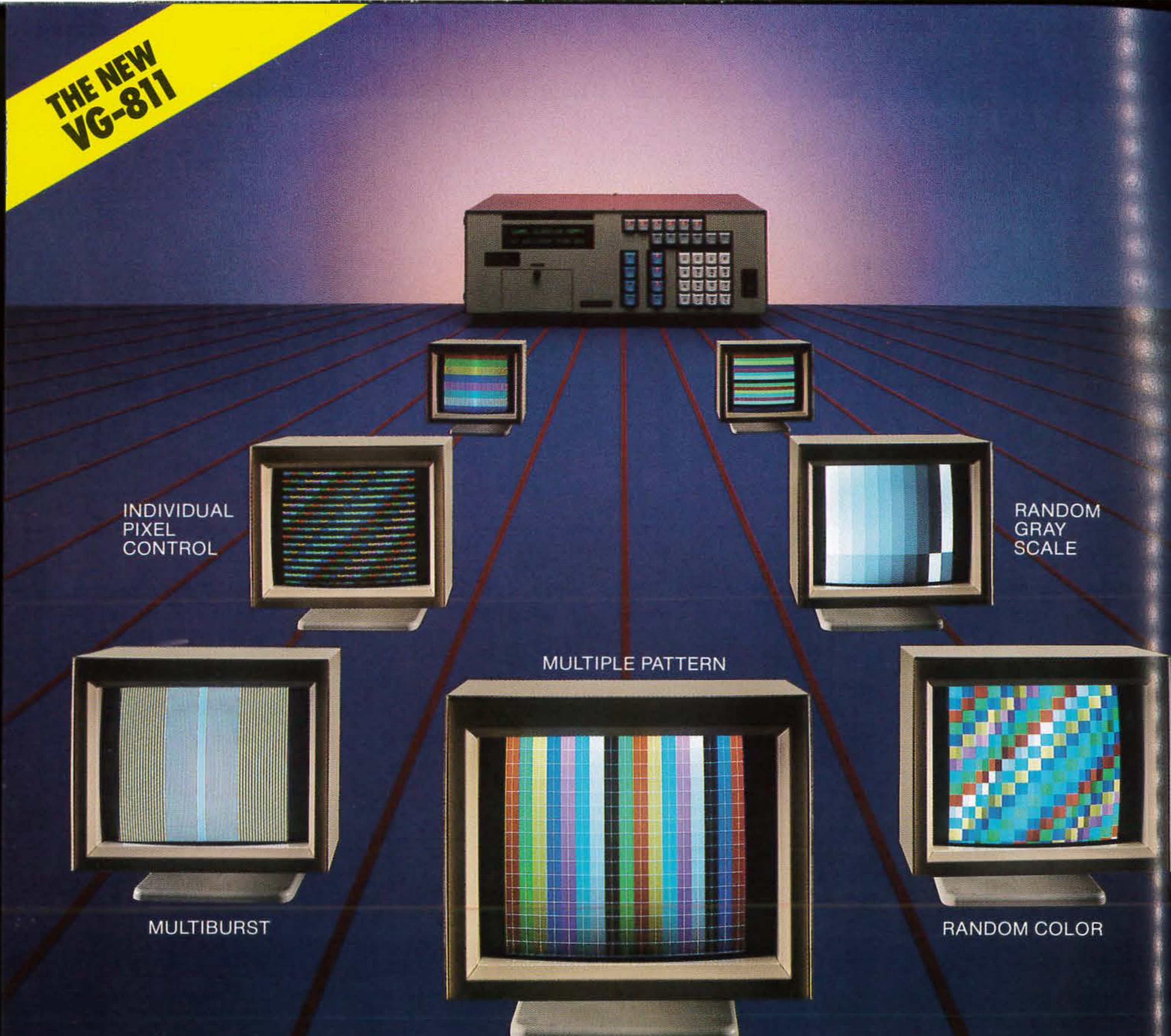
THE OFFICIAL JOURNAL OF THE SOCIETY FOR INFORMATION DISPLAY

INFORMATION DISPLAY

SEPTEMBER 1986

LC'S DISPLAY 3-D FLIGHT SIMULATION

AVIONIC CRT MEETS HI-RES, COLOR SPECS



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Dot Clocks from 5MHz to 120MHz on all three R-G-B outputs simultaneously. Independently set Scanning Frequencies up to 200KHz. And Flexible Programming with E^2PROM, EPROM or even your own IBM/"Compatible" PC are just the beginning.

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Images That Count

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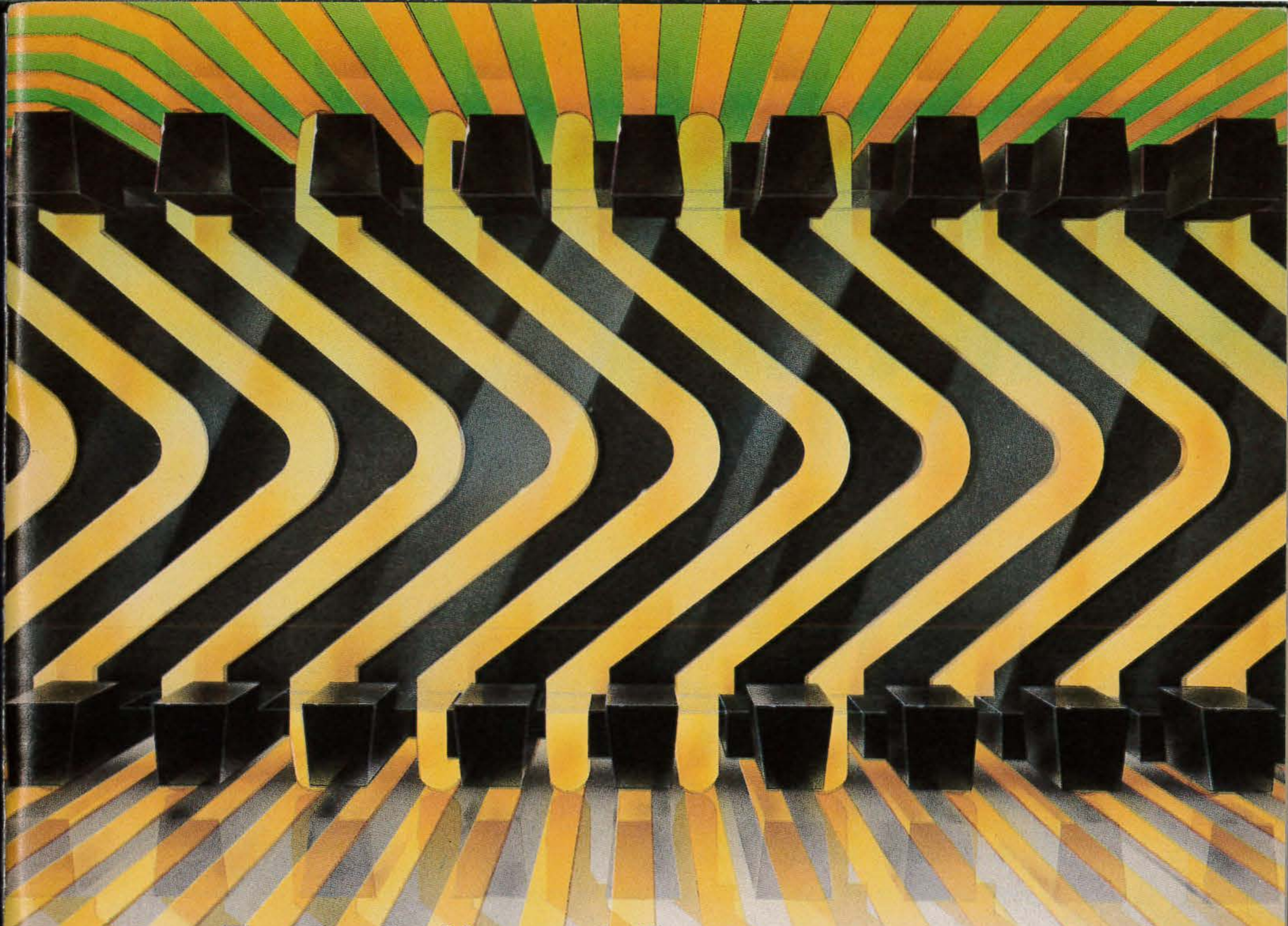
Circle Reader Service # 1



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Introducing ITT Cannon's Parallel Interconnect (PI).

It takes less than a minute to assemble this high density, low resistance interconnect for flat panel displays. No soldering required.

Using positioning pins, the connector is positively aligned, creating a gas-tight interface with printed circuit boards and glass panels. Its unique design allows it to perform to close tolerances over longer dimensions while handling higher voltages and currents.

In addition, the Parallel Interconnect expands and contracts with the glass or printed circuit boards, ensuring a positive contact interface.

The fast, accurate assembly and high dependability ultimately result in lower installed costs. You save time *and* money.

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Contact ITT Cannon Components, a unit of ITT Corporation, 10550 Talbert Ave., Fountain Valley, CA 92708, or call 714/964-7400.

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Events

NATIONAL

OCTOBER 5-9: MILCOM '86—IEEE Military Communications Conference: Monterey, CA. Contact: Kenneth L. Rose, Ford Aerospace and Communications Corp., 3939 Fabian Way, Palo Alto, CA 94303. (405/852-5550)

OCTOBER 6-8: Modern Radiometric & Photometric Measurements, Washington, DC. Sponsored by Laser Institute of America. Contact: Education Director, LIA, 5151 Monroe St.—Ste 102W, Toledo, OH 43623. (419/882-8706)

OCTOBER 6-9: IEEE International Conference on Computer Design: VLSI in Computers & Processors, Rye Town Hilton, Rye Brook, NY. Contact: ICCD '86, 1730 Massachusetts Ave. NW, Washington, DC 20036-1903. (202/371-0101)

OCTOBER 7-10: DEXPO WEST 86—Tenth National DEC-Compatible Exposition, Civic Center, San Francisco, CA. Contact: Expoconsul International Inc., 3 Independence Way, Princeton, NJ 08540. (800/628-8185; in New Jersey, 609/987-9400)

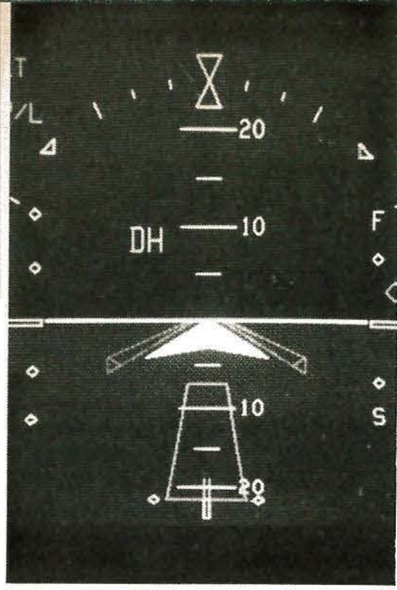
OCTOBER 13-16: ISA/86 International Conference & Exhibit, Houston, TX. Sponsor: Instrument Society of America. Contact: ISA, PO Box 12277, Research Triangle Park, NC 27709. (919/549-8411)

OCTOBER 13-18: 7th Digital Avionics Systems Conference, Worthington Hotel, Fort Worth, TX. Contact: Randall Moore, Fort Worth Div., PO Box 748, MZ 1758, Fort Worth, TX 76101. (817/763-2768)

OCTOBER 14-15: Laser Safety Update, Cincinnati, OH. Sponsor: Laser Institute of America. Contact: Education Director, LIA, 5151 Monroe St.—Ste 102W, Toledo, OH 43623. (419/882-8706)

OCTOBER 14-17: Conference Expo on Electronic Imaging, Hyatt Regency Hotel Crystal City, Arlington, VA. Sponsors: Society of Photographic Scientists and Engineers, American Society of Photogrammetry and Remote Sensing, and Society of Photo-Optical Instrumentation Engineers. Contact: Executive Director, SPSE, 7003 Kilworth Lane, Springfield, VA 22151. (703/642-9090)

OCTOBER 14-17: 1986 International Conference on Systems, Man, and Cybernetics, Atlanta, GA. Sponsored by IEEE Systems, and Cybernetics Society. Contact: Nancy M. Morris, Search Technology Inc., 25-B Technology Park/Atlanta, Norcross, GA 30092. (404/441-1457)



THE OFFICIAL JOURNAL OF THE SOCIETY FOR INFORMATION DISPLAY

INFORMATION DISPLAY

SEPTEMBER 1986 VOL. 2 NO. 9

Cover image: A 5" x 5", color avionic CRT display tube achieves its high resolution through the use of a fine 0.2 mm pitch shadow mask and very rugged in-line electron gun. Innovative self-converging deflection system, static color purity with convergence correction, and an effective contrast enhancement filter contribute to the very bright display. *AEG Corp., Somerville, NJ.*

FEATURES

DEPARTMENTS

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American Federation of Information Processing Societies

INFORMATION DISPLAY (The Official Journal of the Society for Information Display) is edited for corporate research and development management; and engineers, designers, scientists, and ergonomists responsible for design and development of input and output display systems used in various applications such as: computers and peripherals, instruments and controls, communications, transportation, navigation and guidance, commercial signage, and consumer electronics.

