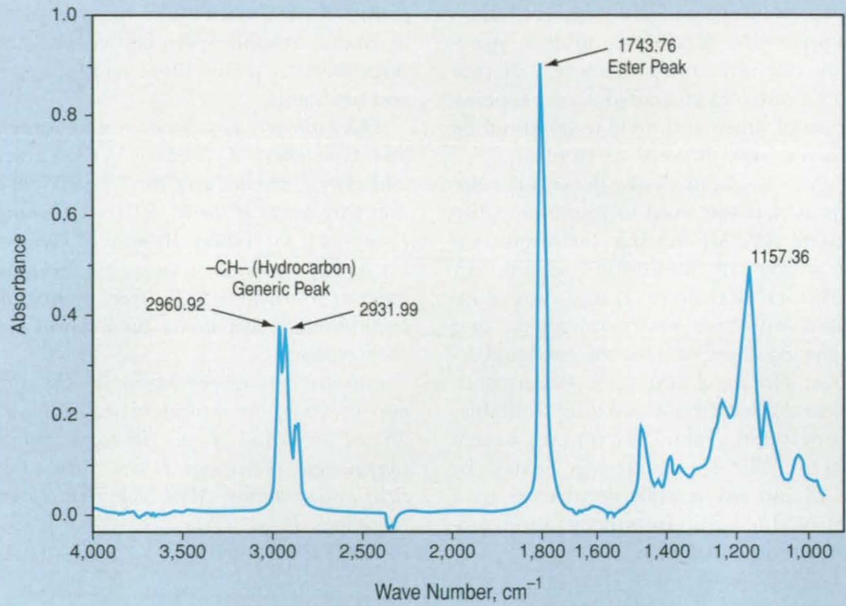
John F. Kennedy Space Center, Florida

An improved solvent-extraction/infrared-analysis technique has been devised to replace an older technique for measuring very small concentrations of nonvolatile residues of industrial hydraulic fluids, oils, and greases on hardware that is required to be cleansed of such residues. The older technique involves solvent extraction of nonvolatile residues followed by gravimetric determination of the quantity of dissolved residues.

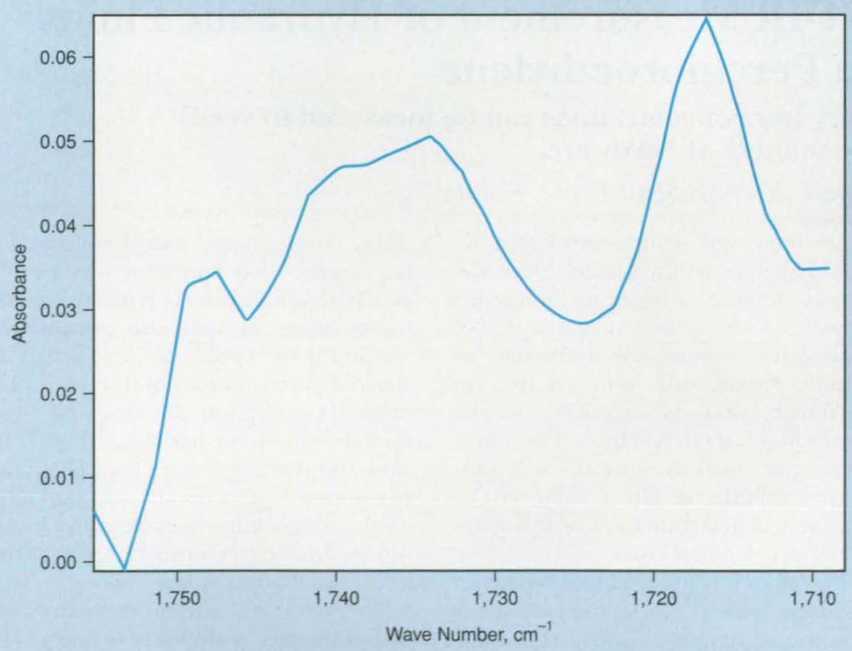
The older technique entails two major disadvantages: The first disadvantage is that the solvent is 1,1,2-trichloro-1,2,2-trifluoroethane (also known by the trade name "Freon 113"). This and other chlorofluorocarbons have been found to contribute to depletion of ozone in the upper atmosphere, and therefore the law requires that they be phased out of production and use. The second major disadvantage is that the gravimetric method is susceptible to large errors at the low concentrations of interest in the original application. In terms of areal mass density on the hardware, these concentrations are typically a few milligrams per square foot ($1\ mg/ft^2 \approx 11\ mg/m^3$); in terms of volume mass densities in solution, these concentrations are typically a few milligrams per liter.

The improved solvent-extraction/infrared-analysis technique features (1) the use of a less-harmful solvent and of (2) Fourier-transform infrared (FT-IR) analysis of an infrared spectral peak specific to the dissolved residues that one seeks to detect. The solvent in this technique is perchloroethylene; in comparison with 1,1,2-trichloro-1,2,2-trifluoroethane, perchloroethylene is relatively environmentally benign and nontoxic. Perchloroethylene is also less volatile; it boils at a temperature of 121 °C, whereas 1,1,2-trichloro-1,2,2-trifluoroethane boils at 48 °C.

The spectral peak in question is one attributable to ester C=O groups conjugated with C=C groups or aromatic rings in organic molecules. This ester peak is suitable because even at relatively low spectral resolution, it stands out from other spectral peaks attributable to C–H bonds (see upper part of figure) and because the residues of interest contain such ester C=O groups. With higher spectral resolution, the ester peak of a typical residue of interest dissolved in perchloroethylene can be seen to be split into two peaks: one at wave numbers from ~1,753 to ~1,724 cm^{-1} and one at wave numbers from ~1,724 to ~1,708 cm^{-1} (see lower part of figure). The splitting has been conjectured to be caused by interactions be-



INFRARED SPECTRUM OF A TYPICAL ESTER-BASED INDUSTRIAL HYDRAULIC FLUID IN PERCHLOROETHYLENE



SPLITTING OF ESTER PEAK OF A MIXTURE OF HYDRAULIC FLUIDS DISSOLVED IN PERCHLOROETHYLENE AT A CONCENTRATION OF 19.9 mg/L

The **Infrared Absorbance Spectrum** of a perchloroethylene solution can be analyzed to find a peak characteristic of C=O ester groups in small amounts of greasy and oily residues dissolved in the solution.

tween the residue and perchloroethylene molecules.

The technique has been tested in experiments on solutions of various industrial hydraulic fluids dissolved in perchloroethylene at known concentrations. The solutions were analyzed on an apparatus that comprised a standard high-intensity infrared source, a Fourier-transform infrared (FT-IR) spectrometer containing a Michelson interferometer, and an HgCdTe photodetector cooled by liquid nitrogen. The output of the spectrometer was digitized and processed by a spectral-analysis computer program. The results of the experiments were interpreted as signifying that the ester spectral peaks can indicate the presence of the residues of interest at the low concentrations of interest, and that at areal concentrations as low as ~1 to ~5 mg/ft² (~11 to ~54 mg/m²), the areas under the two ester spectral peaks are indicative of the concentrations within a factor of 2.

This work was done by Narinder K. Mehta of the University of Puerto Rico for **Kennedy Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category. KSC-11945*

Pressurization and Leak Testing of Sample-Return Canisters

Sealed canisters would be pressurized with a radioactive gas.

NASA's Jet Propulsion Laboratory, Pasadena, California

A technique that involves pressurization with a radioactive gas has been proposed to solve two problems associated with canisters used to transport samples from remote bodies (planets, moons, asteroids, or comets) back to Earth. The canisters must be sealed at the sampling locations. The problems are how to test the canisters for leakage during transit and how to prevent buckling of the containers from the onset of atmospheric pressure upon return to Earth. The solution to these problems could also be adapted to use on Earth to ensure the integrity of canisters used to store material specimens for long times and to prevent the collapse of sealed canisters that must be brought to or stored at pressures higher than those at which the samples are sealed inside.

According to the proposal, a small container of radioactive krypton (mixed with another suitable pure gas or mixture of gases) would be placed in each sample canister. The container of gas would be equipped with means to release the gas into the interior of the canister soon after the canister is hermetically sealed with the sample inside. A Geiger counter or other radioactivity sensor near the canister would provide an indication of the leakage (if any) of radioactive gas from the canister. The amount of gas provided must be large enough so that the pressure in the canister is sufficient to resist buckling of the canister under ambient atmospheric pressure.

This work was done by Joseph C. Lewis of Caltech for **NASA's Jet Propulsion Laboratory**. *No further documentation is available. NPO-20446*

Passive Optical Measurement of Velocity in a Luminous Flow

Neither seeding nor illumination of the flow is necessary.

Lewis Research Center, Cleveland, Ohio

A segmented-image emission velocimeter (SIEVE) is an optical instrument for measuring the velocity of a luminous turbulent flow. More specifically, it measures a component of flow velocity perpendicular to its line of sight. This instrument is not only nonintrusive but is also passive in the sense that unlike other flow-measuring optical instruments, it does not seed the flow and does not illuminate the flow to obtain scattering of light from seed particles in the flow; instead, it utilizes broad-band light emitted by the flow. Flows amenable to SIEVE velocity measurement include flames and rocket exhaust plumes.

The operation of a SIEVE is based on a plasma-diagnostic technique developed in the 1970s. By use of a telescope and beam splitters, identical images of a small region in a luminous flow field are formed on two binary transmission gratings (see figure). The transparent and opaque strips in each grating are of equal width and oriented perpendicularly to the velocity component of interest. The strips in the two gratings are positioned 180° out of phase with each other along the velocity component; that is, each transparent strip of one grating coincides, in the image, with an opaque strip of the other grating. Light that strikes the transparent strips of each grating is focused onto an avalanche photodiode behind the grating.

Small inhomogeneities in the luminosity of the flow (typically associated with turbulence and/or with glowing soot particles) give rise to corresponding inhomogeneities in the patterns of light moving across the gratings. As a result, the output of each photodetector fluctuates. The outputs of the two photodiodes are amplified, then summed and differenced. Because of the complementarity of the gratings, the phase of the difference signal contains information on the motion of the light pattern across the gratings. Differencing also provides a high degree of common-mode rejection, making it possible to resolve small fluctuations in light emitted by the flow.

The sum and difference signals are digitized, then fast Fourier transformed to obtain a frequency (f) characteristic of the passage of the inhomogeneities across the gratings. Then the velocity component (v) of interest is calculated from $v = fD/M$, where D is the spatial period of a grating and M is the magnification of the image projected onto a grating.

The response and noise characteristics of a prototype SIEVE were measured in tests in which an inhomogeneous luminous flow field of known velocity was simulated by use of a back-lighted transparent rotating wheel with a pitted surface. The prototype SIEVE was then used to measure velocities in flames from an oxyacetylene torch. The results of the measurements appeared to confirm that SIEVEs could be used to determine local velocities in turbulent, luminous flows. Further tests are expected to clarify the limitations and capabilities of SIEVEs.

This work was done by S. J. Schneider of **Lewis Research Center** *and S. F. Fulghum and P. S. Rostler of Science Research Laboratory, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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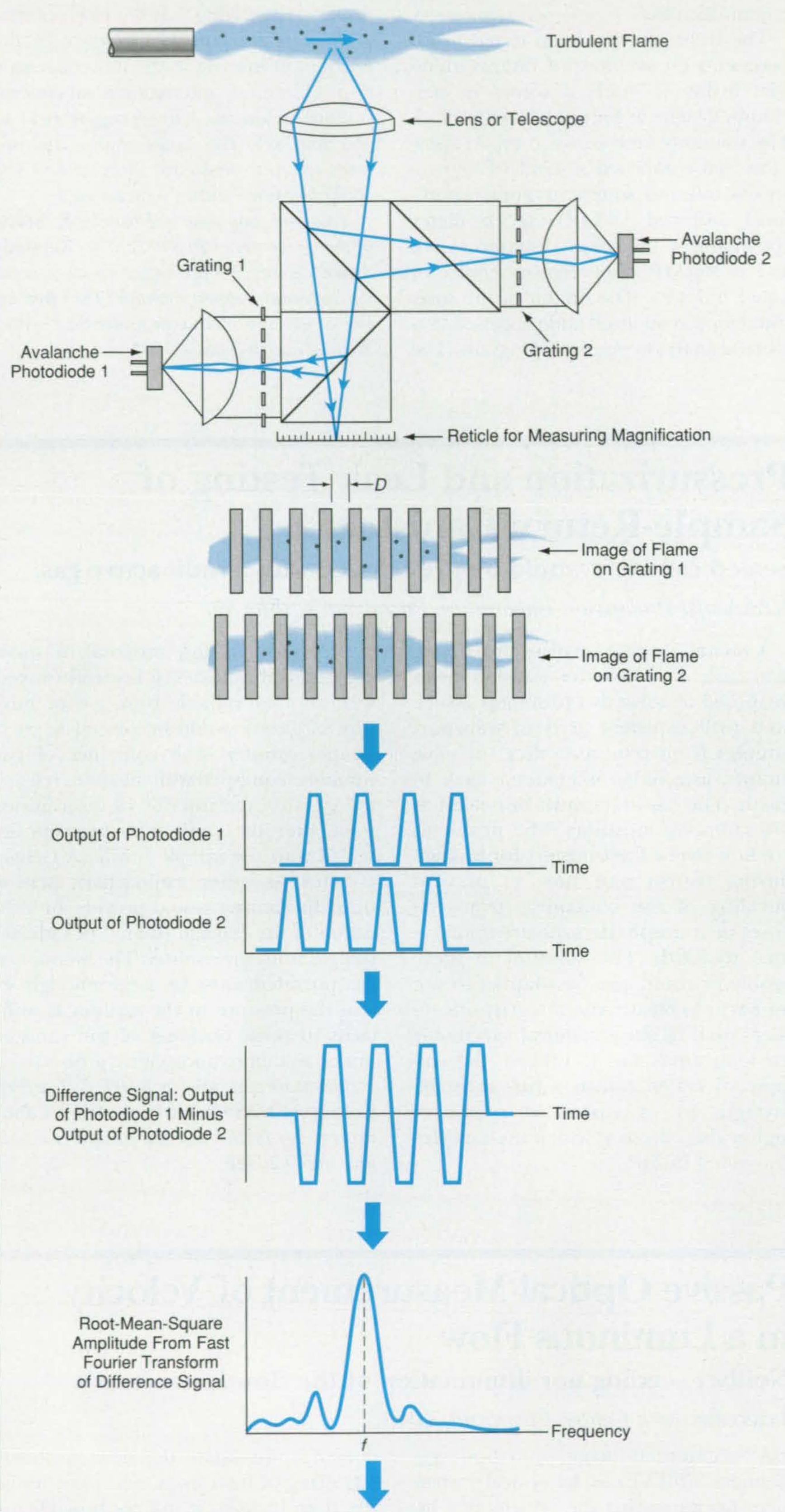


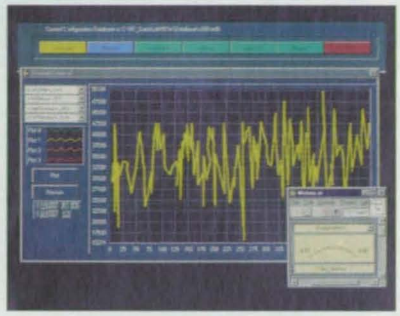
A **Quasi-periodic Signal Is Generated** from the difference between the outputs of the photodetectors behind the gratings. A fast Fourier transform of this signal yields a spectral peak, the frequency of which is proportional to the velocity component to be measured.

Special Coverage: Test & Measurement

Keithley Instruments, Cleveland, OH, has introduced the Model 6514 **electrometer** for use where high throughput and femptoamp resolution are required. Applications include measurement of light detector current, leakage on low-value capacitors, and high-resistance materials. Measurements can be made at speeds up to 1200 readings per second. IEEE-488 and RS-232 interfaces are included for remote PC control.

The instrument combines line cycle integration and a 60 dB normal mode rejection ratio to minimize noise errors. It can resolve a 10 femptoamp measurement out of a 2 nanoamp signal with 15 ms settling time. Other features include a current source for ohms measurements and active cancellation of voltage and current offsets.

For More Information Circle No. 722



DAQ Director™ **testing software** from Kinetic-Systems Corp., Lockport, IL, allows users to configure, calibrate, control, and run a VXI-based test without prior programming knowledge. The program includes a configuration database and can be used with fiber-optic VXI interconnect for local and remote testing. Operating under Windows NT, the software can manage and accelerate VXI-based tests.

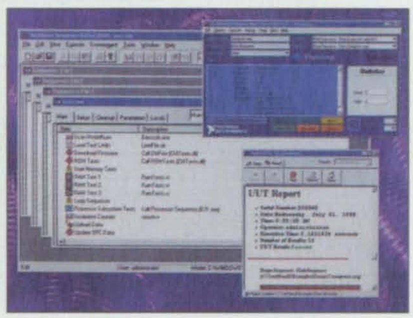
Question-and-answer menus are used to configure and calibrate the VXI hardware to be used; an unlimited number of configuration databases can be created. When acquiring data, users can view information in real time and record the data in continuous or transient mode. The software can be used to export test data to popular software packages such as LabVIEW®, MATLAB®, and SIMULINK®.

For More Information Circle No. 725

Hewlett-Packard, Palo Alto, CA, offers the HP E8751A and HP E8754A VXI-based **test systems**. The 8751A foundation system provides essential components needed for most functional-test applications; the 8754A high-power foundation system enables test-system developers to build complex functional-test systems.

The 8751A includes the HP E8401A VXI mainframe, HP E1406A command module, HP 82350A PCI IEEE-488 card, HP VEE 5.0 visual programming language, and factory-installation of most HP VXI modules. The 8754A also includes a high-power VXI mainframe, PCI IEEE-488 interface card, and visual programming language. Applications include I/O software installation, VXI and IEEE-488 instrumentation integration, and instrument communication and fixturing.

For More Information Circle No. 723



TestStand customizable **test management software** from National Instruments, Austin, TX, organizes, controls, and runs automated production test systems. The software provides advanced test sequencing, looping, branching, conditional execution, and control. Other features include a multithreaded test sequence execution engine and customizable components such as operator interface, reporting options, and test data storage.

The software is compatible with test development languages such as LabVIEW™, LabWindows™/CVI, C/C++, and Visual Basic. It provides connectivity for database logging and distributed test data viewing. The software can automatically generate local report files in ASCII or HTML formats for each unit under test.

For More Information Circle No. 724

Tektronix, Beaverton, OR, offers the U3661 **portable spectrum analyzer,** a 26.5-GHz instrument for field installation applications. The unit weighs 24 pounds with batteries and spans the frequency range of 9 kHz to 26.5 GHz in its standard configuration. The range encompasses PCS, cellular, and television baseband frequencies, as well as microwave frequencies.

The unit has a second-order harmonic distortion level of -100 dB or less. It operates for up to 1-1/2 hours on a fully charged battery. The battery pack is installed integrally with the instrument mainframe.

For More Information Circle No. 720

The Orion noncontact **vibration measurement system** from Nicolet Technologies, Madison, WI, offers a frequency range from 5 Hz to 80 kHz. An optical implementation enables the system to measure vibration at distances up to seven meters. The instrument can be mounted on a variety of surfaces. It mounts on any standard tripod or laser stand. A standard ±10V analog output enables the system to be used with any standard FFT analyzer or data acquisition system.

Applications include rotational vibration such as turbines or wheels where traditional sensor cabling is impractical; small or delicate structures such as tissue membranes; relative vibration measurements in moving structures; and repetitive vibration measurements.

For More Information Circle No. 721

Electronic Components and Circuits

Digital Approximation Premodulation Filter

This filter closely approximates the desired wave shape, regardless of the bit rate.

Dryden Flight Research Center, Edwards, California

A digital solution for the problem of filtering serial digital data prior to modulation of a telemetry transmitter has been developed by engineers at the Dryden Flight Research Center. The solution is described in a patent application entitled "DIGITAL APPROXIMATION PREMODULATION FILTER FOR PULSE-CODE-MODULATED SIGNALS."

When transmission of serial digital data for telemetry is required, care must be taken when modulating the transmitter to avoid any spurious radiated signals outside the assigned radio frequency band. A premodulation filter is used to eliminate undesired harmonics, thereby limiting the frequency bandwidth of the serial digital signal.

The use of a digital approximation (as distinguished from an analog) premodulation filter entails some degradation of the infinite output resolution of a traditional analog filter (see Figure 1), but this degradation should be tolerated in the interest of keeping out-of-band radiation below the maximum allowed by regulations.

The digital approximation premodulation (DAP) filter concept was tested in transmission of a pulse-code-modulation (PCM) system non-return-to-zero-level output via an L-band transmitter. Normally, 16 segments per bit are used, but in this test, the radiated frequency spectrum obtained when using the DAP filter with only 8 segments was essentially identical with that obtained when using an analog filter.

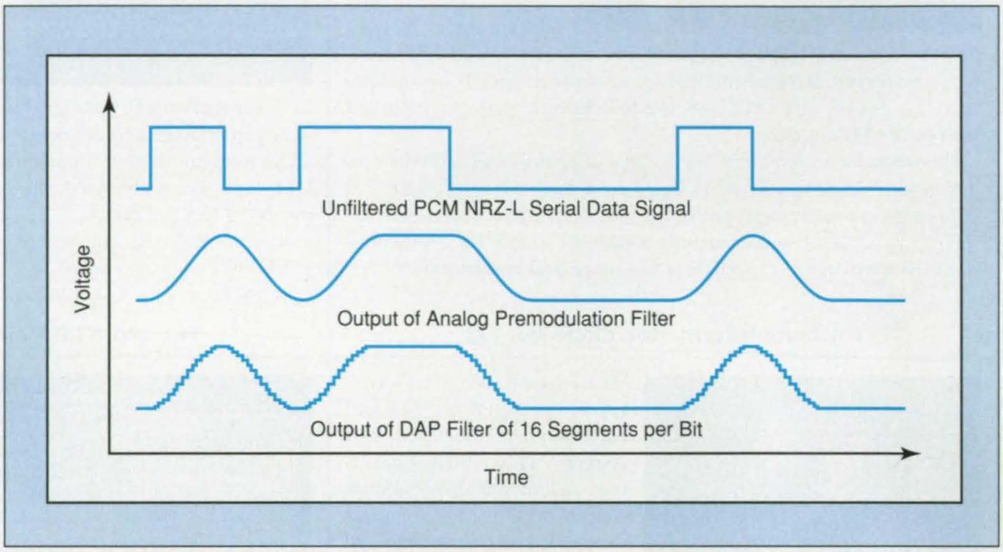


Figure 1. The **Digital Approximation Waveform** is a slightly degraded version of the output of an analog premodulation filter.

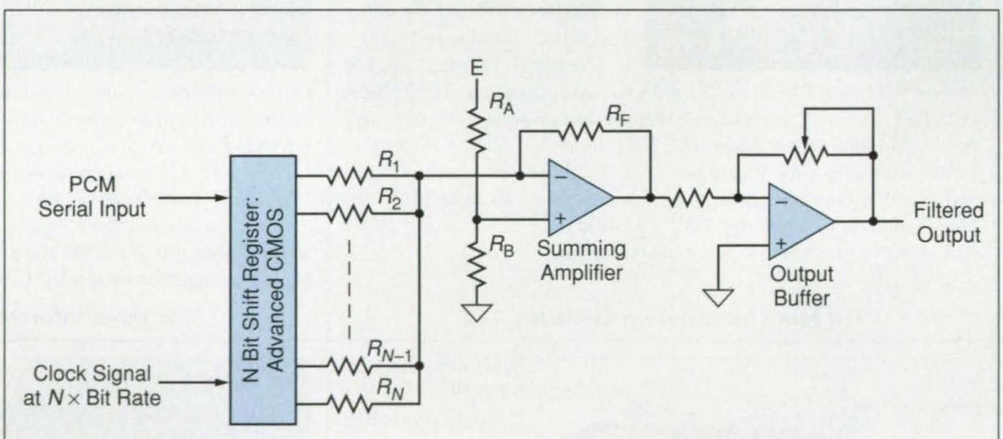


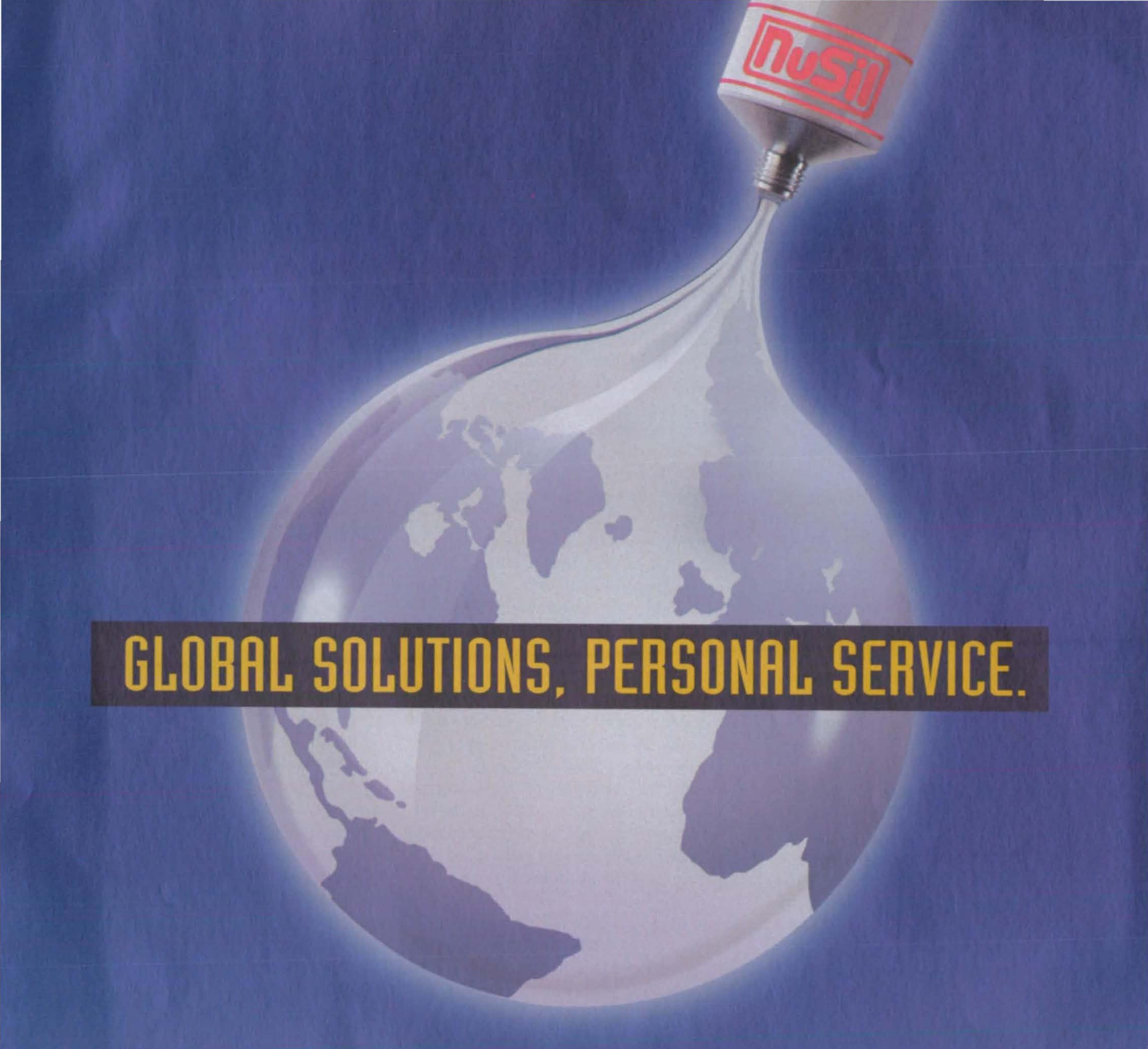
Figure 2. An **N-Segment DAP Filter** includes a shift register, a summing amplifier, and an output buffer.

The DAP filter (Figure 2) comprises three main parts: (1) a part that divides each bit into a number of segments, (2) a part that converts each segment into a voltage that approximates the output of an ideal premodulation filter, and (3) an output buffer amplifier. An integer frequency multiple of the bit-rate clock signal is used to shift the serial digital output through a parallel output shift register to segment each bit. The conversion to a voltage level can be accomplished by a resistor array and summing amplifier to approximate the rise or fall of a half cosine wave for each bit transition. If the integer frequency multiple of the bit-rate clock signal is not available from the signal source, it can be generated from the source bit-rate clock signal by use of a phase-lock loop.

Because the DAP filter is synchronized with the bit-rate clock as described above, it always produces the proper wave shape, regardless of the bit rate of the unfiltered data signal.

This work was done by Harry Chiles and Rod Bogue of **Dryden Flight Research Center.**

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 Technical Information Specialist, Dryden Flight Research Center, (805)258-3720. Refer to DRC-95-28.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Prolonging the Lives of Rechargeable Lithium-Ion Cells

Proposed modifications would prevent dissolution of metal current collectors.

NASA's Jet Propulsion Laboratory, Pasadena, California

Several modifications of the design and operation of lithium-ion rechargeable electrochemical cells have been proposed to prolong the cycle lives of the cells. As explained below, overdischarge can result in dissolution of a metal current collector in the anode of a cell, with consequent internal short-circuiting of the cell and thus loss of cycle life. The proposed modifications are intended to prevent dissolution of the metal current collector and thereby extend the cycle life.

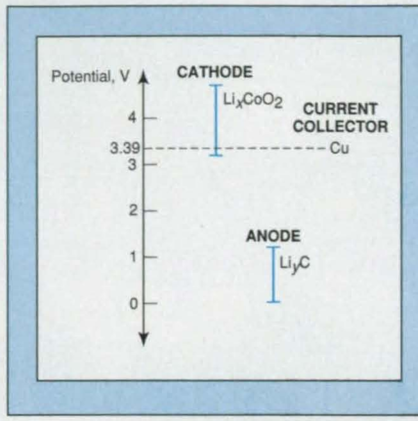
In a typical cell of the type in question, the active cathode material is a lithiated oxide (e.g., Li_xCoO_2) and the active anode material is carbon. These active materials are coated on different substrates or current collectors to make electrodes, and separator paper is used to prevent contact between the two electrodes. The current-collector materials must be chosen for compatibility with the cell chemistry; for example, the anode current collector can be made of copper or nickel.

A freshly fabricated cell is fully discharged: All the lithium is stored in the lithiated oxide cathode material; there is no lithium in the carbon anode material. An initial charging process is necessary to activate the cell. During the charging process, lithium becomes deintercalated from the Li_xCoO_2 cathode material and intercalated into the carbon anode material; the reverse happens when the cell is discharged.

In this context, overdischarge of a previously charged cell can be defined as continuation of discharge after all the reversible lithium has been completely depleted from the carbon anode material. Initial charging of a freshly fabricated cell in reverse polarity is equivalent to overdischarging a previously discharged cell. The figure shows the relative potentials (vs. Li) for relevant materials in a lithium-ion cell with a copper current collector in the anode. During overdischarge or reversal of polarity, the potential of the graphite anode rises above the potential of the copper current collector, causing the formation of a spurious cell between Li_xCoO_2 and copper. The copper then begins to dissolve, causing a short circuit.

The following are the proposed modifications for preventing dissolution of the anode current collector:

1. Raise the cell potential below which discharge is cut off ("discharge cutoff voltage," for short). For example, in a graphite/Li_xCoO_2 Li-ion cell with a cathode/anode weight ratio of 3, the cycling voltage range is between 4.1 V (charge cutoff) and 3.0 V (discharge cutoff). If the discharge cutoff voltage were raised to 3.5 V, the consequent loss of capacity would be only 10 mA·h, while the cycle life would be extended.
2. Configure both internal and external electrical connectors to prevent reversal of polarity in a freshly fabricated cell, and verify correct polarity of connections to test equipment before conducting a test.
3. Use cathode additive(s) for protection against overdischarge, as described in "Preventing Overcharge and Overdischarge of Lithium Cells" (NPO-18343), *NASA Tech Briefs*, Vol. 19, No. 3 (March 1995), page 36. Low-potential cathode additives could help to reverse the potential of the spurious cell so that the copper current collector would not dissolve.
4. Make the anode current collector out of carbon instead of copper. This could be done, for example, by coating a carbon-based material onto an electrically conductive polymer or onto a sheet of separator paper to make an anode.



The **Potentials (Relative to Lithium)** of cathode, anode, and current-collector materials affect the charge, discharge, and overdischarge behavior of a lithium-ion cell.

This work was done by Chen-Kuo Huang of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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

Technology Reporting Office
JPL
Mail Stop 122-116
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-19897, volume and number of this NASA Tech Briefs *issue, and the page number.*

Three-Level Buck dc-to-dc Converter for Low Temperature

This circuit is fully functional at temperatures from room down to liquid-nitrogen temperature.

Lewis Research Center, Cleveland, Ohio

A dc-to-dc switching power converter of the three-level, pulse-width-modulated, buck type has been designed, built, and verified to operate at temperatures from ambient down to −196 °C (the temperature of liquid nitrogen). Circuits like this one could be useful for supplying electric power to low-temperature circuits in such diverse applications as cryogenic instruments, superconductive magnetic energy-storage systems, magnetic-resonance imaging systems, high-speed computer and communication systems, and high-power motor and generator systems.

The design of a multilevel switching dc-to-dc power converter exploits series connection of power semiconductor switches. The sharing of voltage among the series-connected switches, especially during turn-on and turn-off transients, is a major design issue. The duty factor (switch "on" time to duration of switching cycle) can be chosen to obtain a desired input-to-output voltage ratio. Also, different switches can be turned on and off at different times (equivalently, the switches can be operated at different phase shifts relative to each other and to the overall switching cycle) to minimize the generation of harmonics in the filtered output of the converter.

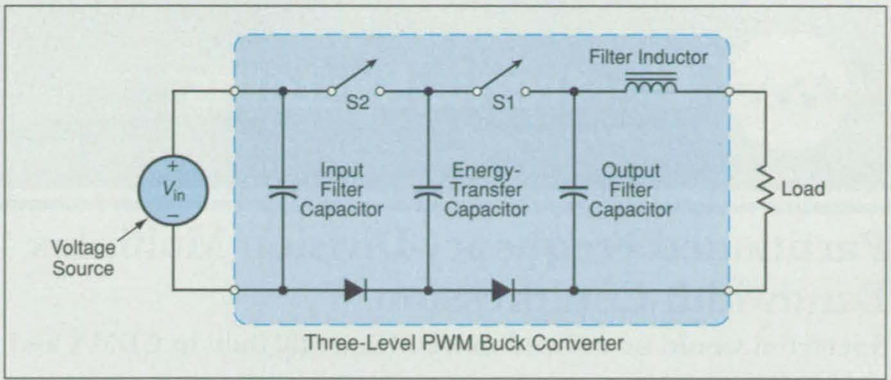
A three-level converter of the present type (see figure) is a special case of a multilevel switching buck dc-to-dc power converter. In comparison with a standard two-level converter, the three-level converter contains one more switch, one more diode, and one more capacitor. An n-level converter (where $n > 2$) offers an advantage over a standard two-level converter; namely, that the voltage ratings applied to the semiconductor devices in the n-level converter are decreased to $1/(n - 1)$ of those of the two-level converter; the reduction in voltage stresses on semiconductor switches and diodes effects a reduction in switching and conduction losses, and enables the use of semiconductor components with correspondingly lower voltage ratings.

The present three-level converter was designed and constructed using standard, commercially available components, including power metal oxide/semiconductor field-effect transistors (MOSFETs), ultrafast semiconductor power rectifiers, complementary metal oxide/semiconductor integrated circuits for pulse-width modulation and control, metallized-polypropylene-film energy-transfer and output capacitors, and an inductor with a core made of a high-permeability powder. The requirement for low-temperature operation was taken into account in the selection of all components. The design specifications include an input potential of 48±10 V; an output potential of 12 V; an output voltage ripple of 120 mV (1 percent of rated output voltage); minimum and maximum load currents of 1 and 5 A, respectively; maximum output power of 60 W, and a switching frequency of 50 kHz.

The converter was tested in operation at temperatures from 25 down to –195 °C. At room temperature, the converter operated with an efficiency of 89.12 percent. At –195 °C, the measured efficiency was slightly lower; namely, 87.27 percent. Even at –195 °C, the converter was found to be fully functional.

This work was done by Richard L. Patterson of **Lewis Research Center** *and Fausto F. Pérez-Guerrero and Biswajit Ray of the University of Puerto Rico. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16675.



A **Three-Level, Pulse-Width-Modulated, Buck-Type dc-to-dc Converter** offers an advantage over a two-level converter of the same type; namely, that the voltage stresses on the semiconductor components are lower.

Electronic Systems

Partitioned Frequency-Division Multiplex for Bandwidth Compression

Spectrum would be utilized more efficiently than in CDMA and FDMA.

NASA's Jet Propulsion Laboratory, Pasadena, California

Frequency-hopped and partitioned frequency-division multiplex (FH/PFDM) is a proposed modulation technique for transmission of digital signals. In FH/PFDM, a serial stream of data (possibly generated by multiple users) coming into a transmitter would be distributed into frequency-hopped, frequency-partitioned subchannels, in such a way as to reduce (in comparison with other modulation techniques) the overall carrier deviation and sidelobe excursion.

Figure 1 presents block diagrams of the bandwidth-compression and -decompression portions of an FH/PFDM transmitter and receiver, respectively. In the transmitter, the incoming data stream to be transmitted would first be converted from serial to parallel format and grouped into data blocks of n slots, each slot corresponding to one of n subcarrier frequencies generated by a digital frequency synthesizer. Next, a serial transfer switch would transfer the data bits into a buffer. Under sequential strobing by clock pulses, data bits would be strobed from the buffer into modulo-2 adders, the outputs of which would be modulated onto the subcarriers by phase-shift keying (PSK). The data bits would be interleaved in the sense that each successive data bit would be phase-modulated onto one of the subcarriers in a sequence of increasing subcarrier frequencies.

Meanwhile, under synchronization by clock pulses from a sequence generator, the frequencies of the n subcarriers would periodically be made to hop; during each clock cycle of the sequence generator, each subcarrier would hop through a total of m different frequencies (see Figure 2). The purpose of the hopping is to achieve spectral isolation between subchannels and thereby reduce self-interference. Finally, the PSK subcarriers would be

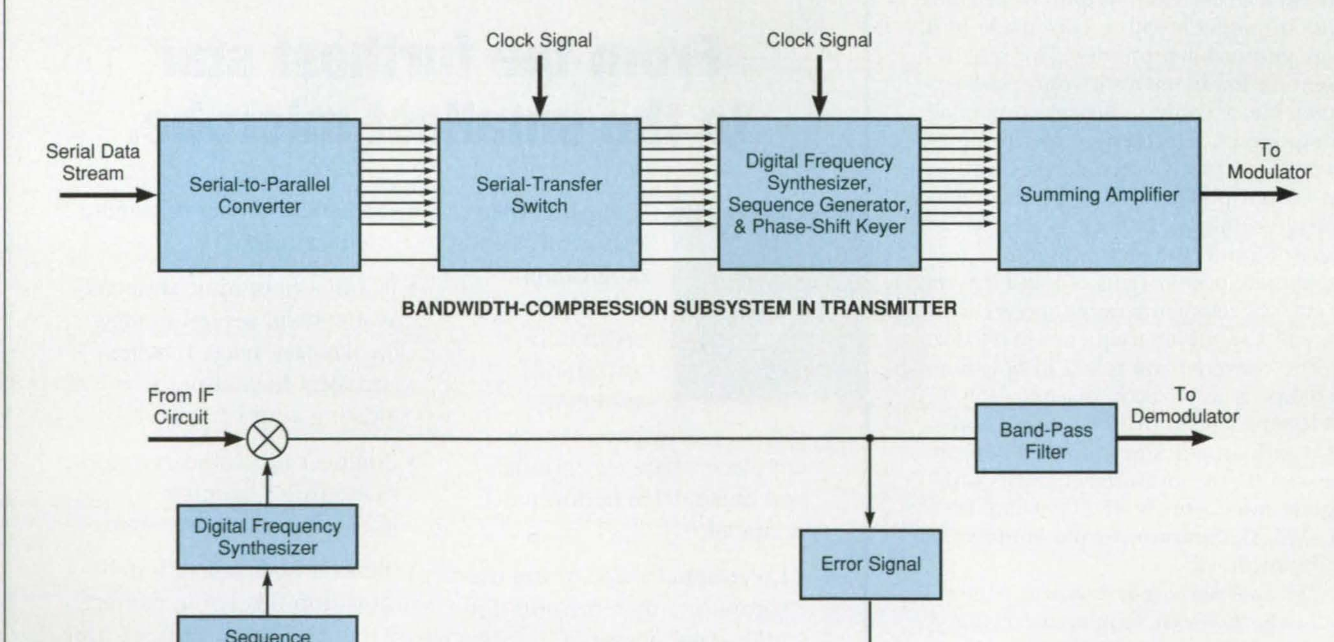


Figure 1. The **FH/PFDM Portions of a Transmitter and Receiver** would increase the efficiency of utilization of the radio spectrum for transmitting a data stream of a given rate.