Editorial covers emerging technologies and state-of-the-art developments in electronic, electromechanical, and hardcopy display devices and equipment; memory; storage media and systems; materials and accessories.

OCTOBER 19-24: 1986 OSA Annual Meeting, Seattle Center, Seattle, WA. Contact: Optical Society of America, Meetings Dept. 1816 Jefferson Place NW, Washington, DC 20036. (202/223-0920)

OCTOBER 20-24: 1986 International Laser Science Conference, Seattle Center, Seattle, WA. Co-sponsors: American Physical Society and the Optical Society of America. Contact: Optical Society of America, ILS Conference, 1816 Jefferson Place NW, Washington, DC 20036. (202/223-0920)

OCTOBER 21-23: Workshop on Optical Fabrication & Testing, Seattle Center, Seattle, WA. Sponsor: Optical Society of America. Contact: Optical Society of America, OF&T '86, 1816 Jefferson Place NW, Washington, DC 20036. (202/223-0920)

OCTOBER 22-23: Third Annual Flat Information Displays Conference, Red Lion Inn, San Jose, Ca. Co-sponsors: Stanford Resources Inc., and International Planning Information Inc. Contact: Murray Disman, IPI Inc., 465 Convention Way—Ste 1, Redwood City, CA 94063. (415/364-9040)

OCTOBER 24-26: Workshop on Charged Coupled Devices, Columbia University's Arden House, Harriman, NY. Contact: Prof. Eric R. Fossum, Dept. of Electrical Engineering, 1321 Mudd Bldg., Columbia University, New York, NY 10027. (212/280-3115)

OCTOBER 26: MEDINFO 86—Fifth World Conference on Medical Informatics, Sheraton Washington Hotel, Washington, DC. Co-sponsors: International Medical Informatics Association, US Council for MEDINFO 86, and International Federation for Information Processing. Contact: Office of Continuing Medical Education, George Washington University Medical Center, 2300 K St. NW, Washington, DC 20037 (202/676-8929)

OCTOBER 27-28: Fifth Annual Pacific Northwest Computer Graphics Conference, Eugene Conference Center/Hilton Hotel Complex and the Hult Center for the Performing Arts, Eugene, OR. Conference features general session presentations, workshops on applications, trade exposition and film and video show. Sponsor: University of Oregon. Contact: Paul Katz, Conference Manager, University of Oregon Continuation Center, 1553 Moss Street, Eugene, OR 97403 (503/686-3537)

NOVEMBER 2-6: ACM/IEEE Computer Society Fall Joint Computer Conference, INFOMART Dallas, TX. Contact: ACM/IEEECS FJCC, 1730 Massachusetts Ave. NW, Washington, DC 20036 (202/371-0101)

NOVEMBER 3-5: Electronic Imaging '86, Sheraton-Boston Hotel, Boston, MA. Contact: Institute for Graphic Communications Inc., 375 Commonwealth Avenue, Boston, MA 02115 (617/267-9425)

NOVEMBER 3-6: AM86 — Man and Machine the New Partnership, Automated Manufacturing Exhibition and Conference, Greenville, SC. Contact: AM86, PO Box 5616, Greenville, SC 29606 (803/242-3170)

NOVEMBER 4-7: PLANS '86 — Position, Location and Navigation Symposium, Caesar's Palace, Las Vegas, NV. Contact: Larry Atkins, Lockheed-California Co., Dept. 96-60/Bldg. 63, Burbank, CA 91520 (818/847-2867)

NOVEMBER 5-7: The Second Scientific Computing & Automation Conference and Exposition, Convention Center, Atlantic City, NJ. Sponsor: Scientific Computing & Automation Magazine. Contact: Expocon Management Associates Inc., 3695 Post Road, Southport, CT 06490 (203/259-5734)

NOVEMBER 5-7: 1986 IEEE ASSP Workshop on Signal Processing, Davidson Conference Center, University of Southern California, Los Angeles, CA. Contact: Dr. S.Y. Kung, Image Processing Institute, Powell Hall, University of Southern California, University Park, Los Angeles, CA 90007 (213/743-6581)

NOVEMBER 7-10: 1986 IEEE/Engineering in Medicine & Biology Society — Eighth Annual Conference, Worthington Hotel, Fort Worth, TX. Contact: George V. Kondraske, University of Texas at Arlington, Box 19138, Arlington, TX 76019 (817/273-2335)

NOVEMBER 10-12: European Computer Equipment Ergonomics Standards, Legislation, Market Requirements, Evolving Trends, San Francisco, CA. Three-day seminar focuses on latest information on interpreting and complying with European laws, and competing in the European and US marketplace. Co-sponsors: The Koffler Group, Santa Monica, CA; Ergonomic Institut fur Arbeits- und Sozialforschung Forschungsgesellschaft mbH, Berlin, Germany; Ergolab, Stockholm, Sweden; System Concepts Ltd., London England. Contact: The Koffler Group, 3029 Wilshire Blvd., Suite 200, Santa Monica CA 90403 (213/453-1844)

INTERNATIONAL

SEPTEMBER 23-25: AI EUROPA—Artificial Intelligence and Advanced Computer Technology Conference/Exhibition, Rhein-Main Halle, Wiesbaden, West Germany. Sponsor: Computer Magazin, Expert System User, DM Data, International Directory of AI companies, Applied Artificial Intelligence Report and Society of Computer Simulation. Contact: Tower Conference Management Co., 331 W. Wesley St., Wheaton, IL 60187. (312/668-8100)

SEPTEMBER 30 - OCTOBER 2: Japan Display '86 - 6th International Display Research Conference, Keidanren Kaikan Hotel, Otemachi, Chiyoda-ku, Tokyo, Japan. Contact: Prof. Shunsuke Kobayashi, Dept. of Electronic Engineering, Faculty of Technology, Tokyo University of Agriculture & Technology, 24-16 Nakamachi 2 chome, Koganei City, Tokyo 184, Japan. (0423-81-4221)

Circle Reader Service #16

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Panasonic® DC Plasma Displays

For small-footprint designs where uniform image and construction quality are important, consider the advantages of Panasonic DC plasma panel technology.

The fixed matrix DC design produces crisp, clear images with uniform brightness and edge-to-edge consistency. Our panels deliver high resolution on a super-thin profile, flat screen. And the ergonomic design eases strain on the eyes.

Design flexibility

Your design options expand immediately with Panasonic DC plasma panels. Simple DC construction offers reliable performance, so you can confidently specify our panels for the most sensitive medical or engineering systems.

In fact, you can design them into virtually any system where compact, light-weight and durable construction is vital.

Many DC formats

Right now you can choose from a growing family of full- and half-page configurations.

Our popular 400 x 600 models offer viewing aspect ratios of 5:8 and 3:4. Both are available with either two-level or four-level gray scale capability. Our half-page 200 x 640 has two-level gray scale with a 3:8 viewing aspect ratio. And the new 12″ diagonal 350 x 720 features a 3:4 ratio and two- or four-level gray scale.

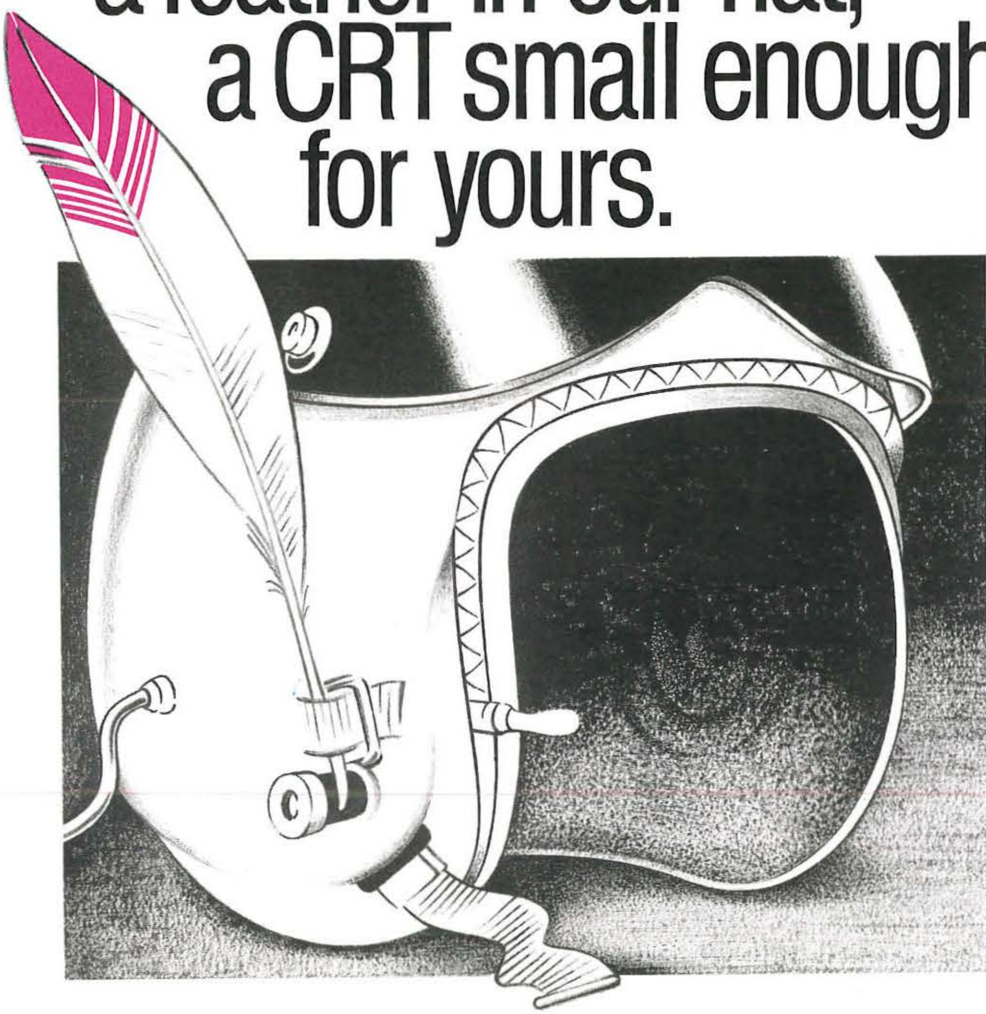
DC plasma technology is available now and Panasonic is ready to deliver OEM quantities. For more information, contact: Panasonic Industrial Company, Custom Components Division, Two Panasonic Way, Secaucus, NJ 07094.
(201) 392-4710.

Panasonic
Industrial Company

Circle Reader Service #4

Another product of experience…

Miniscan – a feather in our hat, a CRT small enough for yours.



As you can see, we're very proud of our revolutionary new MINISCAN display system.

And no wonder! For the first time, we've separated the CRT from its associated drive electronics and power unit.

And, because the CRT is as small and lightweight as ours is, you can install it in places you never thought possible before. Like on a helmet.

Just think of the benefits that could bring to applications like thermal-imaging sights and weapons-aiming systems.

And our CRT is no ordinary tube. Its high resolution means you can get 800 TV lines on a 1-inch diameter screen. It has electrostatic focusing and deflection, so is not only smaller, lighter and more rugged, but consumes less power, than electromagnetic types.

MINISCAN is the product of a collaborative venture between two leaders in their respective fields: MOV in high-performance CRTs, and Brandenburg in specialized CRT power supply and drive systems.

Its use is not confined to helmets, of course. You can use it in any application where display size and weight are critically limiting factors, and install the drive electronics/power unit remotely.

That would put a feather in your hat, too!

For further details contact;

The M-O Valve Company Ltd., Hammersmith, London W6 7PE, England. Tel: 01-603 3431. Telex: 23435. Fax: 01-602 3365.

EEV Incorporated, 7 Westchester Plaza, Elmsford, NY 10523. Telephone: (914) 592-6050. Telex: 6818096. Fax: (914) 682-8922.

MOV

A MEMBER OF THE GEC GROUP

MINISCAN

DISPLAY SYSTEMS

brandenburg

Circle Reader Service #5

> *"Compromise is but the sacrifice of one right or good in the hope of retaining another— too often ending in the loss of both . . ."*
> *—Tryon Edwards*

Our national passion for individuality is engrained in our culture through generations of pioneers and nourished by the sweet smell of success of countless entrepreneurial spirits. It may now be coming back to haunt us as we face the growing threat of losing the technological lead that we've enjoyed for the past four decades.

Unlike their Japanese competitors in the electronics industry, US manufacturers, as a whole, continue to remain fiercely independent ventures. Their Japanese counterparts, on the other hand, not only joint-venture R&D efforts with their government, but also work closely together within the industry (from materials suppliers through distribution channels).