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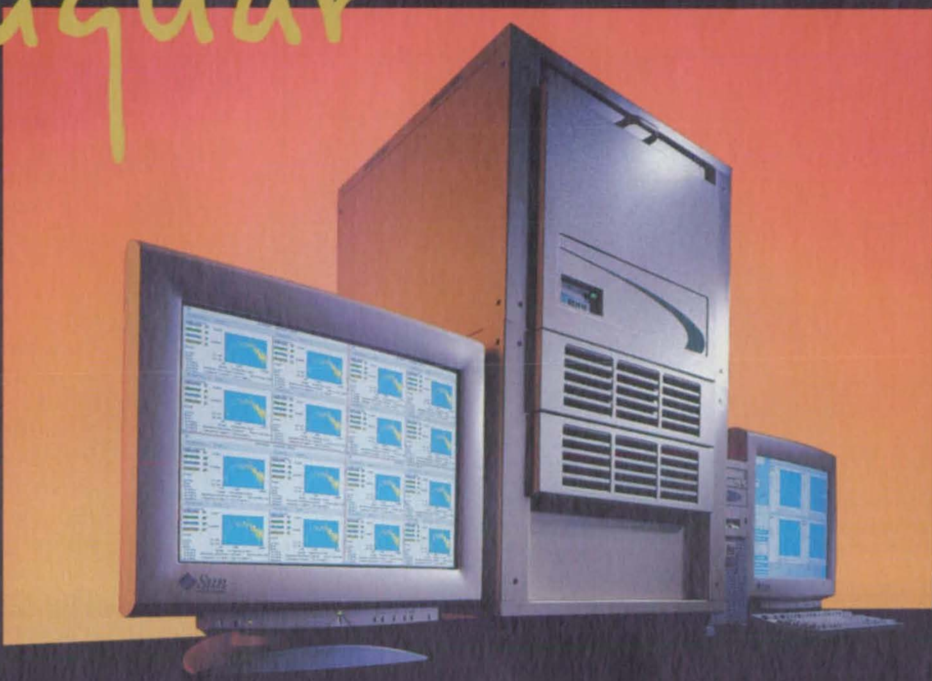

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DYNAMIC

n Subcarriers / *m* Hops

	$i = 1$	$i = 2$	• • • • •	$i = 10$
$j = 1$	202	212	• • • • •	292
$j = 2$	203	213	• • • • •	293
•	•	•	Frequencies are in kilohertz.	•
$j = 1$	211	221	• • • • •	301

Figure 2. This **Table Lists Subcarrier Frequencies** for an example of an array of $n = 10$ subcarriers and $m = 10$ hops. Each cell (i,j) in the table gives the frequency of the *i*th subcarrier during the *j*th interval between frequency hops.

combined in a summing amplifier, which, in turn, would be used to modulate a carrier signal by frequency-shift keying (FSK).

In the receiver, a digital frequency synthesizer driven by a sequence generator would produce the same array of *n* frequencies and sequence of *m* frequency hops as that of the transmitter. This array of hopped frequencies would serve as a local-oscillator signal for use in asynchronously demodulating the received modulated subcarriers. The local-oscillator signal would be multiplied by the incoming intermediate-frequency (IF) signal in a mixer. An error signal derived from the mixer output would be used to control the sequence-generator clock frequency. The mixer output would also be band-pass filtered to remove unwanted mixer products, then passed on to a demodulator.

Theoretical calculations have shown that FH/PFDM would make it possible to utilize the available spectrum more efficiently than is possible in the established techniques of code-division multiple access (CDMA) and frequency-division multiple access (FDMA). In other words, for a given equivalent communication-link power, and performance, FH/PFDM would accommodate a greater number of users or a greater overall data rate in a given bandwidth or, equivalently, require less bandwidth for a given overall data rate or number of users. The cost of this spectrum compression would be an increase in the complexity of transmitters and receivers. One potential additional advantage FH/PFDM is that by interleaving the data and ordering the frequency hops in pseudorandom sequences, one could help to prevent unauthorized interception of data. The most practical route to realization of the potential of FH/PFDM would likely be to develop application-specific integrated circuits to implement the FH/PFDM transmitting and receiving functions.

This work was done by Charles Ruggier of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category.*
NPO-20364

Snapshot CCD Camera With Microelectromechanical Shutter

Microscopic actuated mirrors would divert light from the CCD at selected times.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed charge-coupled-device (CCD) camera would be mechanically shuttered by a planar array of micromachined, electromechanically actuated shutters. This proposal has arisen as part of the solution to the problem of designing a visible/near-infrared imaging spectrometer using a commercial off-the shelf CCD as the image sensor at the focal plane. The need for mechanical shuttering arises because the desired exposure time clashes with the readout times of available CCDs. In particular, what is needed is an exposure time shorter than the readout time. By use of the array of micromachined mirrors, the image could be deflected off the focal plane during the readout cycle to prevent contamination of the captured image with light after the desired charge-integration (exposure) time.

According to the proposal, an object would be imaged on the focal plane via a folding mirror. In this case, the folding mirror would be the array of micromachined mirrors. Such arrays have been fabricated before for other purposes and are examples of what are now denoted generically as microelectromechanical systems (MEMS).

The elements of the array would be of the order of 10 by 10 μm. The mirrors would be operated in a binary mode, in which they would be switched between extreme angular positions 10° apart at megahertz rates. In the normal or unactuated state (mirrors at one of the extreme angular positions), the mirrors would reflect the image light onto the focal plane. In the fully actuated state (mirrors at the other extreme angular position), the mirrors would deflect the image light away from the focal plane and onto a beam dump, which would absorb the light. The exposure time could be set by setting the duty cycle of the two mirror states.

Unlike traditional iris- and leaf-type mechanical shutters, the proposed MEMS-type shutter would be capable of closing off the entire image at once, and would operate without appreciable jitter. Even at submillisecond exposure times, the proposed shutter would not pose any timing or jitter problems.

The proposed shutter could be used with any image sensor, including a 100-percent-fill-factor sensor, which is typically a high-end progressive-scan CCD. Heretofore, fast cameras have typically contained interline-transfer image sensors, which are less sensitive to red and infrared than standard CCDs. Thus, the user can obtain the advantage of the increased signal and increased red and infrared response of a 100-percent-fill-factor, progressive-scan focal-plane device, relative to an interline-transfer device.

The proposed shutter could also be utilized in time-resolved spectroscopy. This would involve (1) imaging a spectrum onto the array of mirrors, with the spectrometer slit oriented along the columns of mirrors and the spectrum along the rows of mirrors and (2) re-imaging the spectrum from the mirror plane onto the CCD array. The spectroscopic cycle would start with all mirrors in the "off" position, so there would be no image on the CCD. Then the mirrors would be switched momentarily to the "on" position, a few rows at a time, in succession across the array, yielding a succession of time-resolved spectra on the CCD.

This work was done by Gregory Bearman, Robert Green, Michael Eastwood, and Thomas Chrien of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category.*
NPO-20396

Software

Software for Developing Autopilots for Launch Rockets

Three integrated software products are being developed for use in the further development of autopilot systems for reusable launch vehicles (RLVs). The need for these products arises because of the unique nature of RLVs:

- RLVs employ differential throttling as the primary means of longitudinal control during ascent. This approach to flight control necessitates autopilot systems because the way in which engine thrust signals control the rockets is counterintuitive to astronauts.
- Conventional controllers are not adequate for the multiple-input/multiple-output autopilot systems that are needed for RLVs (e.g., the VentureStar) that are equipped with linear aerospike engines and small conventional aerodynamic controls. The small conventional aerodynamic controls and the propulsion inefficiency that results from differential throttling necessitate the development of robust reconfigurable autopilot systems, as do the all-consuming goal of minimizing RLV weight and the need for interchangeable, swappable, and cooperative actuators that can alleviate attitude-control concerns in the event of single or multiple actuator failures.

One of the three developmental software products is intended for use in designing and simulating autonomous, robust, reconfigurable flight-control systems of both civil and military RLVs. This is a user-friendly software package that will greatly aid NASA, other government agencies, and industrial organizations working on linear aerospike space transportation systems and RLVs. It enables the designer to develop systems based on several control approaches, including hierarchical robust reconfigurable control and robust identification-based adaptive reconfigurable control. Genetic algorithms serve as the optimization tools in this package.

The second software product is one that provides an advanced software environment of testing and evaluation of the designs and software of autopilot systems. This product will determine the efficacy of these systems by evaluating the ease with which the systems can be reconfigured in the event of the multiple failure scenarios described below.

The third and final product is a real-time software prototype of an advanced robust reconfigurable autopilot system for an RLV. It is an on-line, real-time control software environment that provides control researchers and engineers with a convenient tool for the investigation and application of advanced control methods and real-time control in an RLV system.

The advantages of these three integrated software products and of autopilot systems designed by use of them are the following:

- These products will minimize the engineering design labor as well as the weight, cost, labor, and maintenance associated with the physical RLV.
- Autopilot designers will be able to design, simulate, evaluate, implement (in real time), and test their control system designs within the complete three-product package.
- A robust, reconfigurable autopilot eliminates the need for a human pilot, thus eliminating the possibility of loss of life as the result of a catastrophic failure or human error.
- The use of software products like these reduces the probability of losing an RLV and/or its payload in the event of a mission-threatening failure. A robust, reconfigurable autopilot system would minimize the need to abort the mission in the event of a single or multiple actuator failure by reconfiguring the RLV control system as necessary to approach nominal vehicle attitude control.
- In designing a robust, reconfigurable attitude-control system, the control actuators can be allowed to remain small, minimizing the vehicle weight and avoiding actuator-related overheating during reentry and descent.
- To minimize weight, a typical RLV design calls for fuel for both the main engines and the reaction control system to be depleted before descent. Thus, the need for reconfigurability of aerodynamic control surfaces becomes even more compelling during descent and landing in the event of a single or multiple aerodynamic actuator failure.

This work has been and will be undertaken by the American GNC Corporation, 9131 Mason Avenue, Chatsworth, CA 91311, an SBA 8(a) certified Small Disadvantaged Business concern, as part of a NASA Small Business Technology Transfer (STTR) project monitored by **Marshall Space Flight Center.** *The NASA STTR Contract Number is NAS8-97292; Topic: 5; Topic Title: Advanced Space Transportation. For further information, contact Dr. Ching-Fang Lin, (818) 407-0092 or e-mail: cflin@americangnc.com.*
STTR0001

Zn_4Sb_3: A High-Performance Thermoelectric Material

The thermoelectric figure of merit at 200 to 350 °C is the greatest known.

NASA's Jet Propulsion Laboratory, Pasadena, California

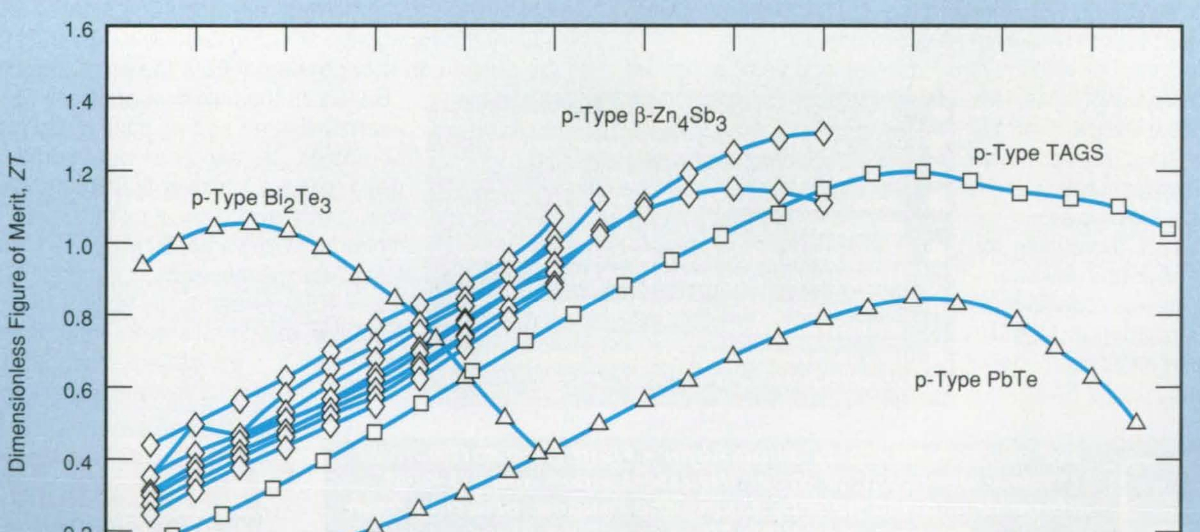
Zn_4Sb_3 has been identified as a high-performance thermoelectric material. In p-type, Zn_4Sb_3 samples have exhibited the greatest dimensionless thermoelectric figure of merit ever observed for a p-type material at temperatures from 200 to 350 °C. In this respect, Zn_4Sb_3 fills a gap in the thermoelectric-performance spectrum between the state-of-the-art thermoelectric materials like (a) p-type Bi_2Te_3-based alloys, which exhibit their greatest figures of merit at lower temperatures and (b) p-type Te/Ag/Ge/Sb ("TAGS") alloys and p-type PbTe-based alloys, which exhibit their greatest figures of merit at higher temperatures. Thus, Zn_4Sb_3 offers an important thermoelectric-performance advantage for generating electrical energy from heat sources in the temperature range from 200 to 350 °C. Zn_4Sb_3 also costs less than do the state-of-the-art lower- and higher-temperature alloys.

Zn_4Sb_3 exists in three phases; α (which is stable below –10 °C), β (which is stable from –10 to 492 °C), and γ (which is stable from 492 °C to the melting temperature of 566 °C). In the temperature range of interest, Zn_4Sb_3 thus manifests itself as β-Zn_4Sb_3, which has been reported in the literature to be characterized by a band gap of about 1.2 eV. Single crystals of β-Zn_4Sb_3 were prepared by the Bridgman gradient-freeze technique. In addition, polycrystalline samples were prepared by melting and direct reaction of powders of Zn and Sb followed by regrinding of the resulting ingots into powder followed by hot pressing to consolidate the powders into solid pellets.

The thermoelectric properties of the crystalline and polycrystalline samples were measured and found to be similar. The results show that β-Zn_4Sb_3 is a heavily-p-doped semiconductor. The dimensionless thermoelectric figure of merit, ZT is defined by $ZT = \alpha^2 T/\rho\lambda$, where α is the Seebeck coefficient, T is the absolute temperature, ρ is the electrical resistivity, and λ is the thermal conductivity. The figure illustrates ZT as a function of temperature as calculated from the measurements on the β-Zn_4Sb_3 samples, plus ZT as a function of temperature for the state-of-the-art thermoelectric materials mentioned previously. One of the most interesting features of β-Zn_4Sb_3 that contributes to its relatively large ZT is its thermal conductivity, which reaches a low value of only 6 mW/(cm·K) at 250 °C. This is the lowest thermal conductivity of any thermoelectric material known thus far.

There are many potential applications for β-Zn_4Sb_3 in thermoelectric generators, especially for recovering electrical energy from waste heat. Sources that generate waste heat in the temperature range of peak thermoelectric performance of β-Zn_4Sb_3 include garbage incinerators, geothermal sources (including hot oil from oil wells), power plants, and automobiles.

This work was done by Thierry Caillat of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*



The **Values of the Dimensionless Figure of Merit** of samples of β-Zn_4Sb_3 in the temperature range of 200 to 350 °C were found to exceed those of other thermoelectric materials.

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

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Refer to NPO-19677, volume and number of this NASA Tech Briefs *issue, and the page number.*

High-Performance Thermoelectric Materials Based on β-Zn_4Sb_3

Even better performances are obtained with solid solutions of β-Zn_4Sb_3 and Cd_4Sb_3.

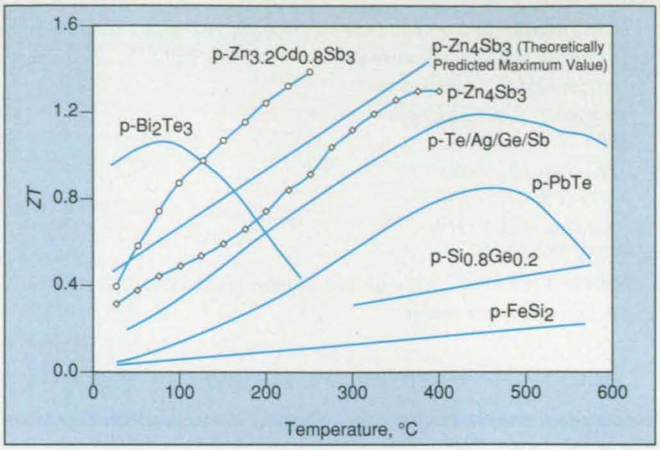
NASA's Jet Propulsion Laboratory, Pasadena, California

Materials based on β-Zn_4Sb_3 have been found to exhibit unusually high values of the dimensionless thermoelectric figure of merit at temperatures between 200 and 400 °C. The discovery that p-type β-Zn_4Sb_3 is a high-performance thermoelectric material was reported in the preceding article. The development reported here extends beyond that discovery to include solid solutions of β-Zn_4Sb_3 and Cd_4Sb_3 (with general compositions given by $Zn_{4-x}Cd_xSb_3$) in the class of high-performance thermoelectric materials based on β-Zn_4Sb_3.

The development has included studies of doping with impurities and of deviation from stoichiometry as means to affect the electrical properties of β-Zn_4Sb_3. These studies have included the preparation of samples with electrical conductivities of both the p- type and the n-type. Theoretical modeling of the thermoelectric properties of p-type β-Zn_4Sb_3 was also performed to predict the maximum achievable figure of merit for this compound as a function of temperature, and experimental values were found to approach the predicted values.

The thermoelectric figure of merit, ZT is given by $ZT = \alpha^2 T/\rho\lambda$, where α is the Seebeck coefficient, T is the absolute temperature, ρ is the electrical resistivity, and λ is the thermal conductivity. The figure illustrates ZT as a function of temperature, both from the theoretical prediction described above and as calculated from measurements on p-doped β-Zn_4Sb_3, on other state-of-the-art p-doped thermoelectric materials, and on a p-type Zn_4Sb_3/Cd_4Sb_3 solid solution of nominal composition $Zn_{3.2}Cd_{0.8}Sb_3$. In the cited prior article, the high ZT of p-type β-Zn_4Sb_3 in the temperature range of interest was attributed partly to its low thermal conductivity, which was then the lowest known thermal conductivity of any thermoelectric material in that temperature range. Since then, the thermal conductivity of the $Zn_{3.2}Cd_{0.8}Sb_3$ solid solution has been found to be even lower. The net result is that the ZT values of $Zn_{3.2}Cd_{0.8}Sb_3$ exceed those of β-Zn_4Sb_3 at temperatures > 50 °C, reaching a high value of 1.4 at a temperature of 250 °C.

Temperature-stability tests have shown that thermoelectric materials based on β-Zn_4Sb_3 are stable in dynamic vacuum at temperatures up to about 250 °C and in static vacuum up to about 400 °C. A Zn/Cd eutectic brazing material has been developed for use in bonding these materials to copper electrodes. Contact electrical resistivities between samples of these materials and copper electrodes have been found to be very low. Thus, it should be relatively easy to incorporate these materials into thermoelectric power-generating and cooling devices.



The **Dimensionless Figure of Merit (*ZT*)** of $Zn_{3.2}Cd_{0.8}Sb_3$ exceeds that of β-Zn_4Sb_3, and exceeds the *ZT*s of other thermoelectric materials even more.

This work was done by Thierry Caillat, Alexander Borshchevsky, and Jean-Pierre Fleurial of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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

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Refer to NPO-19851, volume and number of this NASA Tech Briefs *issue, and the page number.*

Cold Hibernated Elastic Memory (CHEM) Expandable Structures

Compacted structures would be deployed with heat only.

NASA's Jet Propulsion Laboratory, Pasadena, California

Experiments have confirmed the feasibility of a new class of lightweight, reliable, simple, and low-cost expandable structures. The concept called "cold hibernated elastic memory" (CHEM) utilizes the shape memory polymers (SMPs) in open cellular structures. Basically, these structures are SMP foams that are under development by Jet Propulsion Laboratory (JPL) and Mitsubishi Heavy Industry (MHI).

In CHEM concept, the structures of any shape, such as rods, tubes, wheels, boards, chassis, packages, tanks, and the like, are fabricated from larger SMP foam blocks. Subsequently, they are compacted to very small volumes in rubbery (flexible) state above the glass-transition temperature (T_g) and later cooled below T_g to glassy state. When the stowed structure is frozen, the external compacting forces are removed and the part can be stowed in cold hibernated state for unlimited time below T_g. A compacted part can be heated above T_g to rubbery state and the original shape will be precisely restored by simultaneous elastic recovery of the foam and its shape-memory polymer effect. A fully deployed structure can be rigidized by cooling below T_g to glassy state. Once deployed and rigidized, a part could be heated and recompacted. In principle, there should be no limit on achievable number of compaction/deployment/rigidization cycles.

The main advantages of the CHEM structures over conventional polymer foams are as follows:

- Both, elastic and plastic compressive strains are precisely recovered;
- High full/stowed volume ratios are achieved;
- High ratios of elastic modulus (E) below T_g to E above T_g allow to keep original shape in stowed, hibernated condition, without external compacting forces;
- Small temperature range for full transformation from rigid to rubbery state reduces the heat consumption during deployment (shape restoration);
- Wide range of T_g from –70 to +100 °C results in many applications.

Advantages over other expandable/deployable structures are as follows:

- high reliability,
- low cost,
- simplicity,
- no deployment/inflation systems,
- clean deployment and rigidization,
- none or very little long-term stowage effects, and
- inexpensive technology development.

The disadvantage of CHEM structure is that heat energy is needed for deployment. However, natural heat sources are considered to be utilized and studies/proof-of-concept are planned to be conducted.

A wide range of T_g from –70 to +100 °C results in a myriad possible space and terrestrial commercial applications. The CHEM concept could be applied to shelters, hangars, camping tents or outdoor furniture, to mention just a few. Such articles could be made of an SMP foam with a T_g slightly above the highest outdoor summer temperature. The CHEM parts can be transported and stored in small packages, then expanded by heating at the outdoor site. After expansion, the CHEM parts will be allowed to cool to ambient temperature below their T_g and rigidize.

This work was done by Witold Sokolowski and Artur Chmielewski of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category. NPO-20394*

Nonchromic Acid Brightener for Brass and Copper

Lyndon B. Johnson Space Center, Houston, Texas

A process for precleaning brass and copper parts before processing them further in a clean room includes a brightening chemical treatment in solution of 85 volume percent phosphoric acid, 3 volume percent nitric acid, and 12 volume percent acetic acid. This solution acts rapidly and can be discarded easily; it replaces a chromic-acid brightening solution that has become subject to environmental regulation. In preparation for the treatment, a part is first alkaline cleaned, rinsed with water, and dried until no water is visible. The part is then treated by immersing it in the solution for 10 seconds or until bubbles appear on all its surfaces. The part is then rinsed with water and dried.

This work was done by Paul H. Biesinger of AlliedSignal, Inc., for **Johnson Space Center.** *No further documentation is available. MSC-22662*

For More Information Circle No. 418

Analysis of Flutter of the APEX Sailplane

This airplane is expected to be safe from destruction by flutter instabilities.

Dryden Flight Research Center, Edwards, California

The proposed APEX high-altitude aerodynamical-research sailplane (see Figure 1) has been predicted to be free of flutter instabilities within its flight envelope. Designed to fly under remote control at altitudes of up to 100,000 ft (30.5 km), the APEX airplane would feature a stiff boron composite structure, the vibration-mode characteristics of which would be such that they should enable the airplane to fly at relatively high subsonic mach numbers without risk of destruction by flutter.

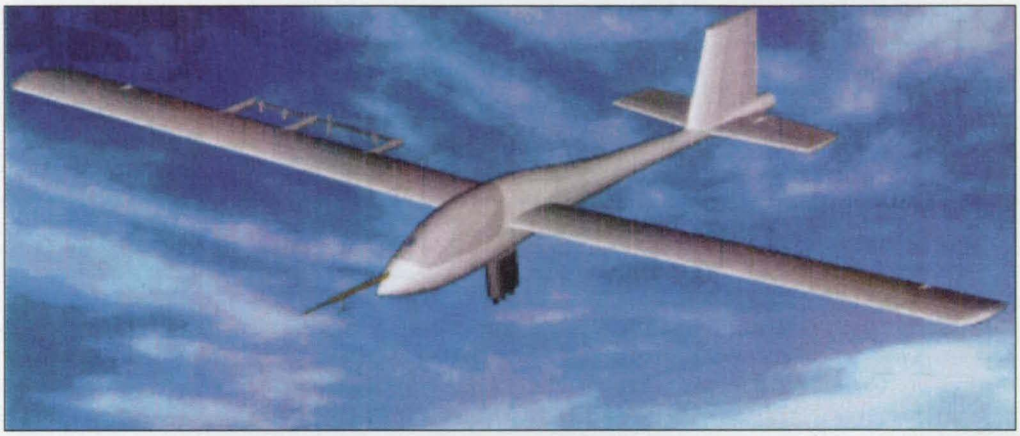


Figure 1. The **APEX Sailplane**, shown here as rendered by an artist, would be a unique, remotely piloted research airplane that would fly at high altitudes.

This prediction is the product of a flutter analysis that included a modal analysis based on a mathematical model of the dynamics of the airplane structure. Modal analysis is an essential part of flutter analysis; it is also needed in analysis of results of ground vibration tests and in the development of control laws. The flutter analysis was performed in lieu of flight tests to provide assurance of flutter stability, which tests are beyond the scope of the APEX project.

In preparation for the flutter analysis, the Advanced Soaring Concepts mathematical model of the structural dynamics was converted from a format denoted "COSMOS" to a format denoted "STARS" and validated. Detailed and accurate mass and stiffness distributions were included in the model.

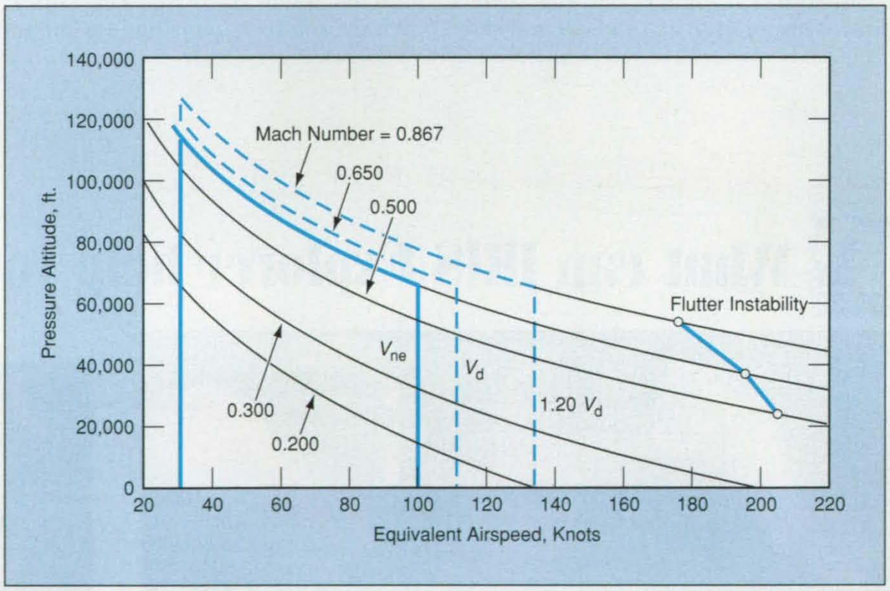


Figure 2. The **APEX Flight Envelope** does not enclose any flutter instability, according to flutter analysis. (V_{ne} = Velocity never exceed; V_d = Velocity in dive.)

The results of modal analyses were examined and plotted, and deflections were interpolated. Final flutter solutions were computed by use of a matched point, so that the flutter-stability calculations could be confirmed by recalculating them with flow parameters at the predicted stability boundary. The updated results of modal analysis were found to follow reasonable patterns. Flutter instabilities were found to lie well outside the flight envelope (see Figure 2).

This work was done by Roger Truax of **Dryden Flight Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*
DRC-98-74

Equipping Quick-Disconnect Fittings To Detect Leaks

John F. Kennedy Space Center, Florida

Quick-disconnect fittings on hoses and bellows can be equipped with sensors to detect leaks and misalignments that cause leaks. Experiments have shown that four types of sensors are effective for this purpose: force sensors, strain gauges, pressure transducers, and microphones. Of these, force sensors appear to be best for indicating misalignments. Microphones pick up the whistling sounds of gas leaks. Pressure transducers in purge cavities can indicate (a) increases in pressure that signify leaks in supply lines and (b) decreases in pressure that signify leaks in vent lines. The instrumented quick-disconnect fittings were conceived for use on the umbilical hoses used to supply gases and cryogenic liquids to spacecraft during preparation for launch. The concept also has potential for enhancing safety and helping to enable automation of fueling systems for cars, trucks, buses, trains, and airplanes.

This work was done by Ronald L. Remus and Perry Hartford of Merritt Systems, Inc., for **Kennedy Space Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373. Refer to KSC-11893.

Ceramic Hybrid Electromechanical Systems

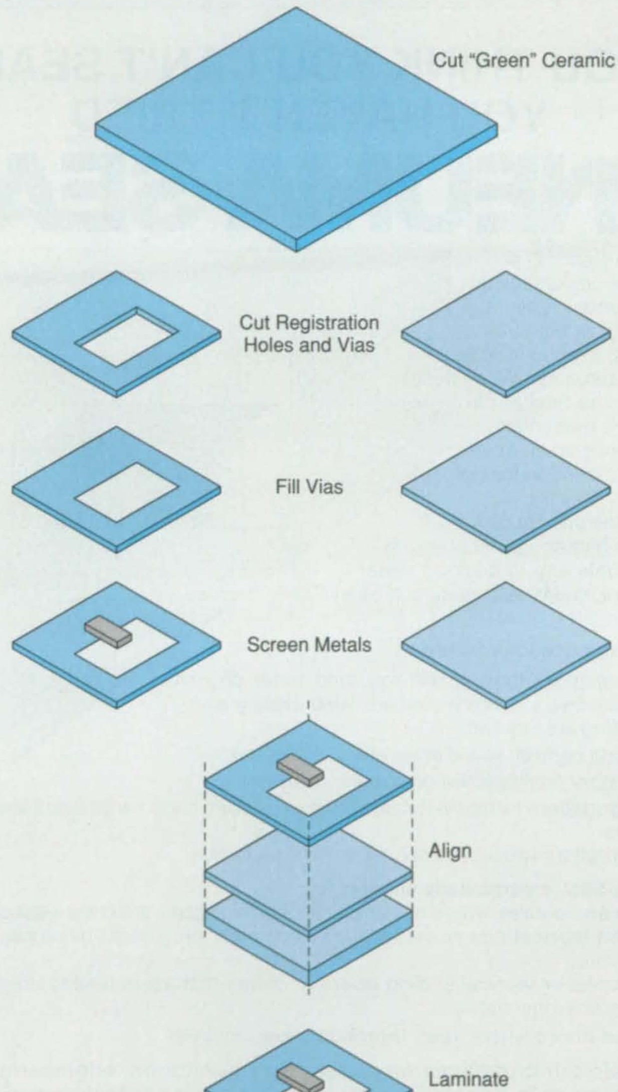
Mesoscopic ceramic-based devices would overcome key limitations of microscopic silicon-based devices.

NASA's Jet Propulsion Laboratory, Pasadena, California

Ceramic hybrid electromechanical systems (CHEMS) have been proposed to overcome some of the disadvantages while retaining most of the advantages of microelectromechanical systems (MEMS). Whereas MEMS are fabricated mostly by micromachining of silicon and have typical feature sizes of the order of microns or smaller, CHEMS could be fabricated on ceramic substrates by a wider variety of techniques and would have typical feature sizes ranging from tens of microns to millimeters. Depending on specific applications, CHEMS could serve as alternatives or complements to MEMS. CHEMS could be readily incorporated, along with integrated circuits and other microscopic components, into ceramic-based hybrid multilayer packages (e.g., multichip modules).

While the development of MEMS has been an important achievement in miniaturization, it turns out that in many practical applications, MEMS are too small to provide the required sensitivity as sensors or to provide the required forces or strokes as actuators. MEMS also suffer from sticton, squeeze-film damping, and damage induced by surface tension in liquids during processing. In addition, silicon is often not the substrate material of choice for applications in which there are requirements for electrically or thermally insulating substrates, low capacitance, resistance to corrosion, or hermetic sealing.

The proposal to develop CHEMS originated from the realization that many of the mechanical problems of MEMS could be solved more readily by fabrication of packaged microelectromechanical devices with dimensions intermediate between those of silicon-based microdevices and those of conventional macroscopic electromechanical devices. Sensors and actuators at the proposed CHEMS mesoscale could be made stronger and could be made to respond over dynamic ranges wider than those of silicon-based microdevices. Seals could be improved



A CHEMS Would Be Fabricated from "green" ceramic tapes in a multistep process by techniques that are established but have not been used to build devices of this type.

and strokes lengthened. Even so, CHEMS would still be small enough to fit into compact packages along with electronic integrated circuits.

In the development of CHEMS, it will be possible to take advantage of the mature technology already available for manufacture of ceramic hybrid structures in the electronics industry. There is an immense data base on ceramic materials with a wide variety of mechanical and electrical characteristics, including such sensor/actuator materials as piezoelectrics and ferroelectrics. Ceramic hybrids and multichip modules, and modern processes for manufacturing them, share many characteristics with those of silicon-based MEMS. Ceramic-hybrid technology affords the means to make laminated assemblies of ceramics, metals, and glasses that can be patterned, fired, and etched to produce three-dimensional structures. Inasmuch as silicon-based MEMS and electronic circuits are already typically integrated on ceramic substrates or headers, the fabrication of CHEMS should pose no obstacle to integration, nor should it entail additional cost. The completed systems would be of the same masses and volumes as those of *packaged* silicon microfabricated devices, but would have greater capabilities because of the larger sizes of the active mechanical components.

The figure illustrates an example of fabrication of a multilayer CHEMS that would include a metal cantilever over a rectangular hole plus metal layers connected to each other electrically and mechanically. Fabrication would be accomplished by use of the low-temperature cofired ceramic (LTCC) process. The starting materials for the layers would be 250-µm-thick "green" (that is, not yet fired) ceramic tapes, typically composed of 40 to 60 percent Al_2O_3 and the balance of filler materials.

Via holes for mechanical registration and electrical contact would be stamped into the tapes by use of computer-aided design and automated cutting tools. The via holes for electrical connection would be filled with metal. The rectangular central hole would be filled with a sacrificial dielectric to support the cantilever to be formed in the next step. Metal layers would be screened onto the broad surfaces of the tapes, forming the cantilever among other metal features. The metal-patterned tapes would be stacked and aligned by use of pins through the registration holes. The stack would be laminated at a pressure of 3 kpsi (21 MPa) and temperature of 70 °C. Next, the laminated structure would be heated to 500 °C to drive out volatiles. The structure would be fired at 850 °C to set the ceramic. Finally, to free the cantilever, the sacrificial dielectric would be removed from the central rectangular hole by wet and/or dry chemical etching.

This work was done by Linda Miller, Michael Hecht, Martin Buehler, Amin Mottiwala, Beverly Eyre, and Indrani Chakraborty of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

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Refer to NPO-20356, volume and number of this NASA Tech Briefs *issue, and the page number.*

Optoelectronic Liquid-Level Gauges for Aircraft Fuel Tanks

Replacement could be accomplished in minutes instead of days.

NASA's Jet Propulsion Laboratory, Pasadena, California

Gauges that would measure liquid levels optically have been proposed for use in aircraft fuel tanks. These gauges would contain no moving parts (no floats) and no wiring inside the tanks. Their overall function could be characterized as that of permanently immersed, self-reading dipsticks.

The proposed gauges are intended to supplant the capacitance probes now used to measure liquid-fuel levels in such tanks. Capacitance probes are mounted at several locations inside a tank and are connected to external instrumentation via wiring. The probes and wiring are usually reliable, but fail occasionally. Because replacement of capacitance probes and/or wiring involves intrusion into the tank, the aircraft could be out of service for days.

In a gauge of the proposed type, the only part intruding into the tank would be a rodlike assembly, mounted from the outside of the tank, that would provide optical access to the liquid inside. The rodlike assembly would include a baffle plus a rod made of a suitable transparent material. The rod would be etched or scored at prescribed intervals along its length to provide optically reflective fiducial marks at known levels. Light would be coupled into the rod from a source at the outer end to illuminate the fiducial marks. A camera or other imaging device would be mounted adjacent to the source of light and would be aimed along the rod to observe the illuminated marks.

The rod material would be chosen so that its index of refraction would approximately match that of the liquid in the tank. As a result, the fiducial marks immersed in the liquid would appear dark to the imaging device, while those above the surface of the liquid would appear bright to the imaging device. The liquid level would thus be assumed to lie between the lowest bright mark and the dark mark just below it. The output of the imaging device would be processed to into an indication of the liquid level in increments of depth between fiducial marks.

A mass-produced gauge of this type would likely include a miniature imaging device containing an active-pixel sensor, plus input/output circuits, all integrated on a single chip. An application-specific integrated circuit (ASIC) for processing the image-sensor output could also be included. Clock and command signals and signal input voltage would be supplied to the chip from external instrumentation. The overall size of the unit on the outer end of the rod assembly (including the ASIC) would be of the order of 1 in.^{3} (≈16 cm^3).

In a typical case, it would be necessary to place gauges at several locations. Then the fuel-level readings from the several locations could be processed by an algorithm that would take account of the shape of the tank in determining the amount of fuel remaining. It should also be possible to implement some form of autocalibration in software. The level readings or the final calculated quantity of fuel could be integrated or averaged before being displayed in nearly real time (update every few seconds).

With respect to initial costs, the proposed gauges would be competitive with capacitive fuel gauges. However, recurring costs of the proposed gauges would be much lower because their rodlike assemblies could be replaced in minutes instead of days.

This work was done by Philip Moynihan, Paul Henry, Tien-Hsin Chao, William Lincoln, William King, and Lloyd Adams of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category. NPO-20105*

Shape-Memory-Alloy Thermal-Conduction Switches

These devices would be simple, cheap, and reliable.

NASA's Jet Propulsion Laboratory, Pasadena, California

Variable-thermal-conduction devices containing shape-memory-alloy (SMA) actuators have been proposed for use in situations in which it is desired to switch on (or increase) thermal conduction when temperatures rise above specified values and to switch off (or decrease) thermal conduction when temperatures fall below those values. The proposed SMA thermal-conduction switches could be used, for example, to connect equipment to heat sinks to prevent overheating, and to disconnect the equipment from heat sinks to help maintain required operating temperatures when ambient temperatures become too low. In comparison with variable-conductance heat pipes and with thermostatic mechanisms that include such components as bimetallic strips, springs, linkages, and/or louvers, the proposed SMA thermal-conduction switches would be simple, cheap, and reliable.

The basic design and principle of operation of an SMA thermal-conduction switch is derived from an application in which thermal conduction from hot components to a cooling radiator takes place through the contact area of bolted joints. The thermal conductance depends on the preload in each joint. One could construct an SMA thermal-conduction switch by simply mounting an appropriately designed SMA washer under the bolthead. As the temperature falls below (or rises above) the SMA transition temperature, the SMA washer would contract (or expand) axially by an amount sufficient to unload (or load) the bolt, thereby shutting off (or turning on) most of the thermal conduction through the joint contact area. SMA washers with various transition temperatures can be made to suit specific applications.

This work was done by Virginia Ford and Richard Parks of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category. NPO-20437*

February 1999

Motion Control Tech Briefs

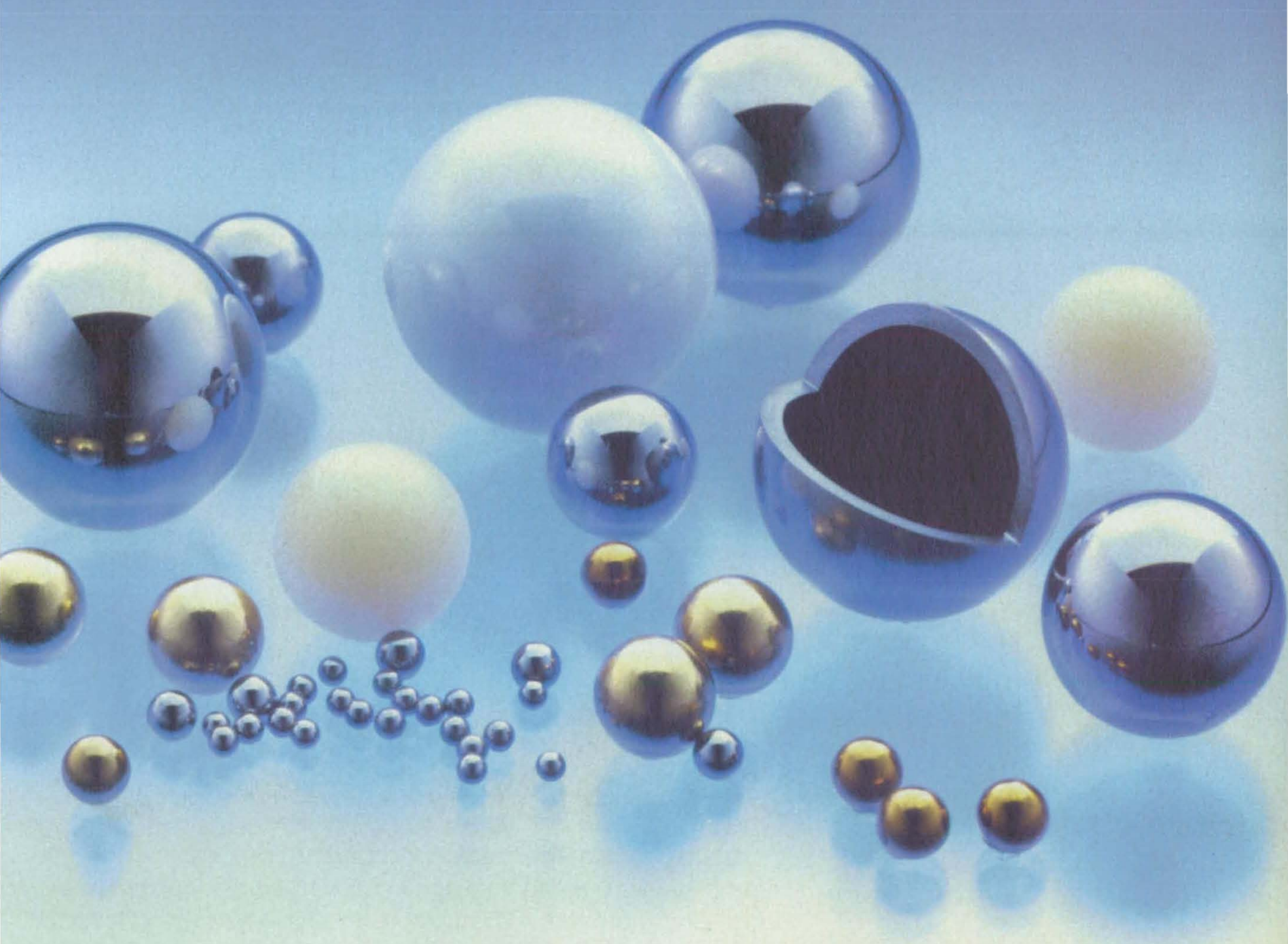


Photo courtesy of Thomson Precision Ball Co.