Only recently have US industry and government leaders begun to recognize the need for implementing cooperative programs in an effort to catch up with the Japanese. Such joint ventures, however, may be some time coming to fruition.

Meanwhile there is an urgent need within the US electronics industry to shore up its defenses through concerted efforts to:

- Improve basic cooperation among its ranks,
- Expand essential interchange with its suppliers,
- Tap the federal government's technology transfer opportunities, and
- Work hand-in-hand with universities and colleges helping to bring state-of-the-art products from laboratory bench to manufacturing floor.

Military contracts are no longer sufficient to prime new electronic technologies within the time-frame required to remain competitive in a rapidly evolving world market.

* * *

Under the Stevenson-Wydler Technology Innovation Act of 1980, Congress created the Center for Utilization of Federal Technology (CUFT) to serve as a clearinghouse for information on federal inventions and technological developments of importance to US industry. And this Spring, Congress amended the act to permit federal agencies' laboratories to engage in cooperative research ventures with industry, university, state and local governments, as well as other interested parties.

To help companies take advantage of federal technology opportunities, CUFT has prepared a government-wide reference tool that an engineer, scientist, or decision-maker can use to locate those federal laboratories and engineering facilities engaged in research and development of new technologies. **The Directory of Federal Laboratory and Technology Resources (1986-1987): A Guide to Services, Facilities, and Expertise** is available from the National Technical Information Service, US Dept. of Commerce, 5285 Port Royal Road, Springfield, VA 22161. Order No. PB86-1Q0013. Price: $29.

Joseph A. MacDonald
Editorial Director

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Technology Update

Computer program evaluates IC test structure data

An updated computer program, called STAT2 Version 1.7, allows users to analyze, map, and correlate different data sets from automatic test equipment, thus simplifying the evaluation of IC test structure data used in checking the integrity of the various semiconductor manufacuring steps.

STAT2 was developed by the National Bureau of Standards (NBS) for use in its semiconductor research. NBS is now making the program available for industrial applications. The program is written in FORTRAN for the VMS (VAX) operating system, but may be adapted for other equipment. Program files can be transferred to a user-supplied tape. Contact: Richard Mattis (301/921-3801)

NATIONAL BUREAU OF STANDARDS, B360 Technology Building, Gaithersburg, MD 20899

Laser microscope offers higher magnification, resolution

Using a laser rather than electron-scan, British researchers have developed an optical microscope that they claim has considerably higher magnification and sharper resolution than conventional optical microscopes. And, using a light rather than electrons as the probe ensures that specimens are not damaged.

The microscope — LASERSCAN — uses a finely focused (diffraction-limited) laser beam as the specimen probe. Point-by-point illumination eliminates any stray reflections, so that high-contrast images are produced. The scanning system is a rastered table on which the sample is mounted with illumination uniform over the entire field of view.

Magnification can be varied continuously over an X30 to X10,000 range without changing the objective lens. Viewing is on a display screen set at a height and angle that enable the operator to work without strain over long periods. The microscope uses confocal (optical sectioning) imaging for improving the resolution; therefore, layered or structural samples can be imaged in optical section.

For topographic inspection, the differential phase contrast gives better images with more control of significant contrasts than comparable techniques in conventional microscopy, and objects of weak or varying contrast can be imaged clearly. It also allows electrically active devices to be probed by the Optical Beam Induced Current (OBIC) technique. Because the system does not require a vacuum for operation, as does an electron-scan microscope, operating and maintenance costs are considerably less, according to the device's developers.

IBT DUBILIER LTD, 7 Suffolk Way, Abingdon, Oxon OX14 5JX England.

Transparent plastic film provides wrap-around conductor

Researchers at Honeywell's Physical Sciences Center have developed a lightweight, flexible plastic film that conducts electricity and offers numerous advantages over existing inorganic conductor technology. The film is versatile enough to defog a car window or help control a building's temperature by reflecting heat and cold.

Made from the polymer polydiiodocarbazole (PDICZ) and doped with bromine, the film is fabricated into thicknesses from 1μ to 3μ — approximately less than one-third the thickness of a human hair. The conductivity of the film can be changed by varying the thickness and level of doping — from insulating levels (no conductivity) up to 0.1 to 1.0 $ohm^{-1}cm^{-1}$. Light transmission can be varied from 60% to 90%.

According to Honeywell, the transparent conductor is easy to make and should cost much less to produce commercially than currently used inorganic oxide films made from combinations of tin, indium, cadmium, and zinc. Additionally, organics, which conduct positive and negative charges, can be used in "active" applications such as semiconductor devices as well as in tradtional "passive" applications where the film conducts electricity as wires do.

Honeywell developed the thin film conductor under an Office of Naval Research contract in conjunction with the University of Minnesota.

Honeywell Inc., Honeywell Plaza, Minneapolis, MN 55408 (612/870-2207)

Piezoelectric measurement techniques under study

Westinghouse Electric Corp. has established a Research Associate Program at the National Bureau of Standards to study the bureau's experience in pooling techniques and measurement methods for piezoelectric materials.

The NBS Research Associate Program provides an opportunity for engineers and scientists from industry, technical societies, and other organizations to conduct cooperative research at NBS on projects of mutual interest, with salaries paid by the sponsor.

Dr. K.F. Schoch, Jr., from Westinghouse's Research and Development Center, Pittsburgh, PA, is conducting a series of comparative measurements at the bureau to develop an industrial instrument for

MINOLTA INDUSTRIAL METERS

REMARKABLE VERSATILITY COMBINED WITH SUPERB ACCURACY– MINOLTA METERS CONFORM TO CIE SPECTRAL RESPONSE STANDARDS.

MINOLTA TV COLOR ANALYZER II

- Enables objective white-balance measurement and adjustment of color monitors.
- Clear, accurate digital and analog displays simplify adjustment of monitors on production lines.
- The analyzer has four memory channels for white standard plus four CRT memory channels. This enables measurement and adjustment of different models of CRT's.

LUMINANCE METERS

- The Luminance Meter ft-1°, nt-1°, or nt-⅓° is the perfect choice for readings of light source or surface brightness. The single-lens-reflex viewing system provides a bright, magnified circular view with a clearly marked 1° or ⅓° center spot to measure the light with no influence from surrounding areas.
- The meter instantly displays foot-lamberts (or cd/m^2) on the viewfinder's LED digital display.
- The ability to read flickering sources makes the Luminance Meter ideal for measuring TV and movie screens, cathode-ray tubes, etc.

ILLUMINANCE METERS

- Accurate light measuring capabilities in a versatile, hand-held meter.
- A custom-designed liquid crystal display indicates illuminance in either foot-candles or lux.
- Measuring range of .001 fcd to 9,990 fcd enables measurements in virtually any situation.
- Stores a single reading for simplified comparison with other sources or monitoring of single source illumination.

CHROMA METER CL-100

- Ability to measure light source color and color difference between sources.
- Chromaticity and color difference are measured instantly and displayed as Yxy (CIE 1931), Yu'v' (CIE 1976), or △ (Yxy), △ (Yu'v'), or △ u'v'.
- The user can calibrate the meter to their own standard. Once input into memory, the user calibration value remains until changed. Several meters can be unified to eliminate any variations in their spectral response.
- Built-in terminals for remote operation or attachment to Minolta Data Processor DP-100.

For more information, write Minolta Corporation, Industrial Meter Division, 101 Williams Drive, Ramsey, N.J. 07446. Or, call (201) 825-4000.

ONLY FROM THE MIND OF MINOLTA

MINOLTA

measuring and characterizing the piezoelectric responses of thermally stable ceramic powders in flexible polymer films for use as transducers in hydrophones. Contact: Roger Rensberger (301/921-3181)
NATIONAL BUREAU OF STANDARDS, Washington, DC.

Standards permit moving information between systems

A recently approved Dept. of Commerce standard for the federal government promises to make it easier to interchange videotext and teletext information. The standard describes how to encode alphanumeric text and pictorial information for moving information between different processing and communications systems.

The National Bureau of Standards helped develop the voluntary industry standard used in both the US and Canada (American National Standard X3.110-1985/Canadian Standard T500-1983), and has also developed test methods that the industry can use to ensure the standard is being implemented correctly.

To order a copy of the standard, refer to Federal Information Processing Standard (FIPS) 121: Videotext/Teletext Presentation Level Protocol Syntax (North America PLPS). Contact: Jan Kosko (301/921-3181).
NATIONAL TECHNICAL INFORMATION SERVICE, Springfield, VA 22161.

Master Index speeds database referencing

A single, comprehensive Master Index now contains information on over 250,000 products, including military, federal and industry specifications, standards, codes and testing methods. Available on-line and in hard-copy format, Master Index listings not only provide document film/fiche locations but also often suggest alternative products to research and give supportive documentation from other sources. All pertinent databases — Industry Standards, Vendor Selector, Defense Specifications, and Construction Regulations — are cross-referenced under both product name and document number.
INFORMATION MARKETING INTERNATIONAL, Oak Park, MI (800/ 821-8612)
Circle Reader Service #32

Novel thermometer uses optical fiber technology

An optical fiber thermometer, capable of measuring temperatures reliably to 2000C (about 3600F) uses a sapphire optical fiber rod whose tip is thinly coated with films of irridium or platinum and aluminum oxide to create a "black-body cavity." When placed in a high-temperature stream, the cavity emits intense light composed of many wavelengths, which the fiber transmits to a remote detector for temperature measurement. Researchers at the National Bureau of Standards, where the thermometer was developed, hope the device will help them produce a more accurate temperature scale at 630C to 1064C.

Invented four years ago by Ray R. Dils, a former NBS engineer, the thermometer (recently assigned patent No. 4,576,486) is now the chief offering of Dil's company, Accufiber Inc., Vancouver, WA. Contact: John Henkel (301/921-3181).
NATIONAL BUREAU OF STANDARDS, Gaithersburg, MD 20899

Circle Reader Service #7

VDT bibliography is international in scope

Visual Display Terminals: A Bibliography (Bildschirmarbeitsplaetze: Eine Bibliographie)
by Siegfried Grune
Saur, Munich, New York — 1985
456 pages, $30.00

A comprehensive bibliography on visual display terminals presents over 3,000 references (from 25 countries), including articles, monographs, and bibliographies listed alphabetically under the following subject headings:

- Basic ergonomic aspects with special reference to human-machine interaction
- Studies of the relationship between humans and computers
- Comprehensive descriptions of work with VDTs
- Technical aspects and design of the various parts of the hardware
- Microfiche and microfilm readers
- Ergonomic design of furniture and environments
- Medical and physiological aspects of work with VDTs
- Social aspects of work with VDTs, organization and content of VDT workstations
- Legal aspects of work with VDTs
- Norms, rules, and regulations for VDT workstations.

An 80-page author and title index, plus an eight-page code register on the report literature, is included.

F.G. SAUR, 175 Fifth Ave., New York, NY 10010 (212/982-1302)

Fiber-optics, lasers topics of multi-conferences

Five multi-conference programs on fiber-optics, optoelectronics, and laser applications in science and engineering are scheduled for September 14-26, 1986, at the Hyatt Regency, in Cambridge, MA.

Sponsored by SPIE (The International Society for Optical Engineering), Fiber/LASE '86 is a two-week program that includes, in addition to the technical conference sessions, tutorial educational program, engineering update courses, and technical instrument exhibit. Twenty-five conferences are scheduled in the five programs:

- Sept. 14-20
  Fibers and Lasers in Medicine (3)
  Photonics and Optoelectronics (5)
  Optoelectronics for Computers (3)
  Lasers (3)
- Sept. 21-26
  Fiber Optics (11)

SID member Elliott Schlam (US Army Electronics Research and Development Command) is chairman of the Computer Display Technology Conference.

SPIE, PO Box 10, Bellingham, WA 98227-0010 (206/676-3290)

Network offers international scientific/engineering database

INSPEC, the bibliographic database on physics, electronics and electrical engineering, computers and controls, and information technology is now available on STN International—The Scientific & Technical Information Network.

(Continued on page 21 . . .)

Hi-res color CRT meets stringent avionic requirements

Display engineers at AEG Corp., Ulm, Germany, using new fabricating methods and new materials, have successfully developed a 5" x 5" high-resolution, full-color CRT display that meets the stringent in-flight requirements for resolution, luminance, and contrast. (The new avionic display tube, M18-E851, was introduced at SID '86 in San Diego, CA last May.)

Resolution

The resolution requirements for today's high performance cockpits necessitated using an extremely small mask hole — the current physical limit being 100 μm, spaced 2 mm apart — with phosphor dots on the screen measuring 85 μm. The resultant viewing surface contains 1.4 million color dots.

Conventional matrix technology for producing such a fine screen, based on graphite suspension, could not be used because it would have produced ragged edges with graphite particles clogging the holes — and thus would have impaired the quality of the screen.

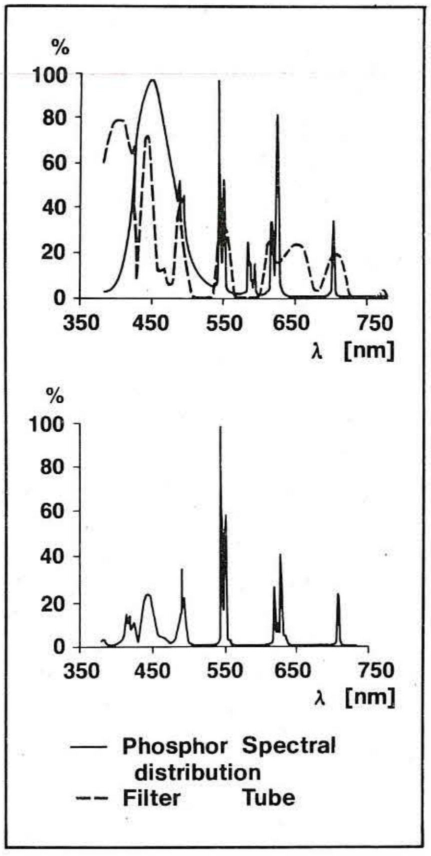
To overcome this problem, AEG engineers used a thin-film process to apply the black layer by vacuum evaporation, and then photoetched the hole pattern. Phosphor was applied by a photochemical method.

Luminance

To achieve the required luminance, they used phosphors of rare-earth compounds that have a linear response, emitting approximately line spectra at high current densities:

- Red — yttrium compounds activated with europium,
- Green — gadolinium compounds activated with terbium, and
- Blue — silver-doped zinc sulphide.

(The emission spectrum of a viewing screen made up of these materials is shown in Fig. 1 — upstream of the con-



trast filter, on top; downstream, on the bottom; with the transmission profile shown as a dotted line.)

Contrast

Required contrast was obtained by connecting a special upstream multi-band filter that has a transmission characteristic adapted to the emission spectra of the phosphors. Transmission level of the filters currently used are approximately 16% for red, 24% for green, 17% for blue, and only about 10% for the incident white light from the sky. Because the latter passes the filter twice and is not reflected fully on the partly black screen, white light is effectively suppressed to less than 0.5%.

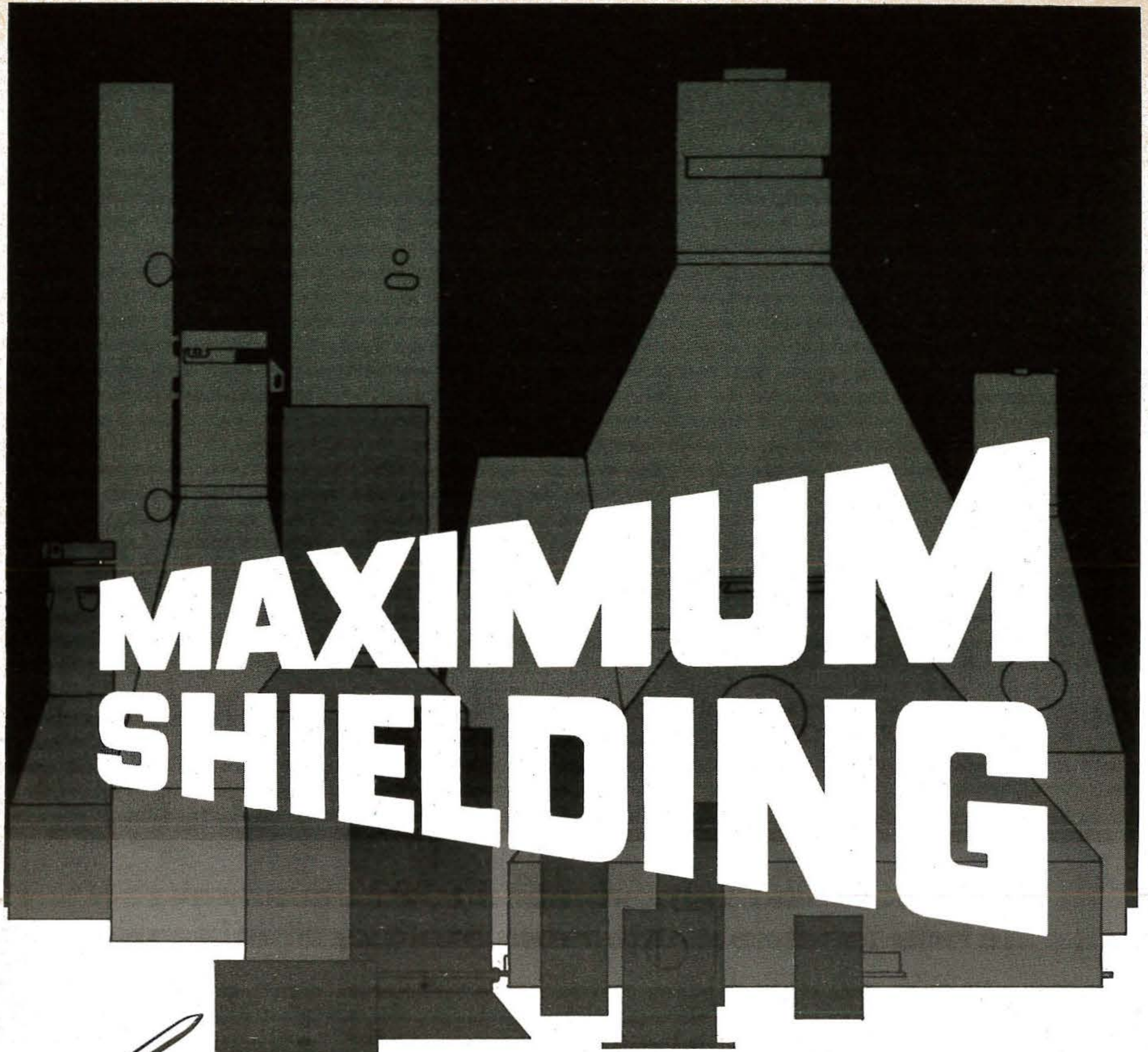
The filter is bloomed with several evaporated coatings to reduce surface reflection. It is also given an additional transparent, conductive coating to screen off electromagnetic interference. Reflection-free coupling to the screen face is assured by bonding with special synthetic resins having matched refractive indexes.

Contrast can be increased even further by fitting the screen with louvre filters. The louvre effect results from the relative positions of display and pilot that establish the viewing direction, whereas the ambient light to be suppressed does not have this preferred direction.

Shadowmask

The traditional shadowmask used in the display is a self-supporting, "domed" type mounted on a frame for increased rigidity. For avionic use, special dimensioning and reinforced mounting assure that the mask can withstand the high

(Continued on p 14...)



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(... continued from p. 12)

shock and vibration stresses of the aircraft.

Because the shadowmask absorbs some 80% of the beam current and converts this energy into heat, conventional steel masks expand, creating a "doming" effect, which can introduce color errors. To overcome this problem, an iron-nickel alloy with a very low coefficient of thermal expansion (invar) was used, instead, for both the shadowmask and its mounting frame. This required adapting etching, drawing, and annealing methods to meet the requirements of the invar material.

As an alternative solution, the designers examined the use of a flat, stretched shadow mask, which has inherent advantages for the high mask load needed in cockpit applications. If enough tension is incorporated in the mask, doming effects can be disregarded. But, the harsh environmental requirements (temperature and vibration), as well as strain relief with time, proved to be major problems — so the special invar mask was developed for this display.

Changing only the mask material, however, was not sufficient to keep inside the purity margin for high beam currents. Additional measures in design and process were taken to reduce the mask temperature and to optimize the direction of the remaining mask movement. The improved invar mask permits a screen loading up to 50 $\mu A/in^2$ without loss of purity.

Gun and yoke

An in-line, electron gun configuration and yoke form a self-converging system for the new display. The electron-optical design achieves a line width of only 0.5 mm on the screen (at a beam current of 1 mA).

The system's deflection coil is designed to permit not only conventional raster scan, but also vector notation and hybrid representation — a mixture of the two. This requires identical designs for horizontal and vertical windings with very low inductances (approximately 120 μH).

The wires are guided in grooves on the ferrite core to ensure precision and stability of the winding. This yields a residual convergence error at the corners of the display area of less than 0.3 mm. Vector notation techniques also impose particularly demanding requirements on the ferrite materials, especially residual magnetism and recovery time. A DC-excited, eight-pole electromagnet mounted on the tube neck corrects the static beam position.

Picture tube and neck components are potted in a metal housing with special-purpose synthetic resins to provide compact, sturdy assembly. Mounting points in the housing act as electrical and magnetic screens at the same time. The potting compound permanently secures the relative positions of all components and also absorbs the greater part of shocks and vibrations.

(Developed from **High-Resolution Color Displays for the Cockpit**, by Helmut Seifert, AEG Aktiengesellschaft, Professional Tubes Div., Ulm, Germany.)

New generation color displays planned for flight control system

Projected increases in aircraft traffic in the US through the year 2000 and beyond have triggered a major overhaul and upgrading of the Federal Aviation Administration's (FAA) Air Traffic Control system.

Currently under development, the new Advanced Automation System (AAS), as it is called, includes a totally new system based on a full set of functional requirements. It includes new software, new hardware, and most importantly, a new traffic controller workstation, or "sector suite."

The sector suite is the heart of the AAS and includes a new generation, high-resolution, color CRT with a 20 x 20-in. square screen.

At present, air traffic controllers work with a Plan View Display (PVD), a 19-in. diameter CRT monochrome stroke writer that displays several kinds of information.

- Actual ground track of each aircraft,
- Local navaid locations,
- Weather and other environmental data, and
- All airways passing through the controller's sector, displayed as lines.

Flight data is still handled manually, although initially a computer outputs a paper flight progress strip based on the approved flight plan. Thereafter, actual flight progress is manually recorded on the strip by the controller. Throughout an aircraft's flight, the controller maintains radio contact with the pilot as well as with other controllers who will later assume control responsibility for the aircraft as it moves to the next sector. Additionally, the controller provides regular inputs to the air traffic control computer through the use of a keyboard or track ball, or both.

The existing system is labor-intensive and taxes the air traffic controller beyond reasonable demand. Among other things, the controller is obliged to use his or her own judgment in considering various sources of data and in using information received through automation services in preference to information received through non-automation channels.

The new system will allow the controller to achieve greater productivity, controlling more flights per unit time; and will provide new functions to increase the controller's ability to deal with complex air traffic conditions. Additionally, the AAS will be able to provide new sources of data to the flight controller from future generations of sensor systems; and accommodate new technology when it becomes available.

Hi-res color display

The future air traffic system requires an extremely high-resolution, high-availability color CRT that is capable of displaying the flight data for all of the flights within the jurisdiction of a given sector of airspace. This data consists of alphanumeric character groupings, with a full display of flight data specified as 7,500, 0.1-in. characters with a refresh rate of 60 Hz.

The 20-in. square display is specified to accommodate the configuration of air space to be managed without waste of available display screen. To reduce distortion, the display surface has a flatness specification of not less than 135 in. radius. And, extremely high brightness levels are specified for displayed colors, because the air traffic control centers maintain a rather higher ambient illumination level than the usual real-time control rooms.

The future air traffic system requires an extremely high-resolution, high availability color CRT that can display the flight data for all flights within a given sector of airspace.

Separation of aircraft in the airways largely depends upon the information presented to the air traffic controller on the display. Thus, the new display must have high precision and a high degree of uniformity over the entire screen. These parameters include a line width of 25 mils; a linearity of 2% over a 1-in. line segment, which may be any place on the display surface; beam splitting accuracy within 20 mils in a basic 20-in. circle, and 40 mils in the corners of the display.

Sector suite

Among major requirements for the sector suite, probably the most important is its extremely high availability — 0.9999996 — which translates to 11

Air Traffic Control System

Providing for safe and efficient movement of aircraft — maintaining adequate separation distance between aircraft at all times — is the principal and most challenging function of the FAA's Air Traffic Control System.

The system basically is simple.

The problem lies in its implementation — which is somewhat more complex.

The sequence begins with a pilot requesting a detailed flight plan from the air traffic controller. Permission to fly this path, called clearance, is issued by the controller.

As the aircraft travels along the approved flight path, it is continuously tracked through a network of ground-based radars that pick up the aircraft's position from data transmitted by on-board transponders.

A ground-to-air communications network provides the means of delivering clearances to the pilot and receiving position reports from the pilot along the flight path.

In addition to determining and maintaining safe aircraft distances, the air traffic controller's duties also include such tasks as:

- Handling air ambulance and evacuation procedures,
- Expediting special flights for the President or for military personnel,
- Accepting or acting on air crew requests, when possible, and
- Providing traffic advisories, weather and other environmental information.

The complexity of this air traffic service stems from the fact that there are 800,000 to 900,000 licensed pilots in the system (military, commercial airlines, and general aviation), some 15,000 airports, and 400,000 miles of airways to monitor and control.