Rolling Stock: Precision Balls in Motion Control

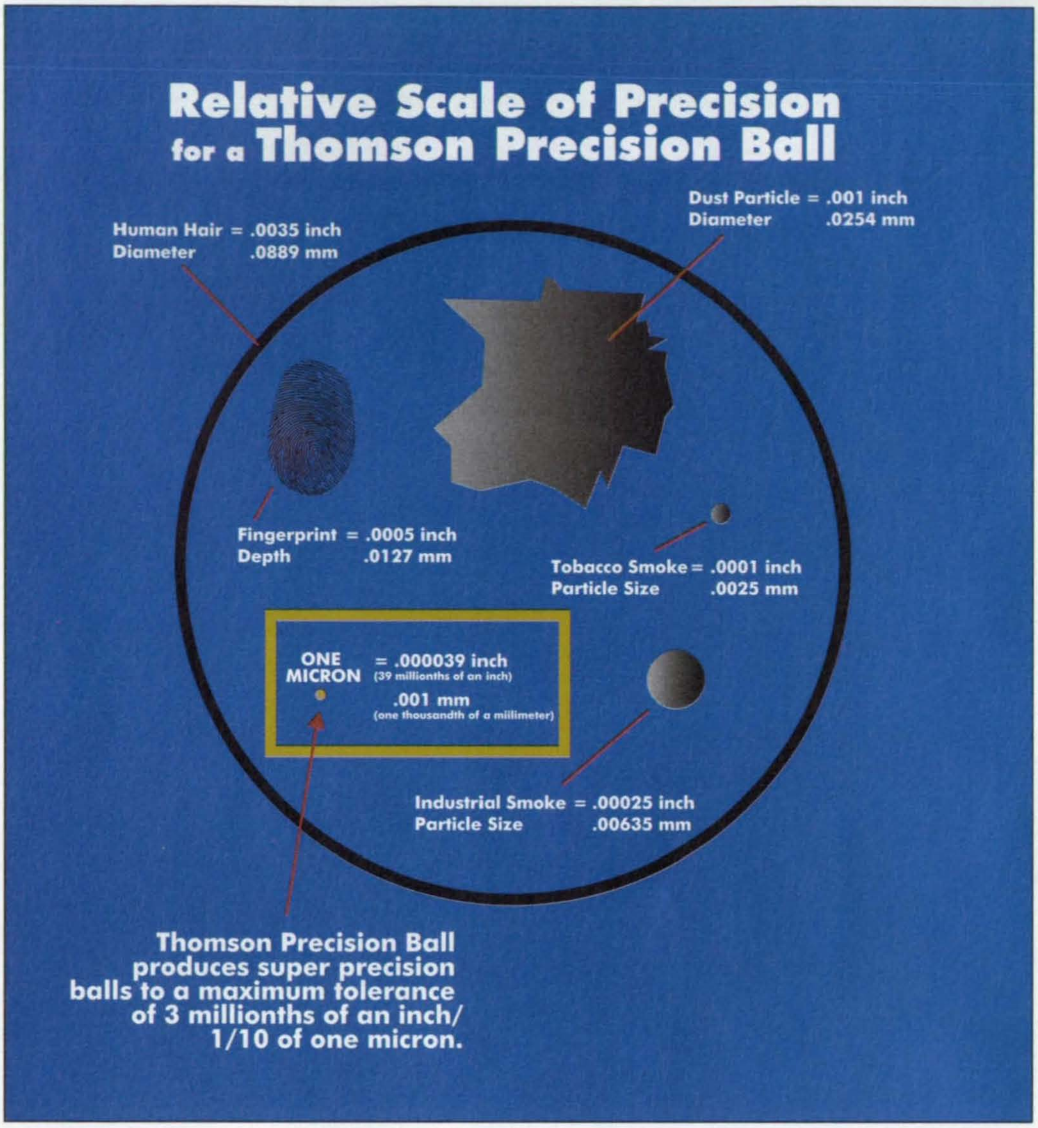
Spherical rolling elements are a critical component in the efficient transfer of motion.

Whether the application be a radial bearing, linear bearing, thrust bearing, or ball screw, high-precision spherical rolling elements such as those from Thomson Precision Ball Co. provide the means of minimizing friction during the transfer of mechanical motion. The end-use application, based primarily on load, speed, and accuracy requirements, determines the ultimate configuration of the bearing and/or ball-screw assembly in relation to the spherical rolling-element type.

The determining attributes of precision balls used as rolling elements include material type, nominal diameter size, incremental size, and tolerance grade. The key criterion in precision ball selection is to establish a balanced component design considering the tolerance requirements of the mating components of the precision balls in conjunction with the desired end-use operating characteristics of the bearing/ball-screw assembly.

Common material types include through-hardened chromium steel, through-hardened corrosion-resistant steel, and ceramics. Bearing-grade low-alloy chromium steel is the most widely used material today on a global basis. Through-hardened chromium steel has a Rockwell hardness of Rc 60-67, which minimizes wear, and provides high strength and and a high degree of fracture toughness. Domestically, this material is known as AISI 52100; in Europe the designation is 100 Cr6.

In the stainless steel family, AISI 440C is by far the most common corrosion-resistant material for bearing and ball-screw applications. Having a chromium content of 16-18 percent, it exhibits cor-



rosion-inhibiting characteristics in a variety of operating environments. Furthermore, this material provides good wear characteristics because of through-hardening, which yields an Rc 58-65 hardness rating. While a direct material replacement is not yet available to the European DIN/ISO standards, the X102CrMo17 material offers element properties very close to the domestic 440C material.

Ceramic material use in precision rolling-element applications started on a production volume basis approximately fifteen years ago for extremely high-tolerance radial bearing applications. The benefits of silicon nitride ceramic material are numerous, including a 40-percent reduction in weight, increased hardness, and 70-percent less thermal expansion when compared to type 52100 steel material. In addition, silicon nitride can safely operate in temperature environments up to 1800 degrees F. Essentially, any application requiring tight radial and/or axial clearance can benefit from the use of silicon nitride balls. These are most commonly used in corrosive environments, weight-sensitive applications, extreme temperature environments, and vacuum applications.

At this time, the relatively high cost of this material makes its use prohibitive in many applications. However, in those where increased performance can offset such costs, silicon nitride is often the material of choice.

Titanium balls represent a new product for Thomson. This highly inert material is lightweight, offers exceptional anticorrosive properties, operates effectively in high-temperature applications, provides a high level of tension/compression strength, and has expansion characteristics similar to steel. Titanium is used extensively in aerospace applications.

Size Matters

Precision balls are manufactured in both standard inch-diameter and metric-diameter sizes, *i.e.*, 1/8", 3 millimeter, etc. Below 1/32", sizes are typically expressed in decimal format, such as 0.008". These basic diameter dimensions are referred to as the nominal ball diameter size. In many applications, this is the only diameter requirement referenced. However, there are products that use precision balls not only as rolling elements but also as the means to build in specified free-play, preload, or backlash requirements such as bearing and ball-screw applications.

In these applications, precision balls are manufactured with either undersized or oversized diameters in increments of 0.0001" for customary inch units or by microns for metric units from the baseline nominal ball-diameter size. For example, in a radial bearing assembly requiring a radial play of 0.0002"-0.0005", the inner and outer ring ball track diameters are measured. From these measurements, a standard-diameter ball such as a 1/8"-size is adjusted to take into account the oversized/undersized condition of the inner and outer rings relative to the desired radial play requirements for the final bearing assembly. After these calculations are made, a determination of ball incremental size can be made. This concept also holds true for determining free play or preload in linear bearings as well as ball-screw assemblies.

The final design parameter is the ball grade. These industry standards are governed in the U.S. by the American Bearing Manufacturers Association (ABMA), in Europe by DIN specifications, and in Japan by the JIS reference specifications. In a very basic context, ball grade specifies the sphericity (roundness), diameter variation, and surface finish of the ball. For example, a Grade 5 ball would have a sphericity of 0.000005" (five millionths of an inch), a ball-to-ball diameter variation within a manufacturing lot or batch of ±0.000005", and a maximum surface-finish roughness of 0.8 Ra. In comparison, a Grade 24 ball will have a sphericity of 0.000024" (24 millionths), a lot diameter variation of ±0.000024", and a maximum surface condition of 2.0 Ra.

Tooling to Suit

For the majority of applications, precision balls maintain higher tolerance requirements in relation to their mating components. Using a Grade 5 ball as an example, it will have a sphericity within 5 millionths of an inch. Keep in mind that a human hair has a diameter of 3 thousandths of an inch. Therefore, the sphericity tolerance of a Grade 5 ball would equal 1/600 the diameter of a hair. With tolerances this small, sophisticated measurement techniques are mandatory to accurately identify ball grade. At Thomson, the latest specially designed equipment is used to measure sphericity and surface finish, with tooling uniquely designed to measure spherical objects.

In order to maintain a controlled environment for consistent readings, these measuring devices are maintained in an on-site A2LA-certified metrology laboratory with temperature control held to ±1/2 degree F, humidity control to a maximum of 50 percent, and particulate control to 0.5 micron.

It is critical to have a controlled environment such as this for spherical measurement, as a one-degree Fahrenheit increase in temperature will result in the diameter of the precision ball growing 17 millionths of an inch. This amount of diameter growth is significant when considering that the total tolerance limit of a Grade 3 through Grade 10 product is between 3-10 millionths of an inch. To assure that accurately measured products reach our customers, Thomas Precision Ball is both ISO 9002 and QS-9000 certified. We believe our A2LA accredited metrology laboratory is the only one certified in the U.S. for both the diametrical measurement of a sphere as well as form measurement and surface finish of any item configuration.

With the ability to manufacture and verify precision balls within a range of Grade 3-10 tolerances, the opportunity now exists to produce faster, quieter, smaller and higher-precision end-use items that require high-precision rolling elements. Examples of products that benefit from such balls include those made by the machine tool industry, which manufactures equipment capable of producing parts to tight tolerances. Items used in machine tools would include high-precision Ball Bushing® bearings and related linear guides; ball screws manufactured to high-tolerance JIS Class CO, ISO Class I specifications; and radial bearings utilizing ABEC 9 tolerances that minimize axial and radial play and can better maintain axial rigidity. Electric motors now run quieter due to tighter bearing tolerances ascribed in part to high-precision balls. Aerospace applications have longer component run time, which reduces aircraft down time for scheduled overhaul.

Tighter component tolerances as well as utilization of advanced precision ball materials such as ceramics result in longer assembly life and greater accuracy. For consumer electronic products, the VCR, PC computer disk drives, camcorders and CD players have all been reduced in size yet with increased performance and capabilities through precision ball/precision bearing technology. As mechanical components become smaller, faster, quieter, and more complex, high-precision rolling element ball technology will continue to be a key factor in the quest to minimize friction and extend component life.

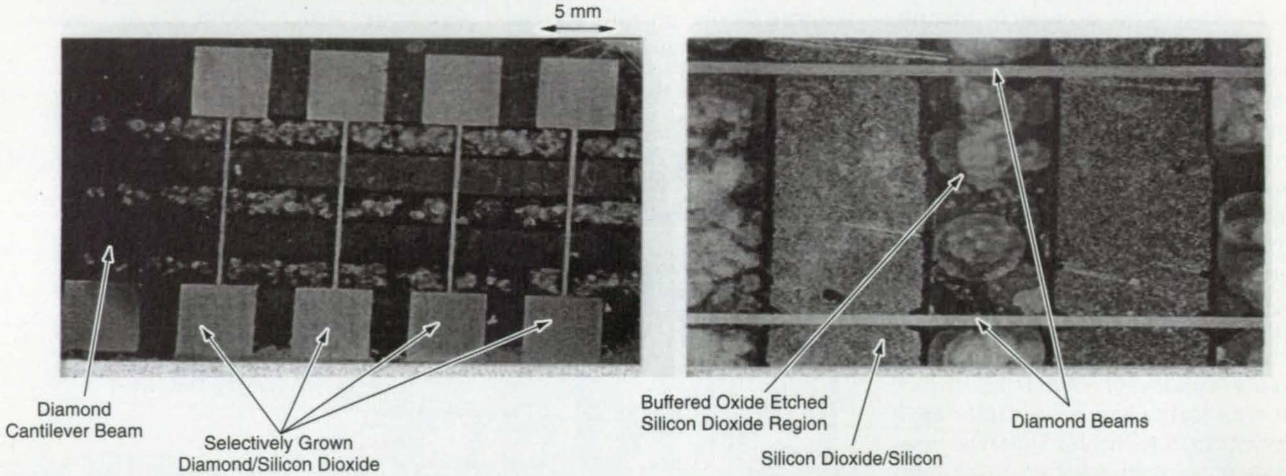
For further information please contact James W. Carle, the author of this article and manager of sales and marketing at Thomson Precision Ball Corp., 2 Channel Drive, Port Washington, NY 11050; 1-800-345-2534; (860) 673-2534; fax: (860) 673-5398; E-mail: precisionball@thomsonmail.com.

Surface Micromachining of Diamond for Fabrication of MEMS Microstructures

Diamond bridges and cantilevers are formed by selective deposition and selective etching.

NASA's Jet Propulsion Laboratory, Pasadena, California

A surface-micromachining process has been devised for use in fabricating microscopic polycrystalline diamond structures (e.g., bridges and cantilevers) as integral parts of microelectromechanical systems (MEMS). The general concept of MEMS encompasses such diverse objects as simple mechanical actuators, simple mechanical sensors, or complex units containing electronic or optoelectronic circuitry integrated with mechanical sensors and/or actuators. Because diamond is highly resistant to corrosion and is transparent, the ability to form diamond structures could contribute to



Optical photographs show **Diamond Beams and Diamond Cantilever Beams** that were fabricated using selective diamond deposition and subsequent micromachining process.

the development of MEMS to withstand corrosive environments. For example, diamond structures could serve as supports for corrosion-resistant electrodes in MEMS designed for biomedical applications. MEMS containing diamond films could also prove useful as automotive sensor and display devices.

An explanation of the distinction between surface and bulk micromachining is prerequisite to a description of the present diamond-surface-micromachining process. In bulk micromachining, three-dimensional features are etched into the bulk of a crystalline or noncrystalline material. In surface micromachining, features are built up, layer by layer, on a substrate of single-crystal silicon or other suitable material. The features in a given layer are defined by dry etching or selective deposition. Then the structure containing the feature is released from the substrate by wet etching (and consequent undercutting) of the substrate material.

The present diamond-surface-micromachining process is best described in terms of experiments in which it was first demonstrated. The starting substrates in the experiments were mirror-smooth, (100)-oriented single-crystal silicon wafers that were, variously, p- or n-doped to a resistivity <20 Ω·cm. The wafers were cleaned, then thermally oxidized to a depth of 1 to 1.5 micrometers.

Each substrate was prepared for selective deposition of diamond, following either procedure A or procedure B described below:

Procedure A. To increase the density of nucleation sites for diamond and thereby make it possible to obtain a pinhole-free diamond deposit, the surface of the oxidized substrate was damaged by ultrasonic agitation in methanol containing diamond particles. The ultrasonically damaged SiO_2 substrate surface was photolithographically patterned. By use of a buffered oxide-etch solution, the wafer was partially chemically etched through the openings in the photoresist to remove the damaged oxide surface layer and thereby define the areas where diamond was not to be deposited. The photoresist was then removed by commercial stripping solutions and the substrate cleaned in an oxygen plasma.

Procedure B. The SiO_2 substrate surface was photolithographically patterned, then the substrate was hard-baked at a temperature of 150 to 200 °C. The substrate (with the photoresist still in place) was subjected to ultrasonic agitation in methanol containing diamond particles, so that the SiO_2 surface areas exposed through the holes in the photoresist mask would be damaged and would therefore become sites for deposition of diamond. Then the photoresist was stripped off and the substrate cleaned as in procedure A.

Following procedure A or B, the substrate was cleaned, then placed in a chemical-vapor-deposition (CVD) chamber. Polycrystalline diamond was grown on the patterned and damaged SiO_2 areas by CVD from a flowing mixture of methane and hydrogen, typically at a total pressure of 45 torr (6 kPa) and a substrate temperature of 950 °C.

The diamond-patterned substrate was cleaned in solvents. In a photolithographic process, a new photoresist pattern was formed to define the portions of the substrate to be etched away from the diamond. Then by use of a buffered oxide-etch solution, the SiO_2 layer on the substrate was removed from under selected diamond-patterned areas, leaving diamond structures supported over airgaps (bridges and cantilevers).

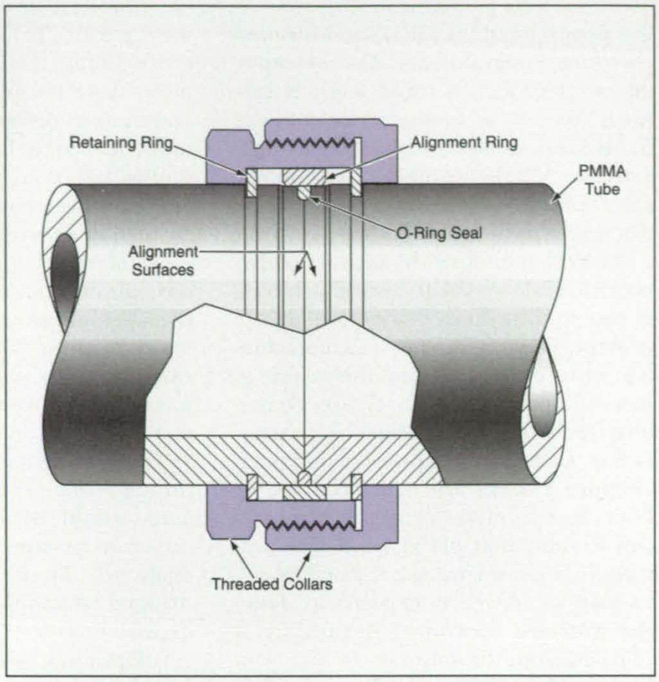
This work was done by Rajeshuni Ramesham of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category.*
NPO-20529

Coupling Fixture Aligns and Seals Ends of Two Tubes

Inner diameters are matched and aligned to present a smooth surface to flow.

Lewis Research Center, Cleveland, Ohio

The figure presents a partial cross section of two poly(methyl methacrylate) (PMMA) tubes with machined ends butted and sealed together in a special coupling fixture. This coupling scheme, in conjunction with the careful selection of PMMA tubes to match inner diameters, ensures the precise alignment of the inner tube surfaces. The scheme was devised to satisfy a re-



Two Tubes Are Sealed at a butt joint and held in alignment by a special coupling fixture.

quirement in a liquid-flow experiment to ensure a smooth, continuous inner tube surface to prevent both flow disturbances and trapping of bubbles. If the inner diameters were not matched and/or the inner tube surfaces not aligned precisely, the junction between the tubes would feature small, sharp corners that could give rise to waves and could trap bubbles.

The end surfaces of both tubes are machined flat and perpendicular to the inner surfaces. Cylindrical alignment surfaces referred to the inner surfaces are machined on the adjacent exterior end portions of the tubes. Facing halves of a seal groove are machined on the outer surfaces of the tubes at the butt joint. A retaining ring is placed in a groove on each tube at a short distance from the end. A male threaded collar is placed around one tube and a female threaded collar around the other tube, each collar covering and abutting the retaining ring on its respective tube.

The tubes are butted together along with an alignment ring and with an O-ring placed in the seal groove. The alignment ring is machined for a snug fit with the alignment surfaces on the tubes, thereby ensuring the precise alignment of the inner tube surfaces with each other. The two collars are threaded together until the force on the retaining rings pushes the ends of the tubes together. At this point, the O-ring is squeezed tightly between the tubes and the alignment ring, forming a tight seal.

In an alternative coupling scheme (not shown in the figure), the threaded collars are replaced by a combination of unthreaded collars and a two-piece ring clamp that engages the collars. The clamp features tapered surfaces that exert a longitudinal force to push the tubes together when the two halves of the clamp are bolted together.

This work was done by Robert Mate of the University of Houston for **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16255.

Wipers Based on Electroactive Polymeric Actuators

Advantages are simplicity and light weight.

NASA's Jet Propulsion Laboratory, Pasadena, California

Wiping devices that exploit finger-like bending motions produced by electroactive polymeric (ionomeric) actuators are undergoing development. These wiping devices function similarly to conventional windshield wipers. However, unlike conventional windshield wipers, these devices contain no motors, gears, or drive linkages; as a result, these devices are relatively simple, compact, and lightweight. Conceived for use in wiping dust off solar cells and windows of scientific instruments to be sent to explore Mars, these wiping devices might be useful for similar purposes on Earth.