For purpose of air traffic control jurisdiction, the lower US 48 states are divided into 20 major regions each of which has an enroute control center. The air space in each region is further subdivided into sectors — about 650 in all — with each sector covering a 20-50-mile radius.

seconds or less downtime per year. The reason for this extremely high number is that there are on the order of 250 display consoles within a given AAS installation, and they must all be fully operable for the system to be considered in a full service condition. And all display performance specifications for the CRT tube (having an approximate expected lifetime of 10,000 hours) apply at the end point of the tube lifetime.

Finally, because the air traffic controller must spend many hours a day using the display, the workstation must have an ergonomically designed physical man-machine interface that eliminates operator fatique or inconvenience in working the controls.

System availability

High availability is probably the single most important parameter specified for the overall system — which must operate 24 hours a day, 7 days a week, throughout the entire year. Total system availability is specified at 0.999995, which translates into 3 minutes or less downtime per year. Affordable maintenance for the hardware and software is a requisite throughout the system's full life cycle.

The transition from today's system to the new AAS promises to be one of the most difficult and challenging aspects of the entire process, since the new system must be brought on line without introducing any impact on ongoing operations. This requires that one or more clearly defined fall-back paths be available at all times.

Finally, schedule and cost risks must be minimized throughout the lifetime of the development program.

System architecture

To meet these objectives, a computer architecture was selected that is centered around a local communications network that permits standardizing the interfaces between the computer and the rest of the system. Then, as new computers evolve to more sophisticated hardware designs, it will be a simple matter to replace individual devices without redesigning the entire system.

Equally important is the need for the software system design to be independent of the computer brand name so that as computer replacements occur, the software will still be useable without rework.

As envisioned, the AAS will probably be the most complex real-time computer system in the world, with very demanding response time requirements. To achieve the necessary response time, the system is partitioned functionally so that computation may be done in parallel, thereby speeding up the overall system response.

To assure that the software will be able to evolve continually, the designers must anticipate the direction that future software changes will take. (In the current software system, developed before modern software engineering methods were available, individual software modules are too large and poorly isolated from each other.) The new system will have a top-down traceable design with good modularity and properly partitioned databases.

System simulation

Simulation is an extremely important characteristic of the new system throughout its lifetime. Initially, it will be required during the design stage as a tool for system sizing and for estimating the capabilities of the system. Later, if difficulties in the system should appear at an installed field site, it must be possible to simulate those difficulties in a laboratory environment; and diagnose and repair them. Prior to introducing new capabilities into the field systems, simulation in a laboratory environment will be required to identify and solve bottlenecks before the new software is released to the field. Finally, to develop software with minimal errors, independent verification and validation techniques must be used.

The proposed AAS is currently at the preliminary design review stage, with prototype demonstrations of the sector suites scheduled for next Spring. After a critical design review period, proposals for the system acquisition contract will be submitted by the two competing contractors (IBM Federal Systems Div., Gaithersburg, MD and Hughes Aircraft Co., Ground Systems Div., Fullerton, CA). By January 1988, a contract will be awarded for producing and installing models ready to operate in the first field site by May 1991.

(Developed from **The Next-Generation Air Traffic Control Display**, by Valerio R. Hunt, Federal Aviation Administration, Washington, DC — SID '86, San Diego, May 6-8, 1986.)

(. . . continued from page 12)

The database is drawn from about 3,800 journals and series, as well as reports, books, and conference proceedings; and includes about 2.5 million citations with abstracts from 1969 to present. About 18,000 citations a month will be added to keep the database up-to-date.

This international on-line network is offered cooperatively through the American Chemical Society and the Fachinformationszentrum Energie, Physik, Mathematik GmbH (FIZ Karlsruhe), Federal Republic of Germany, with assistance from the Japan Association for International Chemical Information.
STN-COLUMBUS, Columbus, OH (614/421-2600)

Federal VDT study wins OMB approval

After four years of planning, the National Institute for Occupational Safety and Health (NIOSH) in June finally won approval from the Office of Management and Budget (OMB) to begin a study of the potential reproductive hazards among women who use video display terminals (VDTs). The project is one of the first major attempts to determine scientifically if VDT use is linked to spontaneous abortions and birth defects.

NIOSH proposes to interview 2000 VDT users and an equal number of nonusers, which would provide enough data to detect a 50% increase in miscarriages among VDT users. To minimize recall bias, NIOSH will verify unreported miscarriages by examining medical records. Questions about stress and fertility (proposed in the original plan) will not be included because they have been deemed "intrusive" or "irrelevant" to whether VDT use is associated with spontaneous abortion.

The study will focus on a group of Bell South telephone directory assistance operators who use VDTs, and AT&Ts long distance operators who perform similar tasks without computers. The two groups are also similar in socioeconomic class.

(Developed from Science, June 27, 1986.)

Optical signal processing defines new computing speeds

Computing at the speed of light may not be too far off in the future, according to a recent study — Optical Computers: The Next Frontier in Computing. Twenty-three experts in optical computing, in a March 1986 Delphi survey conducted in conjunction with this study, forecast the market for optical computers in 1990 will be $163 million; and by the year 2000, $1.1 billion. They further project that in the 1990-2000 time frame, optical computing will be dominant over electronic computing for industrial machine vision and military image processing. They do not anticipate initial commercialization of the first optical computer before the year 2000.

The report describes developments such as high-density, 3-D information storage through optical holography; pattern recognition for military industrial applications; and the predominance of digitized optical computers in telecommunications and research/science.

Work being conducted by over 125 major research groups, worldwide, in both the public and the private sector is reviewed and lists name, address, and phone number of organization along with sources for further information. In addition, more than 45 patents on optical computing systems, issued since 1975, are abstracted in the report.
TECHNICAL INSIGHTS INC., Englewood, NJ (201/568-4744)

Circle Reader Service #33

LC shutter glasses provide 3-D display for simulated flight

3D display technology offers tremendous potential to expand the capabilities of computer-generated displays, which may otherwise contain limited depth clues, for crew stations both in conventional aircraft and in aerospace applications — including aircraft approach and landing, in-flight refueling, remote construction in space, and spaceship docking.

Although a number of stereoscopic display technologies exist, liquid crystal shuttered glasses currently constitute the most fully developed and best suited technology for application in a simulated flight environment. (See box) Recent advances in liquid crystal display technology have resulted in an unusually bright, flicker-free image — attributable to a 120 Hz frame rate. And, the resolution of such displays is 240 x 512 pixels.

In studies being conducted under a NASA-funded program, researchers at the NASA Langley Research Center (Hampton, VA) are evaluating just such a system to generate a cockpit display containing 3-D pictorial symbology. Left- and right-eye images are viewed using glasses outfitted with liquid crystal shutters.

Display features

Although it is not perfect, the shutter glasses technology was selected as the best available. Most of the other methods had some drawback that

Technology	Real time	Form factor	Brightness	Flicker	Resolution	Shading	Human factors	Availability (2/85)
Holography	X	n/a	good	n/a	good	good	good	X
Volumetric	good	X	good	?	good	X	good	good
Shuttered glasses								
mechanical	good	good	good	good	ok	good	X	good
PLZT	good	good	X	good	ok	good	prob	good
liquid crystal	good	good	good	good	ok	good	prob	good
Beam splitter	good	X	good	good	good	good	ok	good
Polarizing panel	good	good	good	good	good	good	ok	X

3-D Display Technology

Holography — Holograms are photographic recordings of the interference patterns generated by laser light source and its reflection off the objects in the scene. While holography is capable of very good image quality, it is unlikely that computers will be able to generate holographic displays in real time in the near future.

Volumetric 3-D — These are displays that produce a true, 3-D virtual image by some means. The most notable technique is the varifocal mirror, which is a reflecting membrane set to vibrate, such that the focal length is a periodic function. A calligraphic display generator is used to render a large number of discrete points in depth order, carefully synchronized with the vibrating mirror. The reflected image has depth, due to the changing mirror shape. The main drawback to the varifocal mirror display is that it can only handle discrete points, making flat-shaded, or even wire-frame pictures difficult. Form factor is a problem that might be surmounted by careful placement of the display generator behind the crew.

Shuttered glasses — Several types of 3-D displays use time multiplexing of the left-right eye pairs. The left- and right-eye views are alternately shown on a display screen, such as a CRT. Shuttered glasses are used to ensure that only the left-eye view reaches the left eye; and the right-eye view, the right eye. If the views are switched fast enough, then the flicker is unnoticeable. The three common types of shutters are:

- Mechanical shutters — unsuitable because the sheer size of the mechanism would encumber the user.
- PLZT (lead-lanthanum-zirconium-titanate) glasses — faster than liquid crystal, but cause a 70% loss of brightness; and the PLZT glasses require high voltages (250V-700V, typically).
- Liquid crystal glasses — suffer only a 20% loss of brightness, while requiring only ± 20V.

All these types of shutters cause some degradation of ordinary vision.

Beam-splitting — This approach makes use of two CRTs presenting the left- and right-eye views, polarizing fileliminated them from consideration. (Table 1)

The main features of the display are an own-ship symbol; a wire-frame, follow-me-ship rendered in perspective; a 3-D track showing the path of the follow-me-ship; a ground grid and runway area scene; a 3-D horizon with heading markings and labels, and 3-D pitch grid. Two parameters, the interocular distance and the point of convergence, provide control over the 3-D effect.

Researchers placed the point of convergence at the desired distance to be maintained behind the follow-me-ship. All objects in the scene that are closer than this distance appear to project out of the plane of the CRT screen. All objects at a greater distance appear to recede in from the plane of the screen.

The own-ship symbol is situated in the plane of the screen. Thus, by comparing the apparent depth of the follow-me-ship with that of the own-ship symbol, the pilot can judge the position of error. This 3-D effect strongly reinforces the depth cue provided by the relative size of the perspective follow-me-ship. Having fixed the point of convergence, the interocular distance was established empirically to maximize the 3-D effect, while remaining within the range of comfort of a small number of informal test subjects.

Using a point of convergence 580 ft. away, the method resulted in an interocular distance of 10 ft. Equivalently, to a person whose eyes are 3 in. apart, the objects in the scene appear 40 times closer than their actual values in the simulation. Such distortions are justifiable in the name of providing adequate sensation of depth. They are also necessary due to the inherent limitations of the hardware. The precision in rendering the left- and right-eye views is limited both by the diplay resolution and the arithmetic precision of the display processor (16-bit fixed point).

There is no consensus yet on the use of converging eye views in stereo displays. The manufacturer of the stereo display screen, for example, recommends that only parallel views be generated, citing eye fatigue as the reason. Parallel views have the effect of putting the plane of the screen at infinity. It is possible, however, to set the point of convergence at any distance by shifting the left- and right-eye views after the perspective operation.

Test system

The present test configuration resides in the Crew Station Systems Research Laboratory, of the Crew/Vehicle Interface Research Branch, of NASA Langley Research Center. Relevant hardware

ters in front of each, and a half-silvered mirror to superimpose the two images. The user wears glasses with polarizing lenses to separate the two eye views. The limitation of this technique has been the problem of alignment of the two CRTs to achieve accurate stereo pairs. The form factor presents an additional problem for crew station applications.

Polarizing panel — Similar to the beam splitting approach, this method uses a liquid crystal shutter in front of the CRT that switches between two orthogonal polarizations. The user wears polarizing lenses, as in the beam splitting approach.

Both the beam-splitting and polarizing panel methods are attractive because the glasses do not require any wire connections. With only one CRT being used, the form factor problem inherent in the beam splitting method, however, is avoided with the polarizing panel...and since a liquid crystal shutter is used, the brightness is comparable to the liquid crystal shuttered glasses.

consists of 2 VAX 11/780 computers, an Adage 3000 raster programmable display generator, and a Stereographics 3Display stereoscopic system. A FORTRAN aircraft simulation is used to provide parameters to the display programs residing in the display generator.

Display programs are written in RAP (Real-time Animation Package), a proprietary software product developed at the Research Triangle Institute (RTI), Research Triangle Park, NC. The Stereographics display makes use of liquid crystal shuttered glasses and specially adapted hardware that divides each video frame into two fields corresponding to the left- and right-eye views, each at half the resolution.

The PDG in this system outputs a 60 Hz repeat field, 512 x 512 image. The stereo display system converts this input to a 120 Hz repeat field, 216 x 512 output, with alternating left- and right-eye fields.

Alternative systems

The next stage of this program includes:

- Integration and testing of a helmet-mounted position sensor. 3-D perspective views will be generated as a function of the pilot's head position. In addition to adding greater realism to "out-the-window" displays, this sensor will provide another 3-D depth cue-motion parallax.
- Investigation of a liquid crystal, polarizing panel, stereo display technology.
- Evaluation of the effects of various parameters of the stereo display, as well as the relative merits of candidate 3-D, flight director symbologies. Three flight director concepts have been identified, and performance measures will be extracted from data generated by test runs in which pilots fly the simulator under controlled conditions.