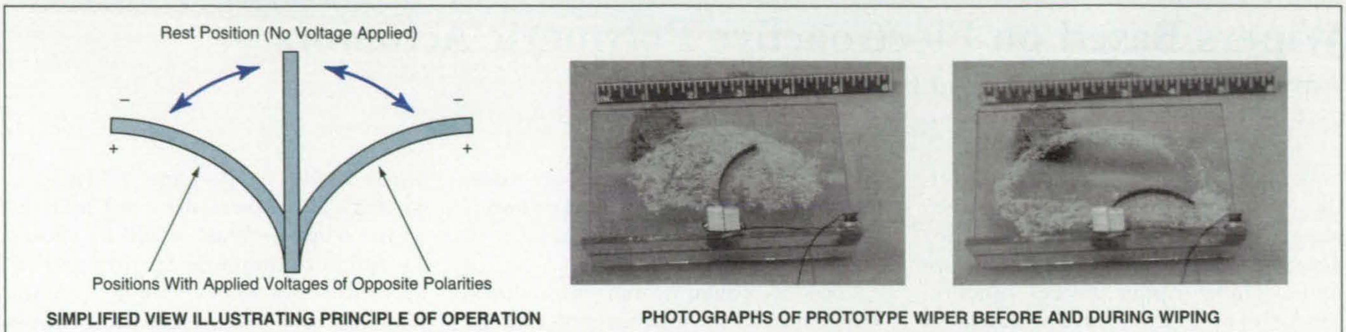
A device of this type is denoted by the acronym "SWEP" (for surface wiper actuated by electroactive polymers). The only moving part in a SWEP is the wiper arm/actuator. This part is made from electroactive polymers; namely, (a) a membrane made of an ion-exchange polymer sandwiched between (b) surface polymeric layers that contain or are coated with platinum and that serve as electrodes. When a small electric potential (typically a few volts) is applied to the electrodes, the sandwich bends. Depending on the magnitude of the applied voltage and the dimensions of the arm, the angle of bending could exceed 180°. The direction of bending depends on the polarity of the applied potential (see figure). Thus, one could make a wiper go back and forth across a surface, in the manner of a conventional windshield wiper, by applying an alternating voltage.

Electroactive polymers (EAPs) exhibit several characteristics that lend themselves well to SWEPs:

- EAPs can be mass-produced at costs much lower than those of piezoelectric materials, in large part because unlike piezoelectric materials, EAPs need not be poled.
- EAPs can readily be formed to desired sizes and shapes.
- Physical characteristics of EAPs that are particularly well suited to actuation in SWEPs include high toughness, large electrostrictive strain, and inherent damping of vibrations.

Another advantage of SWEPs is low power consumption. For example, the prototype unit shown in the figure operates with a drive power of 20 to 30 mW. In a typical application, the frequency of the alternating driving voltage would be a fraction of a hertz; however, the frequency could be made higher if necessary, because the characteristic response time of a SWEP is of the order of milliseconds.

Like a conventional windshield wiper, a SWEP for a typical practical application would preferably be constructed as a wiper/actuator arm with a wiper blade or perhaps a brush attached. The shape, size, and material of the blade or brush could be chosen by design to minimize friction and ensure effectiveness in cleaning. As in the case of a conventional windshield wiper, the wiping should be done at the minimum frequency that provides ef-



A **Wiper Arm/Actuator Made of Ionomeric Film** bends when a voltage is applied across its thickness. The direction of bending depends on the polarity of the voltage.

fective cleaning, in order to minimize scratching.

This work was done by Yoseph Bar-Cohen and Tianji Xue of Caltech and Mohsen Shahinpoor of the University of New Mexico for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*
NPO-20371

Inflatable Strakes for Forebody Vortex Control

It is not necessary to allocate valuable forebody volume to strake-deployment mechanisms.

Ames Research Center, Moffett Field, California

Inflatable nose strakes have been invented to assist in controlling the direction of flight of an airplane, especially a high-performance fighter-type airplane operating at a high angle of attack. In general, adjustments of the sizes, shapes, positions, and/or orientations of nose strakes gives rise to variations in forebody vortices and, consequently, to variations in aerodynamic forces. These variations can be used for flight control. Hinged, rigid nose strakes controlled by mechanical actuators via linkages have been investigated for use in forebody vortex control for

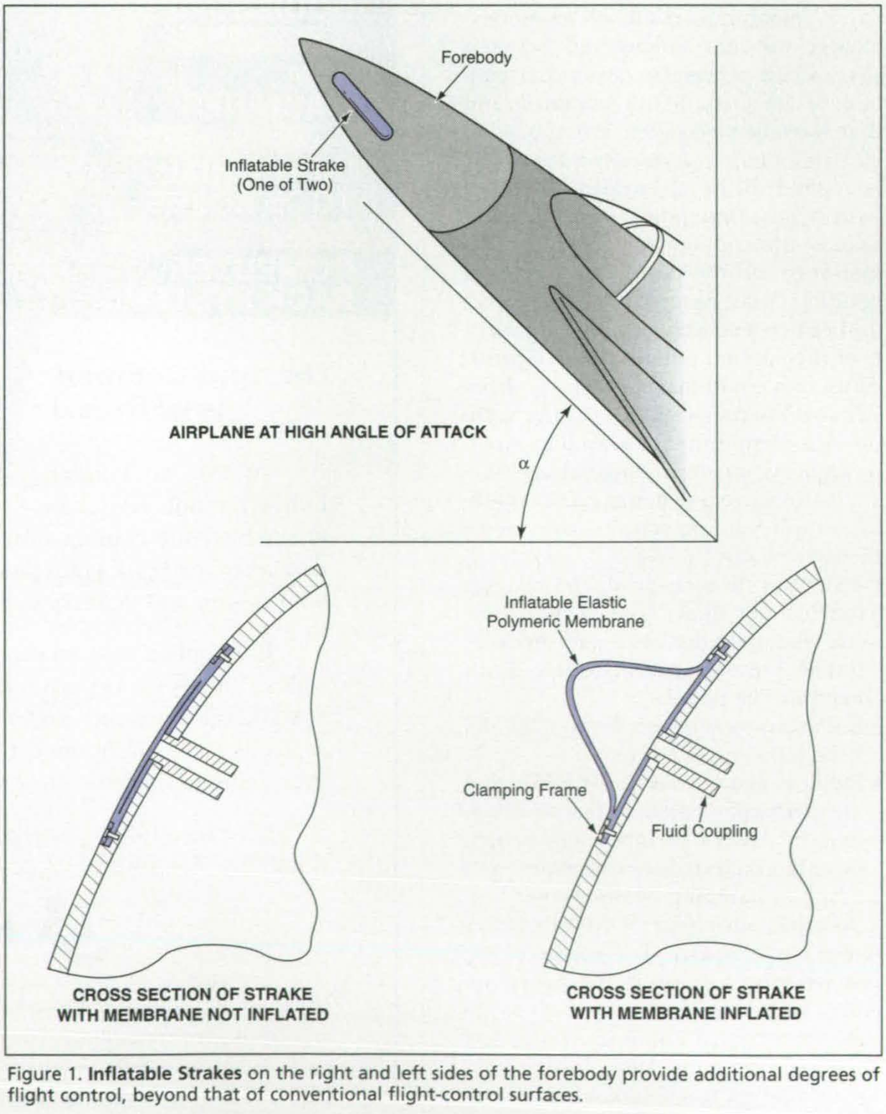


Figure 1. **Inflatable Strakes** on the right and left sides of the forebody provide additional degrees of flight control, beyond that of conventional flight-control surfaces.

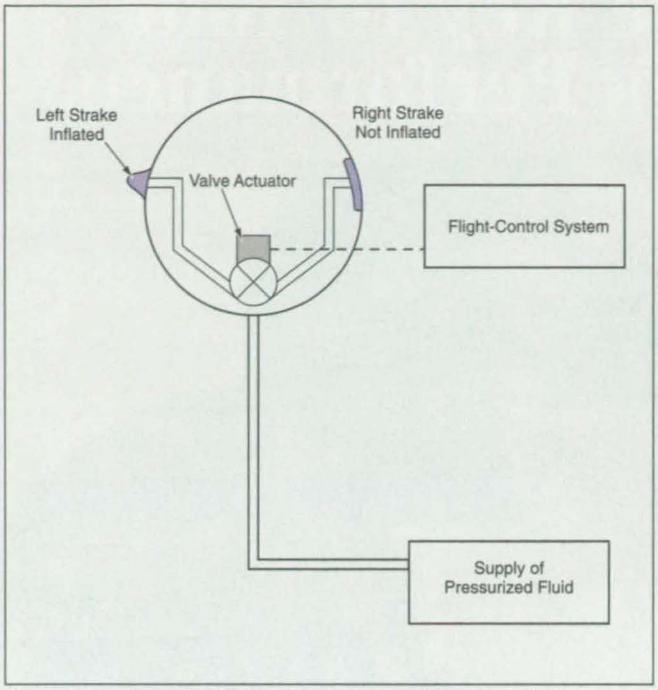


Figure 2. The **Inflatable Strakes Are Controlled** by a lightweight, compact pneumatic system, instead of by mechanical actuators and linkages like those used to control rigid strakes.

flight control, but they entail a significant disadvantage; the actuators and linkages occupy valuable forebody interior volume that is needed for radar and other instrumentation. In contrast, inflatable nose strakes occupy much less forebody interior volume.

Figure 1 depicts a typical fighter-type airplane at a high angle of attack, equipped with inflatable nose strakes. Each inflatable forebody strake includes an inflatable elastic polymeric membrane mounted in a shallow recess in the exterior skin of the forebody. The membrane is held in place by a clamping frame around the edge of the recess. A fluid coupling provides an opening into the volume enclosed by the membrane, for inflation or deflation of the membrane.

When the strakes are not inflated, the outer surfaces of the membranes lie flush with the adjacent forebody surface. When either strake is inflated, the outer surface of the membrane protrudes into the airflow, affecting the forebody vortices. If the strake on the right or left side of the forebody is inflated, the effect on the vortices is such as to give rise to a net leftward or rightward force, thereby causing the airplane to yaw to the left or right, respectively. If the membranes on both sides are inflated equally, the net effect is to generate a longitudinal or a pitch control force.

Figure 2 is a schematic diagram of the system for controlling the inflatable strakes. Any suitable pressurized fluid can be used to inflate the membranes; ordinarily, the preferred fluid is air because it can be handled easily, using equipment that adds little to the overall weight of the airplane. The pressurized air can be obtained via a tap from the airplane engine or from a separate compressor. A valve directs the flow of the pressurized fluid to neither, either, or both strakes. The pilot controls the valve through the airplane flight-control system.

This work was done by Peter T. Zell of **Ames Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

This invention has been patented by NASA (U.S. Patent No. 5,326,050). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (650-604-5104). Refer to ARC-11979.

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Magnetic Random-Access Memories

Advantages include unlimited cyclability and radiation hardness.

NASA's Jet Propulsion Laboratory, Pasadena, California

A Magnetic Random-Access Memory (MagRAM) is an array of bistable magnetic memory elements with semiconductor amplifier and addressing circuitry. MagRAMs are in the early stages of development, which has been motivated by a need for nonvolatile memories with high densities and unlimited cyclability — a combination of properties that has not been achieved in nonvolatile electronic RAMs. In principle, the magnetic memory elements in MagRAMs can be made free of fatigue and thus capable of unlimited cyclability. Magnetic memory elements provide signals of reasonable magnitude that can be amplified by semiconductor electronic circuits, and offer the additional advantage of radiation hardness.

In a MagRAM, data is stored in the magnetic states of the magnetic memory elements, which are hysteretic. The data is read from these elements by using the magnetoresistive effect to sense their magnetization states. Figure 1 is a simplified schematic diagram of a 16-bit MagRAM. A designated bit element is addressed, for reading or writing, by the application of appropriate currents to the word-line (row) conductors and sensing-line (column) conductors that intersect at that element. The current in the word-line conductor generates the magnetic field to write a bit in the designated element. A bit (0 or 1) is written in an element by applying a sensing current I_S, together with a writing word current $-I_W$ for a 0 or $+I_W$ for 1. Nondestructive readout of the bit is effected by applying I_S with (a) a word current $-I_R$ followed by (b) a word current $+I_R$ ($I_R<I_W$). During readout, the analog sensing amplifier and latch act together to convert the change in voltage on the sensing line to a bit. The currents I_W, I_S, and I_R are chosen according to the hysteretic and magnetoresistive properties and the need to prevent spurious writing in inactive cells crossed by active word-line conductors.

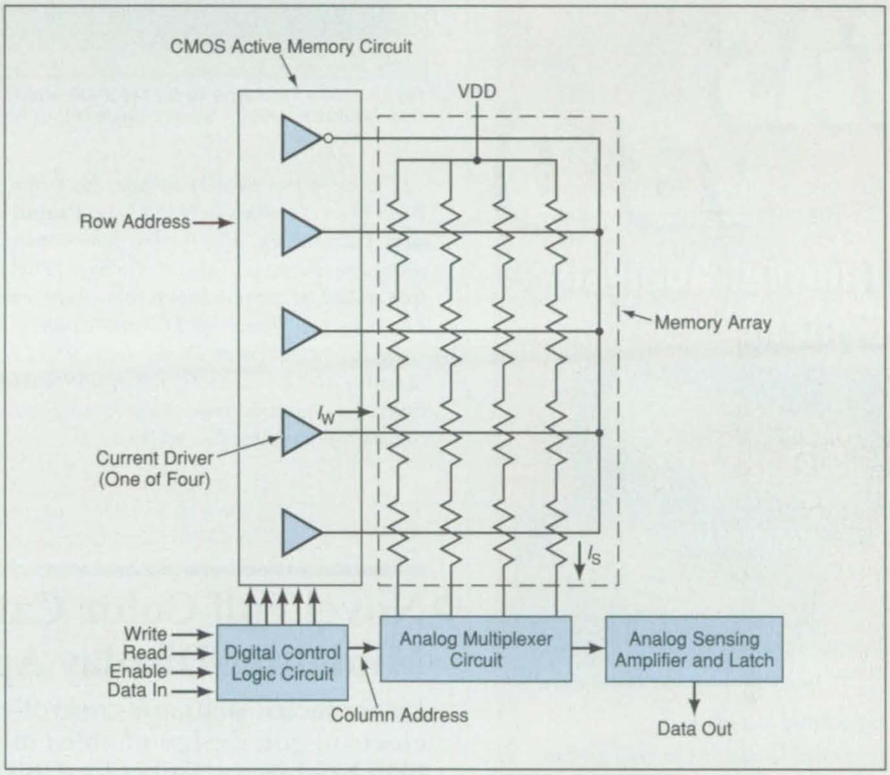

Figure 1. A **MagRAM** is an array of bistable magnetic memory elements within a matrix of semiconductor electronic circuitry that provides amplification, latching, and addressing.

A low-density 16-bit prototype MagRAM based on the concept is illustrated in Figure 2. This assembly is made from discrete subsystems in the sense that the functional blocks indicated in Figure 1 are implemented by means of interconnecting separate integrated-circuit chips. Subsequent development efforts are expected to lead to the integration of all magnetic and electronic MagRAM components onto a single chip that would feature high memory density and low power consumption.

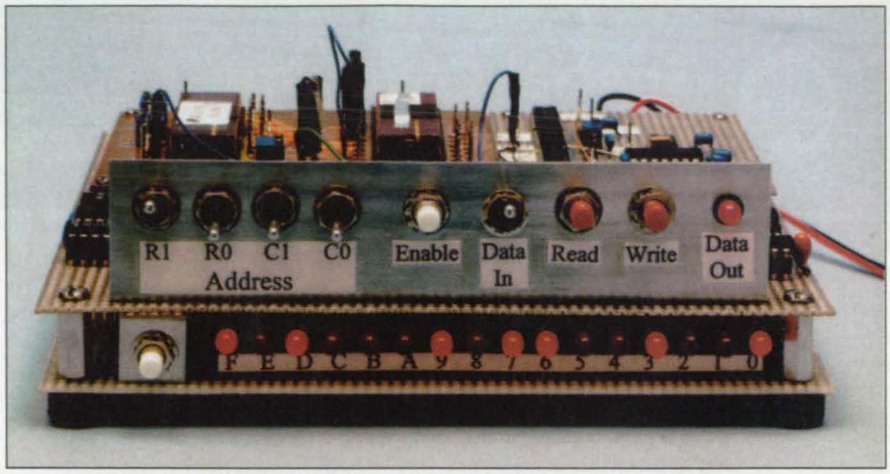

Figure 2. This **Prototype 16-Bit MagRAM and Display Unit** contains discrete integrated-circuit chips that would be combined into a single chip in an advanced production version.

This work was done by Romney Katti and Brent Blaes of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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:

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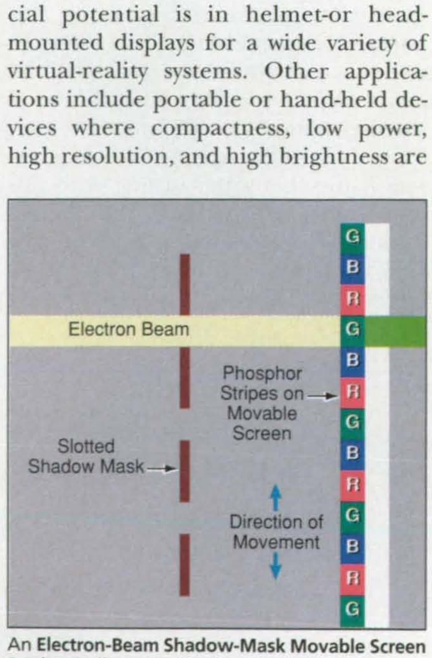
Refer to NPO-20131, volume and number of this NASA Tech Briefs *issue, and the page number.*

Novel Full-Color Cathode Ray Tube for Miniature-Display Applications

Piezoelectric-actuator-controlled, movable-screen, single-electron-gun design enables miniaturization of high-resolution, high-brightness, full-color CRTs for small-display applications.

NASA Lewis Research Center, Cleveland, Ohio

A novel cathode ray tube (CRT), using a single electron gun and a movable screen, has been developed that now enables miniaturization of a full-color CRT with the same excellent viewing quality customarily found in larger-screen CRTs. In addition to the benefits of wide viewing angle, high resolution, high brightness, color purity, and full gray-scale features that are characteristic of CRTs, the need for only one electron gun is expected to also result in reduced power consumption and lower cost. The movable-screen design, a significant improvement over the earlier moving-shadow-mask version (1), is considered feasible for CRTs ranging in size from less than 1 in. (2.5 cm) to greater than 5 in. (12.7 cm). A unique and highly advantageous feature of the improved design, which is described in greater detail below, is the elimination of spatial offset of the color pixels. One obvious application with great commercial potential is in helmet-or head-mounted displays for a wide variety of virtual-reality systems. Other applications include portable or hand-held devices where compactness, low power, high resolution, and high brightness are



An **Electron-Beam Shadow-Mask Movable Screen Region** is illustrated in this top view.

desirable or advantageous, such as TVs, monitors for VCRs, and viewfinders for camcorders, especially for outdoor use.

The conventional CRT uses three electron guns, one for each primary color (red, green, blue), plus a stationary slotted or otherwise perforated shadow mask aligned with the color phosphors on the glass screen. The geometrical relationship between the mask and the guns is designed so that the electron beam from each gun impinges on only the phosphor dots of the desired primary color. Accurate alignment of the guns, shadow masks, and phosphors is critical to the purity of the primary colors and resolution of the display. Achieving the beam convergence and registration required for high resolution becomes extremely difficult for a miniature full-color CRT with three electron guns and is, therefore, commercially impracticable. Other single-electron-gun designs, such as the beam index tube and color shutter tube, lack either the high resolution or high brightness desirable for most miniature-display applications. By default, the miniature color display market is presently dominated by flat-panel displays (FPDs), the most common of which is the active matrix liquid crystal display (AMLCD). This and all other miniature FPDs, either presently on the market or under development, have one or more of the following drawbacks: poor resolution (graininess), low brightness, narrow viewing angle, high cost, or high power consumption. The miniature full-color CRT described here has none of these drawbacks.

A simplified representation of the electron beam — slotted shadow mask — movable screen region is shown in the figure. In contrast to the earlier version (1), the shadow mask remains stationary and the moving part is a thin inner glass sheet that contains the parallel red-green-blue phosphor stripes and is mounted on piezoelectric actuators for precisely controlled movement. To write a given primary color, the electron gun is activated at the beam intensity needed to obtain the desired brightness. At the same time, the piezoelectric actuators are energized to align the phosphor stripes of that color with the slots in the shadow mask and also mask the other two colors with the solid portion. The entire color field is written before the screen is moved to uncover the next color. Full color is achieved by overlaying the three-color fields in time. In the improved movable screen version, the moving element is much lighter; thus shortening the hold-off time between color changes to less than 140 ms. If the mask is not perfectly aligned with the phosphor stripes during assembly of the CRT, it can be accomplished electronically during monitor calibration by applying dc-offset voltages to the piezoelectric actuators. The capability for electronic alignment is an important feature that offers not only the possibility of greater color purity and brightness, but also lower manufacturing cost by reducing the elaborate jigging required for alignment during assembly of the conventional shadow mask CRT. Having the light-emitting element—the screen—moving is a great advantage because the color pixels have no spatial offset as seen by the viewer. Up close, the viewer sees one composite color dot, not three primary color dots that the eye must then attempt to integrate. Except for the color shutter tube, which is seriously lacking in brightness, this feature is not found on other displays including conventional CRT's, AMLCDs, and FEDs (fuel-emission displays). It is particularly important where close-in viewing is necessary, such as in helmet-mounted displays.