Although the use of stereo displays has enormous potential to expand the capabilities of computer-generated displays for crew stations, however, a number of problems still must be solved before this technology gains acceptance in real crew stations. User fatigue must be evaluated and brought under control; and the display must not restrict either the pilot's movements or ordinary vision.

Because they require no special glasses, holographic and volumetric displays could become attractive if their shortcomings could be eliminated. And, the polarizing panel approach is potentially even more attractive, because the glasses required are lighter and simpler—but this technology is not yet commercially available.

(Developed from **A 3-D Pictorial Stereo Cockpit Display**, by Timothy L. Turner Research Technology Institute, Research Triangle Park, NC, and Richard F. Helbaum, NASA Langley Research Center, Hampton, VA—SID '86, May 6-8, 1986, San Diego, CA.)

Spatial misorientation exacerbated by collimated virtual flight display

Years of research have shown that in the absence of specific training to the contrary, a human's "natural," or stereoscopic, response under a wide variety of experimental conditions is to expect a display element to move in the same direction as the control input. (Evidently because we make the control input, we identify ourselves with the element that moves.) But, when a sudden input results in display motion in the direction opposite to that expected, the identity of the moving display element may become momentarily ambiguous or actually reversed.

A pilot's perception of banked and wings-level flight comes through two sensory organs: the eye and the inner ear. When one set of sensations contradicts the other, the pilot must choose which to trust, and vertigo may result. The real problem in flight arises when an aircraft accelerates about its roll axis below the pilot's vestibular (inner ear) sensory threshold.

If the pilot's attention is diverted during this time, when he shifts his attention back to the attitude indicator he will find the display portraying an unexpected attitude. That will result in a conflict between his vestibular sensations, which tell him he is flying straight and level, and his visual sensations, which tell him he is in a banked attitude.

Should he initiate a sharp control movement to correct the undesired attitude shown in the display, he will feel as though he is rotating from a wings-level attitude into a bank, when just the opposite is the case. In other words, his eyes tell him positively that he is correcting an undesirable situation, while his vestibular sensations will tell him positively that he is moving into one. In this situation, the vestibular sensations can be so compelling that the pilot will reverse his visual attitude reference for the brief remainder of his life.

Potential solution

During the past 40 years, the problems and potential solutions associated with flight attitude awareness have received much experimental study in flight simulators and some, but much less, in flight. The most comprehensive and objective flight experiments* were conducted at the University of Illinois, sponsored by the Office of Naval Research, during the early 1970s. (Human Factors, August 1975.) A good solution to the bank-reversal problem with the "inside out" moving horizon, experimentally validated in those studies, is to have both symbols — aircraft and horizon — move.

Such a dual-movement display is known as a "frequency separated" presentation. Changes in aircraft attitude, which are relatively slow (low-frequency responses), are displayed as they always have been by a moving horizon indication. The aircraft symbol rotates in direct response to — and in the same direction as — the relatively fast aileron control inputs (high-frequency responses). Thus, the rapid initial display motion is directionally compatible with the plane's actual motion and predictive of its imminent attitude.

To assure correct roll and pitch response, in all circumstances, display symbology should be seen as the moving "figure" against the fixed "background" of the external world.

The results of the Illinois study of the flight transition of professional pilots to the frequency-separated attitude display in a variety of operationally realistic flight tasks, together with the results of experiments involving subjects with little flight experience, place the display in a unique position.

Non-pilots and pilots of little experience readily learn to use it and show little tendency toward the control reversals to which pilots, inexperienced with the display system, are subject with the conventional moving horizon. Highly experienced pilots readily adapt to it as a moving horizon display to which only a roll-rate prediction has been added, to assist them in maneuvering the aircraft.

*Beringer, Williges, and Roscoe, 1975; Ince, Williges, and Roscoe, 1975; Roscoe and Williges, 1975.

Issues and applications

The problem of spatial misorientation has been exacerbated by the use of collimated virtual flight displays. For many pilots, these heads-up or helmet-mounted displays prevent the eyes from focusing at the real (or simulated) distances of outside objects. Evidently, collimation releases the eyes to lapse toward their dark focus (which varies widely from person to person), and the bold symbology of typical heads-up displays does not require sharp focusing for legibility.

In any case, collimation does not cause the eyes to focus at optical infinity as the advocates of HUDs and HMDs assert, and the consequences are the inability of most pilots to attend concurrently to the collimated symbology and distant objects without conscious focus shifting and associated losses in distant acuity and veridical spatial orientation.

In the context of spatial orientation, misaccommodation can have several adverse consequences. Depending on the direction of the difference between focal distance and object distance, objects will appear smaller or larger than life-size and more or less distant. If the eyes focus too near, as they do when viewing distant scenes through collimated symbolic imagery, objects such as airport runways or surface targets appear shrunken and more distant than they are and consequently higher in the visual field relative to the horizon. As a result, pilots tend to come in too fast, round out high, and land long and hard. They also overestimate the distance to ground targets and pull up too late.

Furthermore, misaccommodation not only blurs images, but the blurring serves to reduce contrast, further interfering with object recognition. Because few pilots can attend to outside objects and collimated symbology simultaneously, conscious switching of attention is necessary. If a pilot dwells too long on either the collimated symbology or outside objects not offering a strong horizontal reference, the pilot may be unaware of gradual attitude changes. In such a case, a suddenly noticed angled orientation of the symbolic horizon bar or pitch ladder can result in perceptually overpowering attitude reversal and a spiral dive into the ground.

I believe that the frequency of design-induced bank-reversal errors with the conventional moving horizon is much higher than is generally recognized. In addition to losses of lives and equipment, sticking with moving horizon displays includes the need for more pilot training than would otherwise be required. And, in this age of fierce product liability litigation, we may be only a step away from a court decision in which a manufacturer will be found responsible for design-induced pilot errors because ways of guarding against them are scientifically established and yet the manufacturer chose not to implement a change in display.

(Developed with permission from Human Factors Society Bulletin, Vol. 29, No.6, June 1986, Copyright ©1986, Human Factors Society Inc. — **Designed for Disaster**, by Stanley N. Roscoe, Professor, Psychology Dept., New Mexico State University.)

Readers are invited to submit their own views on this or other topics of interest to the information display community.

Miniature, lightweight hi-res CRT display features remote drive

Series 300 Miniscan, a 1-in. dia, high-resolution CRT display, gives 800 TV lines per picture height at the screen center. With a circular active phosphor area of 20 mm dia, the device displays a complete 4:3 aspect ratio picture having minimum dimensions of 16 mm x 12 mm. Internal adjustments can be set to overscan the tube face to give either a 20-mm horizontal center line length or, by further overscan, a 20-mm picture height—while maintaining the 4:3 aspect ratio. Maximum positional error is $< 1\%$.

Electrostatic focusing and deflection not only provide a tube that is smaller, lighter, and more rugged, but also one that consumes less power than conventional electromagnetic types—supply voltage is 18-32V. Control of focus, brightness, and contrast is remote, with DC controls used to avoid interference problems. Faceplate luminance is approximately 150 cd/m^2.

The MOV tube is attached to its drive electronics (Brandenburg) by an umbilical cable, which permits mounting the CRT in locations not previously practical and installing the power unit in a remote location where size and weight constraints are not severe. This provides a modular video system for specialized applications such as:

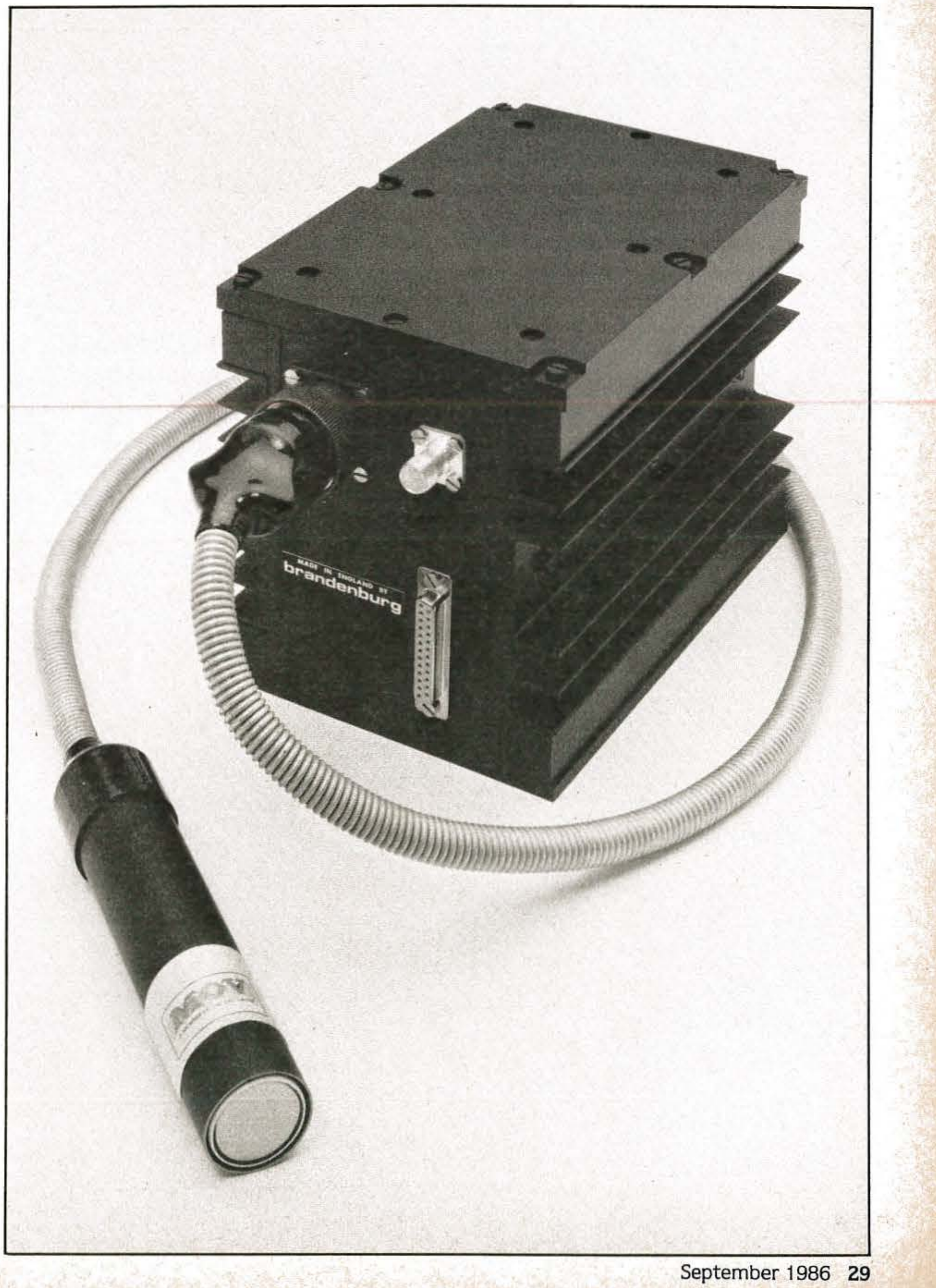
- Helmet-mounted displays for thermal-imaging sights and weapon-aiming systems,
- Portable and vehicle-borne equipment, and
- Weapons simulation and training systems.

The system operates within a temperature range of -40C to $+70$C.

Miniscan accepts standard 1-V composite video: 625 lines/50 Hz or 525 lines/60 Hz; or 0.7V non-composite video with line and field drives—and it can be driven in the X,Y, and Z modes. The tube is normally supplied with a yellow-green, medium-short persistence phosphor (P20); however, other phosphors can be specified.

EEV INC., Elmsford, NY (914/592-5050)

Circle Reader Service #60



Products

Alkali-free glass

AF 45, alkali-free thin glass, has a low coefficient of thermal expansion (a = 45) that assures dimensional stability for use in a number of applications: flat panel screens for liquid crystal and electroluminescent displays; substrates for solar cells in photovoltaic devices; and substrates for electronic thin-films such as hybrid circuits, thin-film transistors and charge-coupled devices.
SCHOTT AMERICA, Yonkers, NY (914/968-8900)

Circle Reader Service #61

Gas discharge displays

The DP-0832-C1 gas discharge subsystem provides 8 lines of 32 characters, 0.26 in. high, in a 5x7 dot matrix format, and displays the complete 96-character upper and lower-case ASCII set. Each subsystem has full control, refresh, and drive electronics. The DP series of displays include alphanumeric panels with configurations up to 480 characters, and graphics panels as large as 96x240 pixels in 32-dot-per-in. resolutions. Price: $636—in production quantities.
BABCOCK DISPLAY PRODUCTS, Anaheim, CA (714/491-5100)

Circle Reader Service #62

Neon plasma displays

NEC's Series PD AC neon plasma displays are fully graphic, high-density panels with all dots in the matrix active. Panel sizes include: 512x256, 640x200, 640x400, and 720x350. All displays are refresh type—there is no memory in the display—with displayed data refreshed at typical rates of 60-65 Hz. Contrast ratio is 20:1 with spot brightness from 16 fL to 20 fL. Panel life is rated at 100,000 MTTF.
WORLD PRODUCTS INC., Sonoma, CA (707/996-5201)

Circle Reader Service #63

Touch control plasma display

Model T-5500 touch control, AC plasma display terminal, has a viewing screen 8.53 x 8.53 in. with a dot matrix of 512 x 512 pixels and resolution of 60 pixels per inch. The screen accommodates up to 51 lines of 84 characters and has a viewing angle of 160 deg.