A further improvement contributing to lower cost is assembly of the mask and actuator components on a laser-cut, multilayer ceramic stack with printed-circuit elements to power the piezoelectric actuators. The ceramic stack is part of the vacuum envelope wall and leads to lower part count, less complexity, and better alignment and rigidity.

By providing the means to rapidly move objects in vacuum with amplitudes up to 0.015 in. (0.38 mm) also the capability to withstand temperatures up to 450 °C, this work advances the state of piezoelectric technology. It is expected to find application in other areas, such as sensors and MEM (micro electromechanical) devices.

(1) B.K. Vancil and E.G. Wintucky, *Ultra-high Resolution Miniature Color CRT for Virtual-Reality Applications,* Proceedings of 5th National Technology Transfer Conference (Technology 2004), Vol. 2, NASA Conference Publication 3313, 1994.

This work was done by Bernard K. Vancil of FDE Associates for **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16187.

Surface-Plasmon Reflective Flat-Panel Color Displays

These displays would be readable in ambient light.

NASA's Jet Propulsion Laboratory, Pasadena, California

Reflective flat-panel color display devices based on surface plasmons are undergoing development. Heretofore, no reflective flat-panel color display devices have been available. The active matrix liquid-crystal devices now used to provide flat-panel color displays must be lit internally, are power-hungry (typically consuming about 80 percent of the power of a laptop computer), and cannot be read in bright ambient light. In contrast, the surface-plasmon display devices would be operated without internal lighting, would consume much less power, and would be readable in bright ambient light (including sunlight).

This development is based on voltage-induced color-selective absorption of light in surface plasmons: When a surface-plasmon wave is excited at a metal/liquid-crystal interface, the absorption spectrum of surface-plasmon resonance can be shifted across the visible range by altering a voltage applied to the liquid crystal. This effect can be exploited to make a tunable notch filter — more specifically, a filter that absorbs most of the incident light in a voltage-adjustable wavelength range (the "notch") and reflects most of the incident light outside that range. If incident white light can be reflected from two tunable notch filters in succession and if the absorption wavelength range of each filter can be made to span about 2/3 of the visible spectrum, then by suitable choice of the notch wavelengths, the resulting display can be made to appear black (most of the incident light absorbed), white (most of the incident light reflected), or any primary color at a selectable level of brightness.

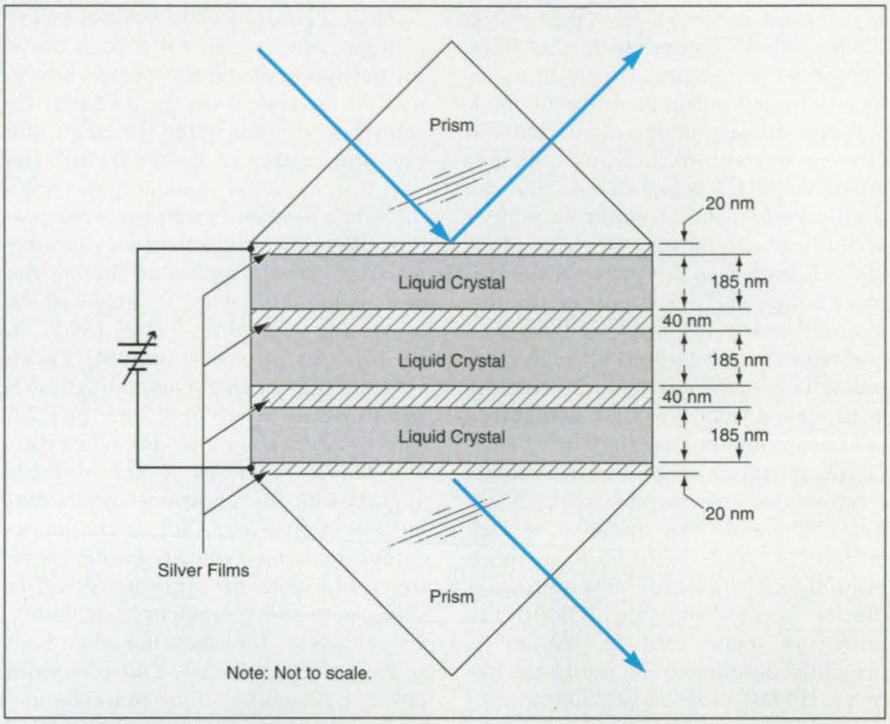


Figure 1. A **Surface-Plasmon Optoelectronic Device** of this general configuration would exhibit the desired voltage-tunable notch-filter characteristic, according to theoretical calculations.

The problem then becomes one of how to implement a voltage-tunable notch filter and to combine a number of such filters into an array of pixels to construct a flat-panel display device. Figure 1 illustrates such a filter, which includes two high-index-of-refraction prisms for coupling, plus four silver films interspersed with three liquid-crystal layers. Surface-plasmon waves are excited at the six liquid-crystal/metal-film interfaces, and the layers are made sufficiently thin that the surface-plasmon waves are coupled together. When a voltage is applied between the two outermost silver films, the device acts electrically like three capacitors in series, and the electric field affects the indices of refraction of the

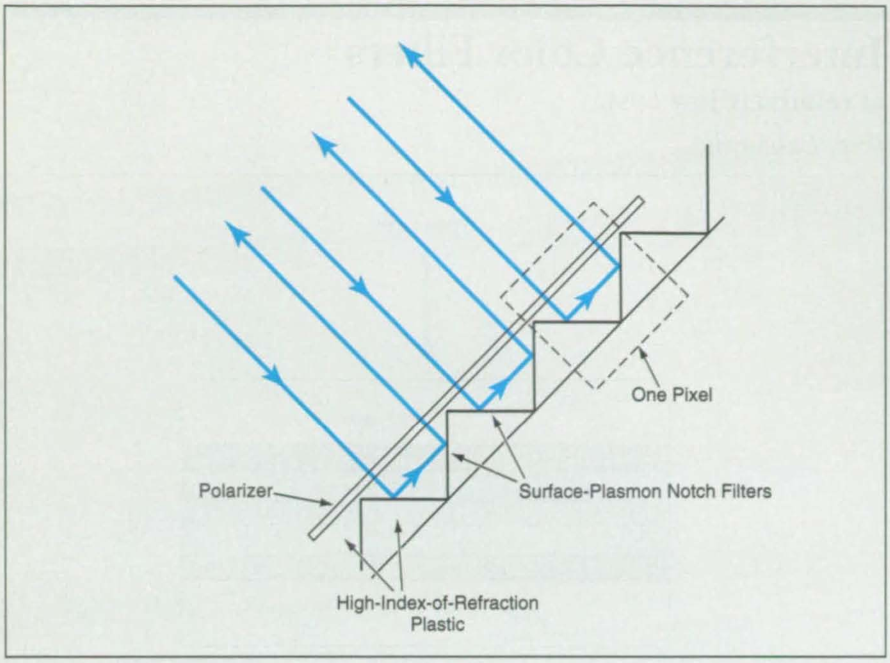


Figure 2. A **Reflective Flat-Panel Color Display Device** would contain two surface-plasmon notch filters, similar to that shown in Figure 1, in each pixel.

liquid-crystal layers, causing a wavelength shift of the absorption spectrum. A theoretical calculation shows that this filter would exhibit the desired notch characteristic, that with no voltage applied, it would absorb primarily in blue-green light, and that its absorption wavelength region could be shifted to red or beyond by applying increasing voltage.

Figure 2 shows part of a proposed flat-panel display device, wherein each pixel would contain two notch filters. The prisms — now microscopic to fit the pixels — would be molded into sheets of high-index-of-refraction plastic. A polarizer sheet would be mounted on the front surface to select p-polarized light. After polarization, the incident light would be reflected from one notch filter, then from the other notch filter. By choice of the voltages applied to the two notch filters in each pixel, one could obtain a desired color combination as described above.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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Refer to NPO-20244, volume and number of this NASA Tech Briefs *issue, and the page number.*

Metal/Dielectric-Film Interference Color Filters

These filters could be fabricated at relatively low cost.

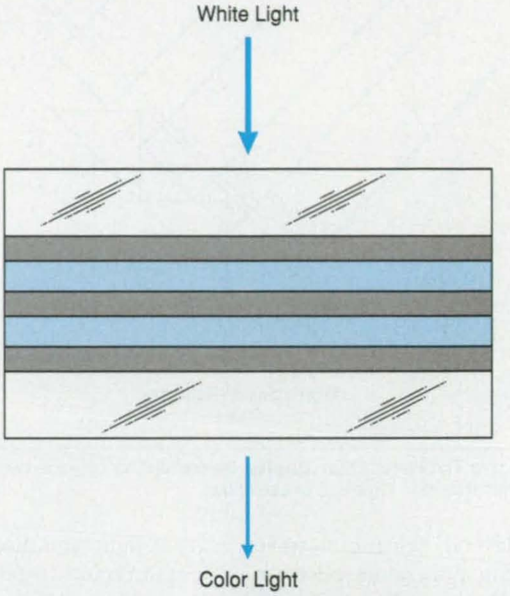
NASA's Jet Propulsion Laboratory, Pasadena, California

Color interference filters for individual pixels in solid-state electronic image and display devices would be made of thin metal and dielectric films, according to a proposal. The proposed filters would overcome the primary disadvantage (high cost) of dye color filters like those used in liquid-crystal display devices, digital cameras, and camcorders. The proposed filters would also offer advantages of cost and functionality over color interference filters made of alternating dielectric layers with different indices of refraction.

The all-dielectric filters are expensive because of the need for large numbers of layers to obtain adequate discrimination among red, green, and blue (RGB). The proposed filters would provide adequate color discrimination with acceptably broad-band response (pass wavelength bands about 100 nm wide). The proposed filters would be relatively inexpensive because they would contain fewer layers — typically no more than five layers, and only two layers need to have different thickness for RGB colors, which means it only needs to be masked 2 × (3 – 1) = 4, as contrasted with more than 10 layers for an all-dielectric filter, and needs to be masked 10 × (3 – 1) = 20.

Figure 1 shows aspects of a proposed five-layer metal/dielectric filter containing three layers of silver alternating with two layers of magnesium fluoride. The table in the figure shows the film thicknesses needed to make the filter transmit each of the three primary colors. The corresponding silver layers for all three color filters could be of the same thicknesses; only the magnesium fluoride layers would differ in thickness among the three colors. The total number of distinct layer thicknesses is only five, three for silver and two for magnesium fluoride.

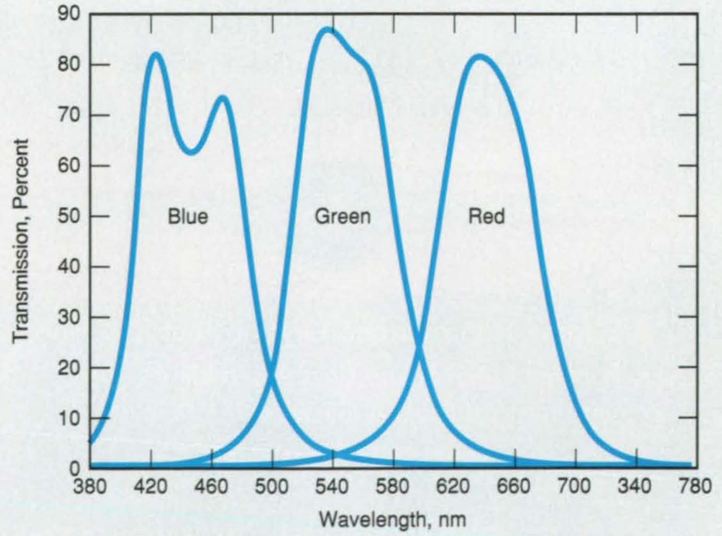
Because of the small number of thicknesses, patterning and other aspects of the fabrication of a device with three primary-color filters in each pixel (see Figure 2) would be relatively easy. The metal patterns could be formed in the presence of photoresist masks temporarily substituting for the magnesium fluoride films. The optical thickness of each photoresist mask would be made equal to that of the magnesium fluoride film to be subsequently deposited in its place.



CROSS SECTION OF FILTER (NOT TO SCALE)

	Ag	MgF_2	Ag	MgF_2	Ag
Red	23	185	40	185	23
Green	23	150	40	150	23
Blue	23	110	40	110	23

LAYER THICKNESSES (IN NANOMETERS) FOR TRANSMITTING EACH OF THE PRIMARY COLORS



CALCULATED TRANSMISSION SPECTRA

Figure 1. A **Broad-Band-Pass Interference Filter** to pass one of the primary colors could be made of three thin layers of silver interspersed with two of magnesium fluoride.

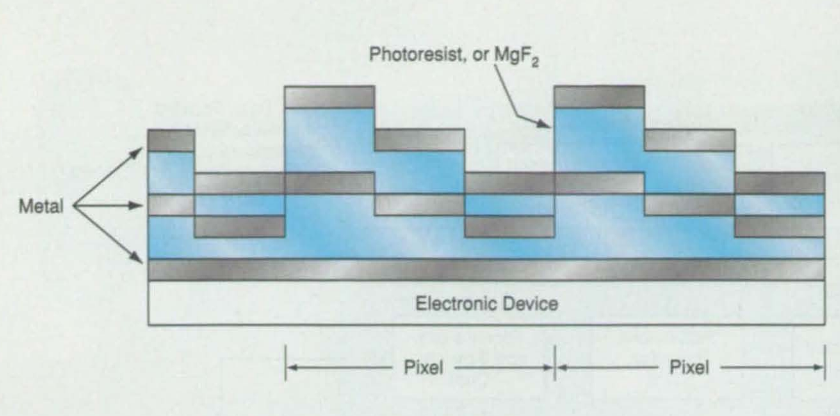


Figure 2. **Filters for All Three Primary Colors** could be fabricated within each pixel of a display or image device, by use of established deposition and photoresist patterning techniques.

Because it is relatively easy to control the thickness of a photoresist mask, fabrication should be relatively simple and inexpensive.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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

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Refer to NPO-20217, volume and number of this NASA Tech Briefs *issue, and the page number.*

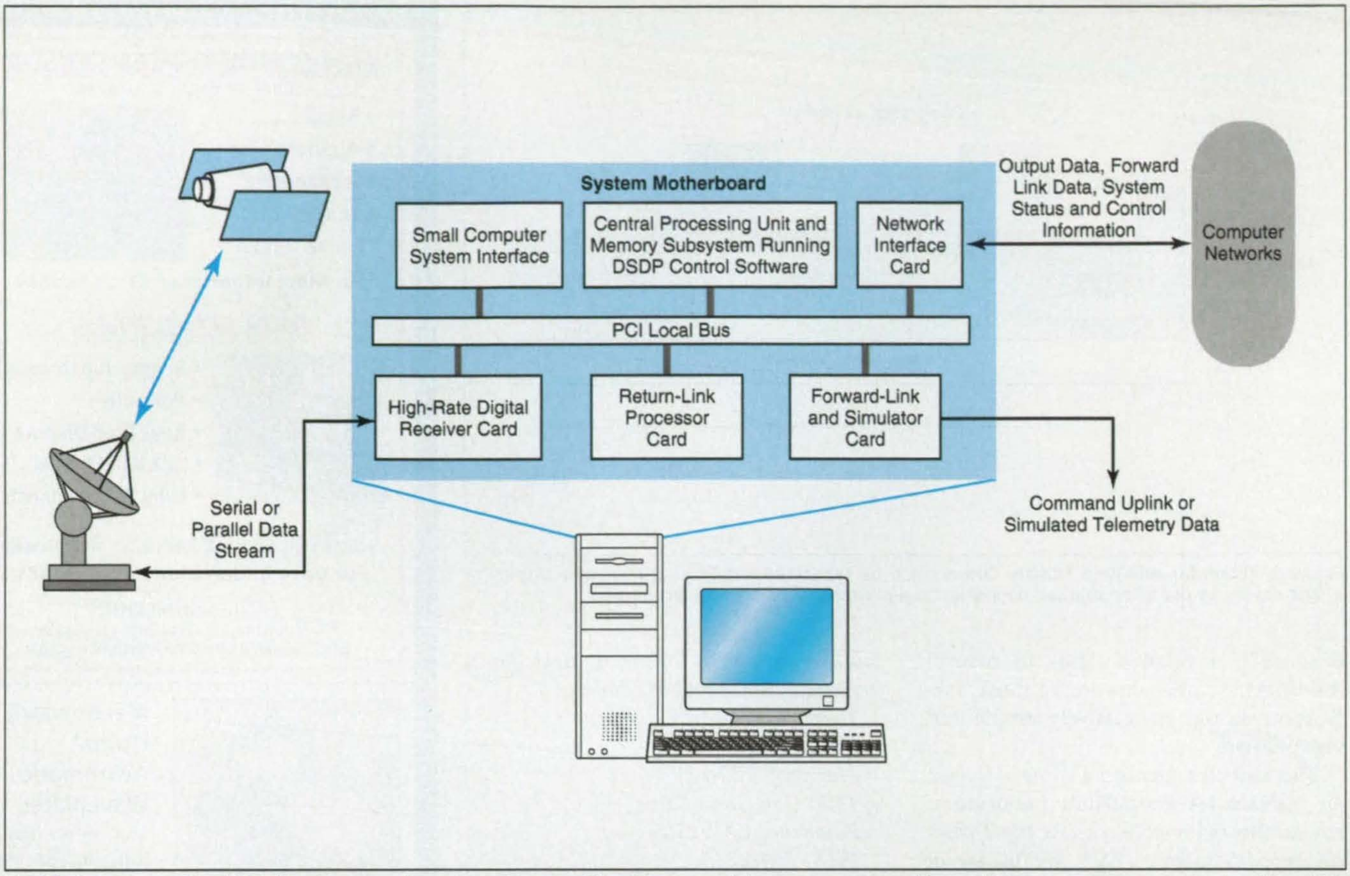
Desktop Computer System Processes Satellite Data

This system is reconfigurable, easy to use, compact, and relatively inexpensive.

Goddard Space Flight Center, Greenbelt, Maryland

The Desktop Satellite Data Processor (DSDP) is a prototype computer system for processing telemetry data received from, and command data to be transmitted to, a spacecraft in orbit around the Earth (see figure). The design of the system utilizes very-large-scale integrated (VLSI) application-specific integrated circuits (ASICs), parallel computer architectures, and pipelined data processing. Advanced software and a high level of integration of hardware and software components are expected to make a fully developed version of the system fit into a desktop-sized package at relatively low cost; the fully developed system is expected to be less than one-fourth as large as an equally capable system made entirely from commercial off-the-shelf (COTS) components.

The DSDP contains ASIC components that perform frame synchronization, Reed-Solomon decoding, and other standard telemetric processing functions (e.g., sorting and annotation of data packets) that are denoted generally as "service processing" and are performed according to recommendations of the Consultative Committee for Space Data Systems (CCSDS). The ASIC components are integrated onto custom-designed, highly reusable circuit cards based on the industry-standard peripheral component interconnect (PCI) bus. By high-level integration of the telemetry-processing functions into VLSI chips and cards, the design of the system affords high performance and high reliability and, relative to older telemetry systems, low cost.



The **DSDP Acts as an Earth/Satellite Gateway** that communicates with other terrestrial computer systems (from which commands are received and to which telemetry data are delivered) via standard commercial computer-network interfaces.

The DSDP hardware comprises several custom-designed PCI-bus modules containing the ASIC circuit cards plus COTS components. The functions of the modules, ASICs, and COTS components are integrated by use of the DSDP control software, which provides a generic environment for controlling and monitoring diverse hardware components within a system.

The DSDP control software is a distributed, modular, platform- (operating-system)-independent, highly reconfigurable, reusable, software system that facilitates customization by and for users and is easily modifiable to support system upgrades and new system components. It affords a general-purpose capability for displaying data and creating graphical user interfaces for controlling and monitoring systems. The graphical user interfaces are easy to use (and highly automated) making it possible for a nonspecialist to configure and operate the system. The software also includes tools for planning and scheduling operations, and for the management, processing, generation, and assurance of the quality of, scientific data products. These characteristics make the DSDP control software attractive for other applications that involve scheduling, planning, and the distribution of data; examples include medical, banking, stock-exchange, and automotive-production applications.

This work was done by Barbie Brown, Parminder Ghuman, Jeremey Jones, Johnny Medina, and Greg Schmidt of **Goddard Space Flight Center***; Tom Brooks, Lisa Koons, and Randy Wilke of Century Computing Inc.; John Stachniewiczs and Keith Wichmann of GS&T; and Daryl Halliday of Visix. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category. GSC-14036*

Special Coverage: Computers & Peripherals

Panasonic Medical & Industrial Video, Secaucus, NJ, has introduced the PanaFlat TX-D5L31FM LCD and CT-1386YWD1 CRT **color monitors**. The LCD monitor features a 15" liquid crystal anti-glare display with a pixel pitch of 0.297 mm and a maximum resolution of 1024 x 768 lines. The display can be detached from its stand and hung on a wall for increased space efficiency. The monitor also features Windows 95/98 Plug and Play functions.

The CRT model is a 13" monitor with three video (BNC) and audio (RCA) inputs/outputs for connection to a variety of sources, plus an S-Video input. A comb filter and notch filter are included for image clarity.

For More Information Circle No. 731

Teknor Industrial Computers, Boisbriand, Quebec, Canada, offers the TEK-CPCI-1004 industrial CompactPCI **single-board computer**, which features a Pentium processor and uses an ALI Aladin V chip set. The computer supports Socket 7 and Super 7 Pentium processors at 133 and 166 MHz, and Pentium processors with MMX technology at 200 and 233 MHz. It also supports a front-side bus of up to 100 MHz.

The board comes in two form factors: 6U single slot and 6U dual slot. The standard configuration includes a built-in EIDE disk interface, which supports up to four hard disks; onboard Ultra Fast/Wide SCSI 3 controller; two onboard PCI 10/100 Base TX Ethernet controllers; a PCI-to-PCI bridge; and standard I/O devices such as serial, parallel, keyboard, mouse, and two USB ports.

For More Information Circle No. 726

The DSU-100 two-port serial **PCI adapter** from Quatech, Akron, OH, is a two-channel asynchronous serial USB peripheral providing two independent, high-speed RS-232 ports. It is compatible with USB specification 1.1, and supports modems, printers, scanners, barcode readers, touchscreens, plotters, ISDN terminal adapters, and other standard serial devices. It is supported under Windows 98.

It comes standard with two independent 16550 UARTs containing 16-byte FIFOs. The FIFOs, with the FIFOs in the USB microcontroller, buffer received and transmitted data. The adapter is bus powered, eliminating the need for an external power supply. All devices are hot-swappable.

For More Information Circle No. 729

The Model CP8000 CompactPCI **rackmount enclosure** from SBS Technologies, Vista, CA, features hot-swappable power supplies and fans. The 9U high enclosure comes standard with an 8-slot CompactPCI backplane for 6U cards, and can accept special telephony backplanes. It also accepts a variety of plug-in CompactPCI CPU cards from the PowerPC to the Pentium II processor.

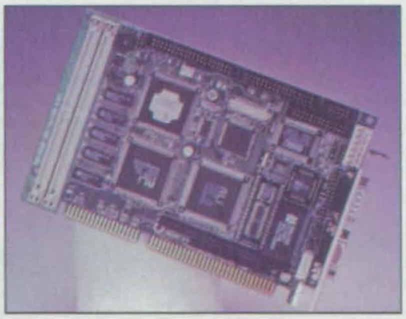
Dual hot-swappable power supplies allow the system to continue operation if one of the supplies malfunctions. Three 5.25" or 3.5" front-accessible, horizontal shock-mounted drive bays are located behind the front panel door. Positive pressure cooling is provided by three 4.7" hot-swappable ball bearing fans located below the card cage. The all-steel enclosure provides EMI/RFI shielding and line transient protection.

For More Information Circle No. 727

CTI Electronics, Stratford, CT, has introduced a family of **rackmount keyboards** that are compatible with all popular computers. Available in 1.75" (1U) or 3.5" (2U) panel heights, the keyboards feature built-in trackball pointers for their respective panel heights. Trackball diameters are 1.5" for the 1U and 2" for the 2U panel heights. The keyboards also feature a patented, fold-down panel that provides a hand rest for the operator.

The keyboard frame and mounting plate are made of heavy-gauge aluminum. Both assemblies fit a standard 19" rack and are available with or without the trackball. The 2U height keyboards feature 104 keys; the 1U feature 87 keys. The trackballs are protected against dust, dirt, and water.

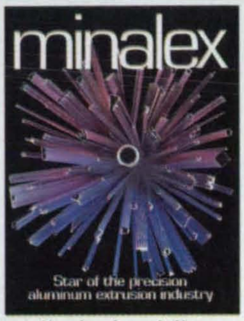
For More Information Circle No. 728



MiTAC Industrial Corp., Fremont, CA, offers the MSC-348 ruggedized **single-board computer**, a half-length ISA bus card that features the AMD 5x86 133 CPU, one PC/104 expansion connector, onboard VGA chip set, enhanced IDE and FDD controllers, and dual serial ports configured as RS-232 or RS-232/422. It has an SSD socket that supports Disk-on-Chip up to 72 MB, providing a small hard disk substitute on the SBC.

Other standard features include a 128 KB pipelined burst SRM L2 cache; two 72-pin SIMM sockets; internal buzzer and external speaker connection; and a 16-level watchdog timer. The VGA interface supports both CRT and LCD displays simultaneously, including STN, TFT, and EL panel modes.

For More Information Circle No. 730



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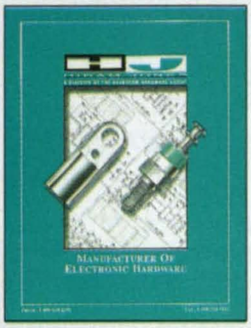

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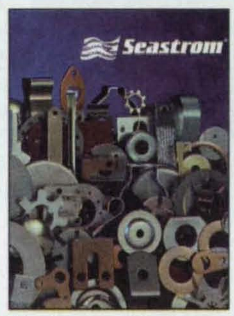

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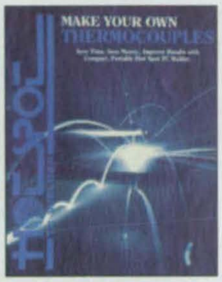

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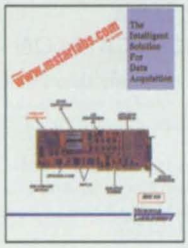

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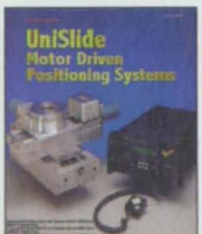

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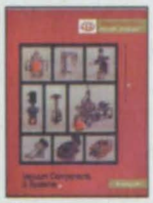

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INSTRUMENT DATA ACQUISITION

The SoftwareWedge™ directs serial (RS-232, RS-485, RS-422) data from any instrument into any Windows 3.x, 95, or NT application such as Excel, MMIs, VB, Control, and Statistical applications. This configurable driver provides full data acquisition and control of PLCs, data loggers, scales, flow meters, lab instruments, etc. Please contact TAL Technologies, Inc., 2027 Wallace St., Philadelphia, PA 19130; Tel: 800-722-6004 or 215-763-7900; Fax: 215-763-9711; http://www.taltech.com

TAL Technologies, Inc.

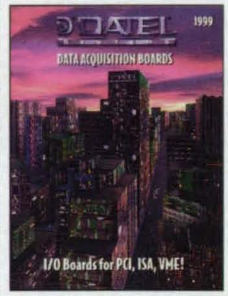
For More Information Circle No. 671

FREE 1999 PC & PCMCIA SOLUTIONS HANDBOOK

Quatech's new 1999 product handbook details our extensive line of quality communication, data acquisition, and signal conditioning products for PCMCIA, ISA, PCI, and USB. New for 1999 are 2-8 port RS-232 and RS-422/485 PCI serial adapters and 2 & 4 port RS-232 USB serial adapters. Product overviews, photos, and complete technical specifications are provided. For your free copy call 1-800-553-1170, e-mail sales@quatech.com, or visit our Web site at www.quatech.com.

Quatech, Inc.

For More Information Circle No. 672



FREE DATA ACQUISITION CATALOG

Datel Systems' new 1999, 224-page catalog offers a wide range of high-speed, high-performance, and multi-function data acquisition boards. Over 100 new products are offered, including advanced-performance boards for PCI, ISA, and VME bus. Tel: 800-233-2765; Fax: 508-339-6356; e-mail: sales@datel.com; www.datel.com

Datel Systems

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1999 PCMCIA PRODUCTS CATALOG

The new 1999 Envoy Data PCMCIA source catalog features the latest PCMCIA drives USB, PCI, and SCSI.

- Rechargeable SRAM Cards, Linear Flash Cards for Routers, Solid State Flash Drives
- PC Card Drives IDE and PC/104 Bus
- I/O Products, Fax/Data, Ethernet Cards
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Envoy Data Corp., 6 East Palo Verde, Ste. 3, Gilbert, AZ 85296; Tel: 800-368-6971; 602-892-0954; Fax: 602-892-0029; e-mail: info@envoydata.com; www.envoydata.com

Envoy Data Corporation

For More Information Circle No. 674

LIGHTED SWITCH CONTROLLER

The Interface Controller, IFC, provides flexible, low-cost digital I/O. Features include up to 16 inputs and 64 outputs @ 250 milliamps and 50 VDC; serial communication to the host processor via RS-232 or RS-422/485 ports; simple software driver set. Controllers are small size, for easy direct mount or DIN Rail mount. StacoSwitch; Tel: 714-549-3041; Fax: 714-549-0930; e-mail: mrktg@stacoswitch.com; www.stacoswitch.com

StacoSwitch

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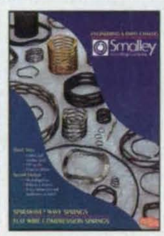

WAVE/COMPRESSION SPRING CATALOG NO. WS-98

Catalog # WS-98 contains hundreds of NEW stock sizes of wave/compression springs, including spring-design formulas, materials guide, and typical applications. This 40-page engineering/parts manual describes advantages of Smalley's edgewinding manufacturing process. Special Springs are easy too! Smalley springs are produced by circle coiling flat wire, with no dies or special tooling charges. Smalley Steel Ring Co., 385 Gilman Ave., Wheeling, IL, 60090; Tel: 847-537-7600; Fax: 847-537-7698; www.smalley.com

Smalley Steel Ring Co.

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GEOTEST'S 1999 CATALOG

The new, free 120-page 1999 PC-Based Test Solution Source Book from Geotest (Marvin Test Systems Inc.) features more than 100 PC-based products for ATE, data acquisition, process control, and test-and-measurement applications. New products include: GT5150 Dynamic Digital I/O; GT1160 - 60 MS/Sec AWG and DDS signal source; GTXI7700 PCI and ISA Instrumentation Chassis; power supplies, and more. Call for your free copy: Geotest/Marvin Test Systems, Inc., Tel: 888-TEST-BY-PC (837-8297) or 949-263-2222; e-mail: sales@geotestinc.com; www.geotestinc.com

Geotest/Marvin Test Systems, Inc.

For More Information Circle No. 677

IEEE-488/RS-232 CONTROL INTERFACE

These units are offered either as a standalone or as an OEM PCB sub-assembly. They are designed to provide complete control of digital I/O and high-resolution analog I/O. They also can form the foundation of a complete data acquisition system requiring no special hardware beyond a standard computer with either a GPIB or RS-232 port. The PCB subassembly is ready to be incorporated into new or existing equipment. Walker Scientific Inc.; Tel: 800-962-4638; Fax: 508-856-9931; www.walkerscientific.com

Walker Scientific Inc.

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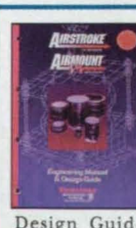

AIRSTROKE®, AIRMOUNT® ENGINEERING MANUAL & DESIGN GUIDE

Firestone Industrial Products Company offers a revised version of its Engineering Manual and Design Guide for Airstroke® actuators and Airmount® isolators. The free manual provides updated guidelines and specs for the air springs, including height, force, and stroke data. Also included are examples of typical isolation and actuation problems that can be solved by using air springs. Firestone Industrial Products Co., 12650 Hamilton Crossing Blvd., Carmel, IN 46032; Tel: 800-888-0650; www.firestoneindustrial.com

Firestone Industrial Products Co.

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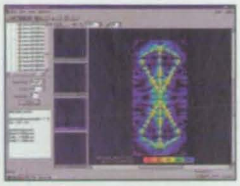
New on DISK

Electromagnetics Analysis



Remcom, State College, PA, has introduced a Windows 95/98/NT version 5.0 of XFDTD (electromagnetics finite difference time domain) software. Its Windows-based GUI is designed to facilitate EM analysis and decrease engineering time on antennas, microwave devices, and biomedical applications. Enhanced biological-analysis capabilities allow designers of cell phones, implantable medical devices, and other products to explore the interactions between such hardware and the human body. **Circle No. 710**

Project Management

Active Project™ Version 4.0 from Framework Technologies, Burlington, MA, is a Web-based communication system for the AEC and product-design/manufacturing sectors. It is designed leveraging the Internet or a corporate intranet to collaborate on project-related information in real time. Information published to an ActiveProject Web site, its publication history, and associated comments are automatically managed and maintained by the system. Other Version 4.0 features include enhanced graphical site organization; built-in search capability; and a template for generating project sites, including graphics and button layout. **Circle No. 714**

CAE Modeling Tool

Enterprise Software Products, Exton, PA, has introduced FEMAP 6, the latest version of FEMAP® analysis modeling and visualization software. Version 6 additions include MP Assistant and SmartResults. MP Assistant is designed for developing idealized analysis models of thin solids by combining automatic and manual tools to create mid-surfaces based on the solid geometry. SmartResults applies intelligent rules to results processing in areas of geometric and material discontinuities, allowing more accurate and intuitive viewing of FEA results. FEMAP 6 also includes a general beam section calculator and enhanced NASTRAN support. **Circle No. 715**

X-ray Image Enhancement

Light Science Technologies, Prescott, AZ, has released the Image Processing eXecutive (IPX) Version 3.0 operating system for the company's Krell PCI Video DSP board. Each board features a parallel DSP processor designed for 2 billion operations per second. This technology allows for 24-bit, 16.7 million colors using harmonic differential resonance. Its user interface consists of four real-time interactive graphic slider controls and various set-up options for presets and color modes. The board is designed to work in a Windows NT Pentium-based chassis with an available full-length expansion slot. OEM applications include X-ray machines, microscopes, radar equipment, and ultrasound machines. **Circle No. 716**

Oscilloscope Software

GageScope for Windows from Gage Applied Sciences, South Burlington, VT, controls the CompuScope family of PC-based data acquisition cards. The software supports up to 32-channel oscilloscope systems, giving the user control of the CompuScope card. Features include waveform cursors, multiple windows with different timebases, and the ability to save and load signals. GageScope is compatible with SIG files used with the CompuGen arbitrary waveform generator. **Circle No. 719**

New on the MARKET

Epoxy Adhesive

Polymer Adhesive EP21ND from Master Bond, Hackensack, NJ, is a two-component epoxy adhesive for general-purpose bonding. It is formulated to cure at room temperature, or more rapidly at elevated temperatures, with a one-to-one mix ratio, weight, or volume. The non-drip epoxy develops a bonding strength of more than 3000 psi at room temperature. The adhesive produces durable, high-strength bonds resistant to thermal cycling, water, oil, and organic solvents, over a temperature range of -60°F to over 250°F. The hardened adhesive is an electrical insulator. **Circle No. 742**

Fiber-Optic Sensors

Keyence Corporation of America, Woodcliff Lake, NJ, offers the FS01 Series of fiber-optic sensors. All FS01 Series amplifiers are housed in super-small bodies requiring very little mounting space. "Tough-Flex" fiber units are constructed with a core bundle of 217/66-micron diameter fibers. They are designed to withstand severe bending, pulls, and impacts and can be routed through tight spaces to keep sensor amplifiers away from operating machinery. **Circle No. 733**

Composite Film Tape

3M Electrical Products Division, Austin, TX, has added a 0.010"-thick composite film tape to a product family that includes 0.0055" and 0.016" tapes. The 3M-brand 44 tapes are polyester-web-reinforced film coated with a pressure-sensitive rubber adhesive. Applications for the 0.0055" tape include insulating, anchoring, and banding in motors and transformers. **Circle No. 735**

Stainless-Steel Parts

New England Electropolishing, Fall River, MA, offers electropolished stainless-steel parts that are resistant to impregnation with bacteria. A stress-free electrochemical process is designed to produce parts that are bright, burr-free, passivated, and thoroughly cleaned. Depending on configuration, the electropolished parts have surface finishes down to RA 2. Parts up to 10 feet long by 5 feet wide are available. **Circle No. 738**

Digital-Imaging System

The DZ-3600U digital-imaging system from Canon U.S.A., Lake Success, NY, is designed to deliver high-resolution and detail-sensitive imaging comparable to that of a 3-CCD camera. Incorporating "Parallel Plate" technology, the system can display an entire 8-1/2 x 11" document at once. Other features include high-speed (4-sec.) image capture; a USB for plug-and-play with USB-compatible PCs; and presentation software that allows integration of images into programs such as PowerPoint and Word. **Circle No. 741**

New LITERATURE

Antistatic Stereomicroscopes

A brochure from Leica Microsystems, Deerfield, IL, features stereomicroscopes designed to protect against electrostatic discharge (ESD). Surfaces of Leica's GZ4, GZ6, MS5, and MZ6 stereomicroscopes have surface resistivity below 1011 ohms/cm². Sockets on the microscope carrier and swing-arm stand ground the instrument, producing an ESD-safe boom stand. **Circle No. 701**

Controls and Gages

Dwyer Instruments, Michigan City, IN, offers a 1999 catalog featuring more than 80 new products. Featured is the company's entire line of 3,500 products, which monitor and control pressure, flow, level, and temperature. New items include Wet/Wet Differential Pressure Transmitters and Programmable Data Loggers. **Circle No. 702**

Electrochemistry Products

A 148-page catalog from Cole-Parmer Instrument, Vernon Hills, IL, showcases products for laboratory and industrial electrochemical measurements. It includes conductivity, oxygen, pH measurement and control, pH electrodes, titration, and water testing. **Circle No. 703**

Automation Innovation

"New Reliance Power" from Rockwell Automation, Milwaukee, WI, highlights Reliance Electric innovations and services. Products include the IQ Intelligent™ motor with PreAlert™ technology and the GV3000/SE line of AC drives, offering three drive modes: volts/hertz, sensorless vector, and flux vector. **Circle No. 704**

EMI-Shielding Design

Tecknit, Cranford, NJ, offers a revised version of its "EMC Compatibility Design Guide." This 44-page reference source provides up-to-date information on EMI-shielding problems. It includes an overview of electromagnetic compatibility (EMC) theory; approaches to solving EMC problems; and a product selection guide. **Circle No. 705**

Slide Assemblies

The 60-page "Catalog M-99" from Velmex, Bloomfield, NY, features more than 235 motor-driven UniSlide Assemblies designed for scanning, feeding, or incremental positioning. Linear and rotary assemblies are available for single- or multi-axis systems. Eight cross-section sizes range from 1.5" to 9" wide; travel ranges from 0.5" to 86". Technical drawings, design specs, and prices are included. **Circle No. 708**

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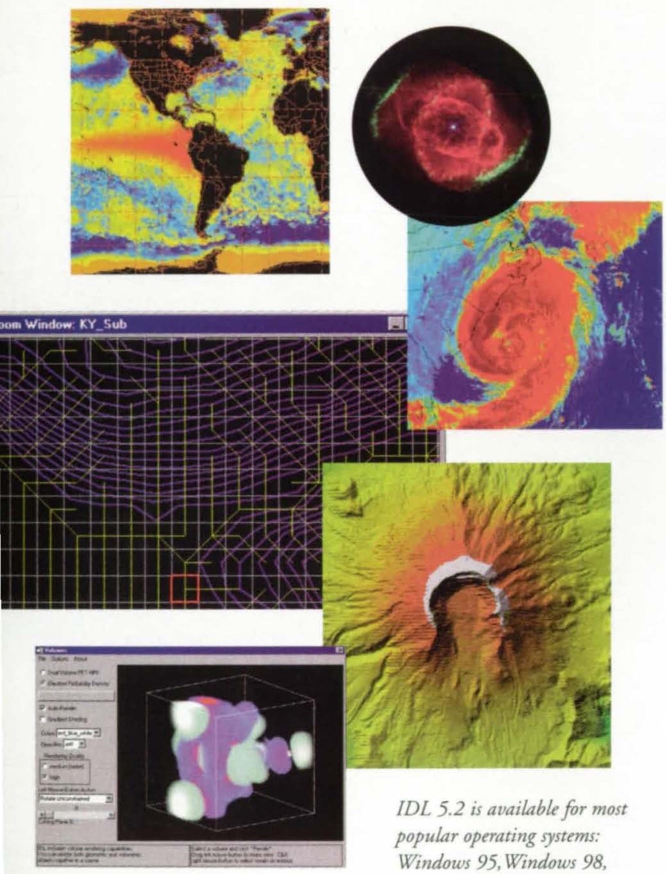

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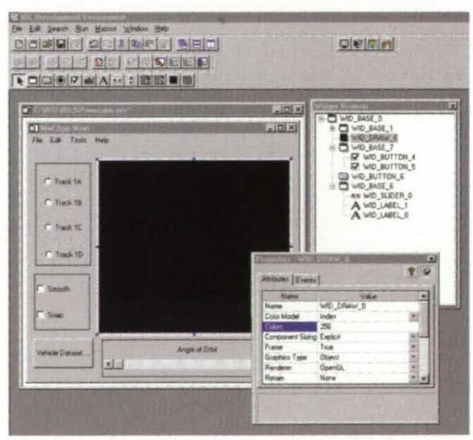

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