At the heart of the system is an Intel 80186 processor—code compatible with most PC hardware. Touch control function permits selection of items from a menu, setting parameters for a function, inputting data, or activating a control mechanism. Flexible programmability permits user to design the control/display system to fit specific requirements.

The display's flat screen is free of distortion, flicker and jitter; and easy to read in any level of illumination—from bright sunny ambient light to total darkness. Two color combinations are available: orange on black, and amber on dark green—in stand-alone, rack-mounted, or console configurations.
ELECTRO-PLASMA, Millbury, OH (419/255-5197)

Circle Reader Service #64

Avionic CRT

Ruggedized shadow-mask color cathode ray tube, designed specifically for avionic and military applications, is a triple beam in-line electron gun that provides bright high resolution color display with minimum convergence at the center and corners of the screen. The tube is encapsulated together with all its coils in a mumetal shield to eliminate any possibility of relative movements between the various components. Useable screen area is 127 mm x 127 mm; horizontal and vertical scan angle is 40 deg nominal; diagonal scan angle is 55 deg nominal; temperature range (operational and storage) is −55C to +85C.
RANK BRIMAR LTD., Kent, England (01-302-0271)

Circle Reader Service #45

Anti-slip mats

STOPSLIP mat eliminates slippery problems in laboratory, workshop, and office. Because of its inherent tackiness, the mat surface will grip any item placed on it, as if glued, without leaving any traces either on the table or on the object. The material is long lasting and requires only occasional washing with warm soapy water to remove accumulated dust and other debris, thereby restoring the mat to its original tackiness. STOPSLIP is available in various sizes and thicknesses of 2 and 3 mm, and can be cut to required sizes with scissors.
SOLDER ABSORBING TECH INC., Springfield, MA (800/628-8862)

Circle Reader Service #46

Laser printer

Talaris 610, six page per minute laser printer with 350 dots per inch resolution, has simple graphics capabilities and can function as a desktop printer for single IBM PC or compatible users, or operate on a local area network. The T610 comes standard with 12 fixed pitch ROM fonts; offers additional fonts on IBM-PC compatible floppy disks. Users can download as many as four fonts from the IBM PC host to the T610 at one time, depending on the size of each font. With built-in Diablo 630 ECS, Qume Sprint, Epson FX-80 and ANSI 3.64 emulation, the T610 is compatible with most popular personal computer software programs. Price: $2850.
TALARIS SYSTEMS INC., San Diego, CA (619/587-0787)

Circle Reader Service #50

LED message display

Flexible message display has a 7000-character memory, nine message memories, and five phrase banks. Twenty characters can be displayed at any one time and a detachable QWERTY "tactile feel" keyboard, with single-key operation for all features, provides inserting, deleting, editing capabilities. The system, called ADSCAN, offers a 2.8-in. high display, 3 ft. 6 in. long—using red, green or amber LEDs.
ELCOMATIC LTD, Glasgow, Scotland (41-881-5825)

Circle Reader Service #49

Fiber optic multiplexer

Model 3128 Fiber Optic Multiplexer provides IBM users the benefits of fiber optic cable, accepting four coaxial inputs from IBM 3274 controllers, IBM or Pilkington multiplexers, or a combination. By using the input from the 4 Pilkington 32 channel multiplexers, the 3128 can be fully expanded to handle 128 ports on one fiber optic cable with full service to all ports. Transmission distance is up to 10,000 ft between multiplexers subject to the IBM controller's time-out period. The 3128 can be rack-mounted or free standing.
PILKINGTON COMMUNICATIONS SYSTEMS, Simi Valley, CA (805/522-3333)

Circle Reader Service #42

Electroluminescent display

A half-page, thin-film electroluminescent display includes a high-contrast layer to provide good legibility in bright sunlight. Under ambient sunlight conditions of up to 7000 fc, the high-contrast display provides a brightness of approximately 50 fL. The device has 512 x 256 pixels.
THIN FILM DEVICE INC., Anaheim, CA (714/535-1964)

Circle Reader Service #43

Opto couplers

Line of TO-5 hermetically sealed Opto Couplers, designed for hostile or high reliability applications, consists of a Gallium-Arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a hermetically sealed TO-5 package. Features include 1KV electrical isolation with a high DC current transfer ratio and its collector electrically isolated from the case.
OPTEK TECHNOLOGY INC., McKinney, TX (214/542-9461)

Circle Reader Service #44

Flexible glass

A thin flexible glass coated with Indium Tin Oxide is available as a continuous film, 5.5 mils thick up to 16½ in. wide, in rolls up to 500 ft long. Light transmission is approximately 80%; resistivity is less than 100 Ohms per square. Applications include LCDs, touch switches, thin film heater elements, microwave attenuators, abrasion resistant laminates, continuous photovoltaic substrate, and many others.

DEPOSITION TECHNOLOGIES INC., San Diego, CA (619/578-9400)

Circle Reader Service #47

Power line monitor

The 4800 PowerScope captures power fluctuations as short as 500 nanoseconds, and presents them in a graphic format that allows rapid diagnosis of the cause of disturbance, and leads to easy selection of an appropriate power conditioning solution. The instrument combines 16 digital oscilloscopes, 32 true RMS voltmeters, 4 frequency meters, and 11 microprocessors in a portable package weighing less than 20 lb. It can monitor single-phase power, three-phase power, or up to 12 phases of power simultaneously. In addition to presenting graphs of power disturbances, the 4800 PowerScope also records disturbances in the environment surrounding sensitive electronic systems, including temperature, humidity, and temperature rate of change. Price: $4,600 (and up)

BASIC MEASURING INSTRUMENTS, Foster City, CA (415/570-5355)

Circle Reader Service #51

Thinfilm design software

LAYERS, an inclusive software package for the computer-aided design and engineering of thinfilm interference coatings, provides engineers and thinfilm specialists with "state-of-the-art" capacity for design in formats directly applicable to manufacturing processes. Input of a multilayer stack can be accomplished in seconds. Once in, the resident stack can be operated on by any LAYERS option and saved in a LAYERS library for future use. At each stage, LAYERS presents clear instructions on the screen for every operation. Options are selected through single keystroke menus, and quick exit keys are provided for possible mistakes.

TALANDIC RESEARCH CORP., Pasedena, CA (818/793-4161)

Circle Reader Service #52

Fiber optic LAN board

Fiber LinkUp PC expansion board, based on the same technology as 3Com's coaxial cable Ethernet adapter, uses the same very large scale integrated (VLSI) circuit chips as the 3Com EtherLink to interface to PC hosts. Because of this, 3Com's 3+ and EtherSeries network operating systems and other EtherLink compatible software will run unaltered on the Codenet-3051 fiber LinkUp. The onboard fiber optic transceiver is based on Codenet-3030A, Ethernet/IEEE-802.3, and therefore Codenet-3051 is fully compatible with the IBM fiber optic Cabling System, AT&T fiber optic Premises Distribution System, and Codenet-FOCUS Fiber Optic Cabling Universal System. Price: $995.

CODENOLL TECHNOLOGY CORP., Yonkers, NY (914/965-6300)

Circle Reader Service #48

Free Literature

Modular digital receivers

Two full-color, four-page technical product bulletins on NSL-1024 and NSL-1027 modular digital IFM receivers describe the basic functions of providing frequency and amplitude measurements of IFM receivers, and also explain in detail the full range of special capabilities available. The two bulletins call out the performance parameters and technical specifications of their respective receivers. Sections provide a system block diagram for each receiver showing the basic modules, as well as the options, in a schematic, complete technical specifications, and peak error plots of frequency accuracy.
NORTHERN SCIENTIFIC LABORATORY, Fairfield, NJ (201/575-5420)

Circle Reader Service #50

Video instruments

Short form bi-annual video instrument catalog features 29 instruments, including a wide variety of video memory products. Other listings include video digitizers, analyzers, micrometers, calipers, multiplexers, test generators, computer digital I/O modules, pseudo-color generators, and freeze-frame television equipment.
COLORADO VIDEO, Boulder, CO (303/444-3972)

Circle Reader Service #51

Tech-Doc access

Literature describes Tech-Doc, a components and materials source database that provides engineers with information needed to specify the components, materials and systems required for designs. The nine-page package includes product specifications and price lists for each component program.
INACOM INTERNATIONAL, Denver, CO (800/443-INFO)

Circle Reader Service #52

Cell library

Data Book describes basic function and operating characteristics of 200 pre-tested Synertek logic function, memory and analog function standard cells. TIL and CMOS cross-reference charts, packaging information and sections on characteristics common to all cells precede individual data sheets. Logic symbols, outline drawings and illustrations accompany tabulations of each cell's propagation delay, power dissipation, input load capacitance and physical size data. An introduction to the standard cell design approach is addressed to systems designers.
SYNERTEK, Santa Clara, CA (408/748-7047)

Circle Reader Service #73

Membrane switches

An 8-page catalog features 20 versions of tactile feedback metal dome stock "off the shelf" membrane keypads and keyboards. Diagrams and specifications are included.
XYMOX, Milwaukee, WI (414/355-8300)

Circle Reader Service #74

DIR board-maker

A six-page brochure describes the shortest distance between idea and prototype circuit board — the DIR Board-Maker. The brochure includes full-color product and application photos, functional diagram, and a graphic comparison of time savings.
DIR, Sunnyvale, CA (408/733-7459)

Circle Reader Service #75

RFI/EMI filters

Updated and expanded 16-page filter catalog contains newly added UL-listed EMI power line filters, filter panels, and extended capability signal, control and data communication filters. Listings cover custom filters, common mode filters, power factor correction networks and Tempest filtering — power line, signal and control line panels. Included are dimensional illustrations, detailed performance specifications, tables and charts.
LECTROMAGNETICS INC., Los Angeles, CA (213/870-9383)

Circle Reader Service #27

Light Emitting Diodes

Eighty-page catalog of electronic components features light emitting diodes, thermal print heads, monolithic ICs, hybrid ICs, transistors, diodes, and resistors. Specifications include component type, function, features, and packaging details plus dimensional diagrams of complete line of products.
ROHM Corp., Irvine, CA (714/855-2131)
Circle Reader Service #81

Electroluminescent Displays

Eight-page four-color folder describes technological breakthrough in EL displays that are constructed using solid-state lightweight materials and have no moving parts or filaments to wear out or break. Specifications, ratings, and power supplies for complete line of EL displays is included.
SHARP Electronics Corp., Paramus, NJ (201/265-5600)
Circle Reader Service #82

Liquid Crystal Displays

Sixteen page brochure provides applications examples for high contrast liquid crystal displays manufactured to end-user specifications. Details describe principle of operation, interconnection and driving technologies, and design dimensions.
AEG Corp., Somerville, NJ (201/722-9800)
Circle Reader Service #83

Cathode ray tube displays

Six-page specifications sheet outlines high resolution CRT systems, including tubes, coils, and drive electronics. Details on packaging and phosphors are included.
RANK BRIMAR, Manchester, England (061-681-7072)
Circle Reader Service #84

Portable oscilloscopes

Twenty-page selection guide provides descriptions, specifications, and probe/instrument compatibility chart for complete line of portable oscilloscopes from 3.5 to 30 lb; in bandwidths from 500 kHz to 350 MHz.
TEKTRONIX INC., Beaverton, OR (800/547-1512)
Circle Reader Service #90

Optical filters

Twenty-page catalog includes general filter information on available filter designs (bandpass, extra narrowband, neutral density, reflective, extreme UV/soft X-ray), filter reference curves, filter specifications, and current price list.
ACTON RESEARCH CORP., Acton, MA (617/263-3584)
Circle Reader Service #91

Digital delay generators

Twelve-page catalog provides specifications and applications for digital delay generators, light pulse generators, oscillators, amplifiers and power supplies.
BERKELEY NUCLEONICS CORP., Berkeley, CA (415/527-1121)
Circle Reader Service #87

Modems

Four-page folder describes CLX 96 series modems in point-to-point or multidrop configurations, or for use with several terminals sharing a single voice grade line. Modems provide 9600 bps for applications ranging from small inexpensive networks to sophisticated data communications systems.
OKIDATA, Mt. Laurel, NJ (609/235-2600)
Circle Reader Service #85

Industrial meters

Twelve-page catalog covers line of illuminance meters, luminance meters, chroma meters, TV-color analyzer; and includes spectral response graphs, acceptance angle characteristics and technical details.
MINOLTA Corp., Ramsey, NJ (201/825-4000)
Circle Reader Service #86

Spectrum analyzers

Twenty-page brochure describes line of measurement systems including system mainframe and display, and spectrum analyzer modules. Complete specifications and application examples included.
HEWLETT-PACKARD, Palo Alto, CA
Circle Reader Service #88

Optical products

Twenty-four-page package of optical supplies and thin-film coating services includes beamsplitters, filters, mirrors, coatings, and polarizers. Current price list is included.
REYNARD ENTERPRISES INC., Laguna Niguel, CA (714/831-6026)
Circle Reader Service #89

Spectrum analyzers

Sixteen-page brochure describes line of spectrum analyzers and accessories and includes specifications, scan characteristics and typical applications.
ROHDE & SCHWARZ POLARAD, Lake Success, NY (516/328-1100)
Circle Reader Service #92

OCTOBER
ELECTRONIC IMAGING
SHOW ISSUE

President's Message

SOCIETY FOR INFORMATION DISPLAY
8055 West Manchester Avenue-Suite 615
Playa Del Rey, CA 90293 - 213/305-1502

I attended two graduation exercises this past June: my daughter's from St. Lawrence University and my niece's from high school in New Jersey. Both ceremonies were joyous, festive occasions that gave parents and relatives plenty of opportunity to feel proud. Both graduation ceremonies also honored students who had distinguished themselves with outstanding scholastic performances. As I listened to my niece deliver the Salutatorian Address I wondered what significance receiving this honor early in her life held for her future career.

The custom of honoring outstanding achievements is of course quite common in societies, industry and academia. SID, too, honors a few persons each year for their contributions to the field of information display or for their service to our Society. In each instance, the recipients of these awards (the Frances Rice Darne Award, fellow awards, special awards, and in the future also the Johann Gutenberg Prize for hardcopy contributions) have been carefully selected by the Honors and Awards Committee (chaired by Dr. Webster Howard this year).

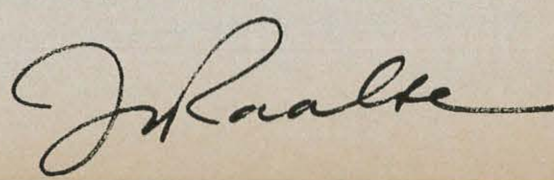
I remember how difficult selecting the awardees often was during the years I was a member of the Honors and Awards Committee. There invariably were several qualified candidates for each award. Often, too, the nominees were known to members of the Honors and Awards Committee and we had to be very careful to ignore those considerations. We always tried to base our selections strictly on the information supplied by the nominators.

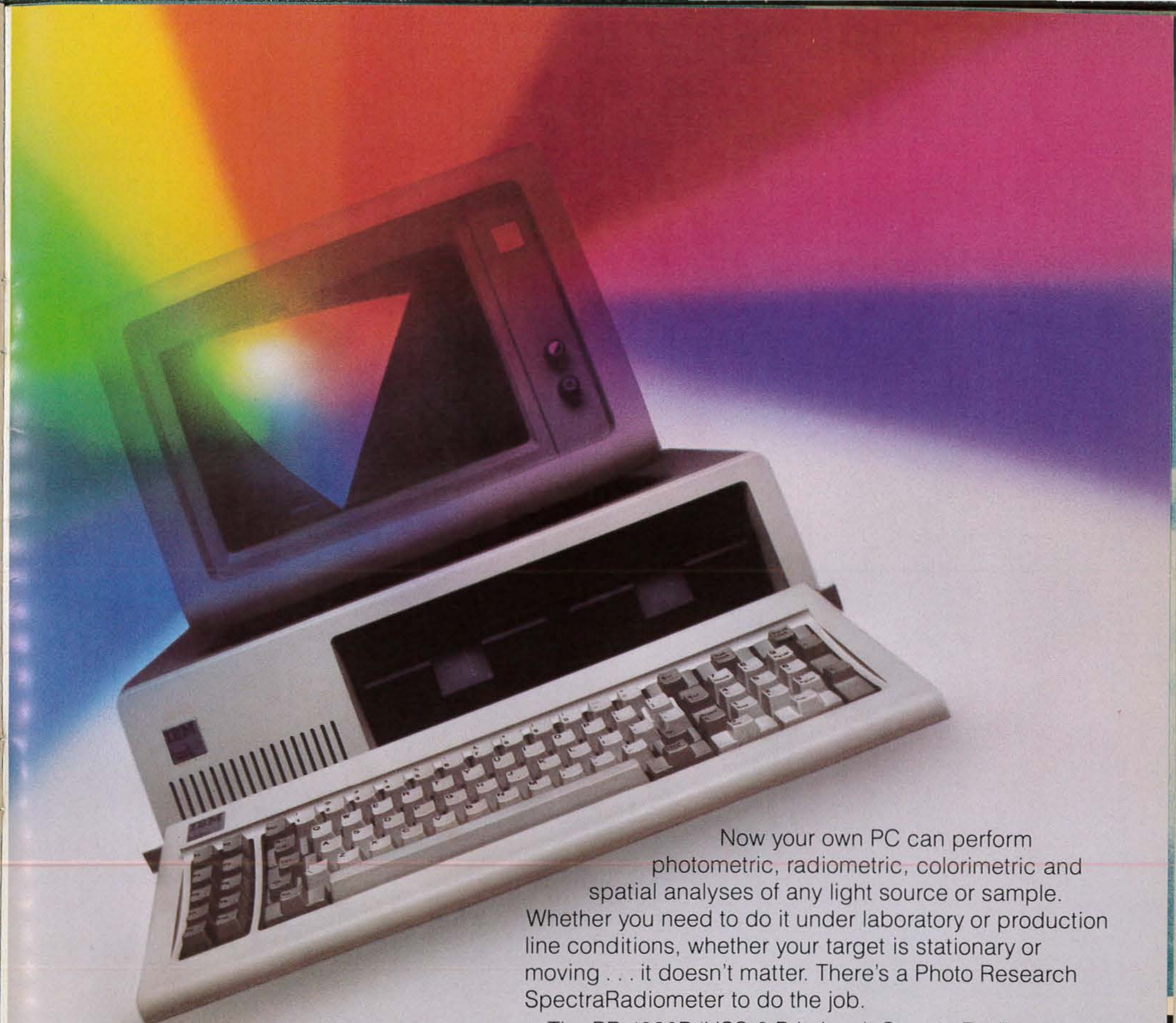
I also remember our frequent concern that many more SID members should have been considered because of their qualifications and achievements, but they were not nominated. Unfortunately the selection process is no better than the nominating process. And the way to improve both is for each SID member, each chapter, each geographic area, and even each organization to take the time and make the effort to nominate the most deserving candidates.

It is important to carefully prepare and submit these nominations. I don't mean one should exaggerate or distort the facts, but one should include *all* the factors that the Honors and Awards Committee should consider, such as technical achievements, creativity, evidence of excellence and leadership, service to SID or other technical and academic organizations, publications, and patents. SID does not have a standard form for these nominations (we will someday soon). In the interim the IEEE Fellow nomination form, which should be readily available, can serve as can excellent model.

In the past it also frequently appeared that some organizations and geographical areas were more comfortable with our nominations process. The information needed is often very difficult to obtain without consulting the nominee and I believe, therefore, that it is both reasonable and fair to do so. Of course, it goes without saying that a person shouldn't nominate himself or herself. There has been much debate on this issue but I believe the quality of the nominations and the selection of those we honor each year will be improved by allowing the candidates to supply background information on request. Moreover, it should become easier to prepare nominations and, hopefully, more qualified candidates can be considered in the future.

Because SID is an international society, we should have a common policy in such matters. I therefore suggest that you use these guidelines to nominate your most deserving colleagues and forward this information to Webster Howard; I know he looks forward to being flooded by nominations from every corner of the globe where SID is represented. (Dr. Howard's address is: IBM Corp., Research Div., IBM Research Center, P.O. Box 218, Yorktown Hts, NY 10598.)

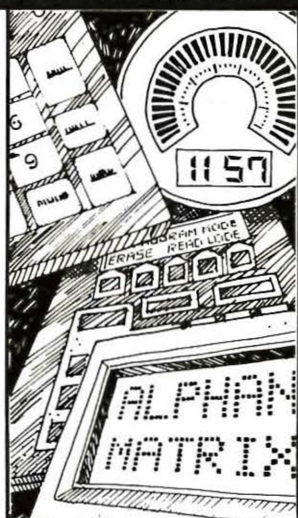




Chapter Notes

UK & Ireland: September 19, 1986
Program: One-day Symposium
Location: RSRE, Great Malvern
Topic: Military Displays
Speakers: Allan Cox & Dennis Hind, RARDE—Fighting Vehicles; Doug Burgess, RSRE—Thermal Imagers; Andy Smith, RARDE—Military Command & Control Applications; Paul Beatty, Ferranti—Aircraft Head-Down Displays; David Cochrane, Plessey—Naval Command & Control Consoles.

Los Angeles: June 25, 1986
Program: Technical Meeting
Location: Hacienda Hotel, El Segundo, CA
Topic: Color: A Status Report on Standards and Measurement Techniques
Speaker: Jay Rennildson, Retrotech
Demos: Ken Miller, Photo Research—Spectroscan 700 and Spectroradiometer 1980B; and Robert Ruff, EG&G—Computerbased Spectroradiometer C9 and Silicon Diode Spectroradiometer 880.



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A limited number of travel grants, up to $2,000 each, for student authors of accepted papers and their professors to attend SID '87. Papers must be original student work in any of the following subject areas:

- Emissive Flat Panels
- Non-emissive Flat Panels
- CRT Displays
- Hard Copy/Printers
- Display Systems/Applications
- Automotive Displays
- Display Addressing/Packaging
- Interactive I/O Technology
- Human Factors
- Large-Area Displays

Papers may be presented either by the student or by the professor. If presented by the student, the paper becomes eligible for an additional $500 cash award for "Best Student Paper at SID '87."

Deadline for abstracts: DECEMBER 9, 1986
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For detailed information phone or write:

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Japan
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Long Island Expressway
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516/921-7300

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70 Constantine Dr.
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201/327-1123

Cherry Electrical Prod. Corp.
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312/662-9200

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Stamford, CT 06901
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Electronic Materials Dept.
MP21-3
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607/974-7451

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UKG46-7TH

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P.O. Box 609
Columbus, NE 68601
402/564-3131

Data Images
1283 Algoma Road
Ottawa, Ontario
Canada, K1B3W7

Digital Electronics Corp.
26142 Eden Landing Road
Hayward, CA 94545
415/786-0520

Displays Inc.
RD #4, Box 6AAA
Lewistown, PA 17044
717/242-2541

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334 Littleton Rd.
Westford, MA 01886
617/692-6000

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P.O. Box 24283
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GEC Avionics
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p.l.c. of England)
4500 N. Shallowford Rd.
Atlanta, GA 30338
404/394-7800

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Sub. of Magnavox Govt. & Ind.
Electronics Co.
1200 E. Mermaid Lane
Philadelphia, PA 19118
215/233-4100

General Electric Co.
Aircraft Instrument Dept.
50 Fordham Rd.
Wilmington, MA 01887

George D. Harris Assoc. Inc.
The Plaza Building
Fairlawn, NJ 07410
201/796-5200

GML Information Services
594 Marrett Rd.
Lexington, MA 02173
617/861-0515

Grid Systems Corp.
2535 Garcia Ave.
Mt. View, CA 94043
415/961-4800

GTE
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617/777-1900

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Huntington Station, NY 11746
516/427-7500

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Basel, Switzerland
0707-328128 (x3208)

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Van Nuys, CA 91405
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203/757-9291

Interstate Electronics Corp.
Display Product Operations
1001 E. Ball Rd.
Anaheim, CA 92803
714/635-7210

ISE Electronics Corp.
P.O. Box 46
Ise, Mie, Japan
0596/39-1111

K & R Engrg. Sales Corp.
354 Route 206
Flanders, N.J. 07836
201/584-5235

Litton Systems Canada Ltd.
25 Cityview Dr.
Rexdale, Ontario, Canada M9W 5A7

Litton Systems Inc.
1215 South 52nd Street
Tempe, AZ 85281
602/968-4471

Magnavox Govt. &
Ind. Elec. Co.
1313 Production Rd.
Fort Wayne, IN 46808
219/429-5263

Magnetic Radiation Inc.
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Elk Grove Village, IL 60007
312/437-5200

Microfield Graphics Inc.
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Beaverton, OR 97005
503/626-9393

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Palo Alto, CA 94306
415/885-9433

Mitsubishi Electronics
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991 Knox St.
Torrance, CA 90502
213/515-3993

NEC Electronics Inc.
401 Ellis St., PO BOX 7241
Mountain View, CA 94039
415/960-6041

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Philips Bedrijven B.V.
PO Box 218
5600MD Eindhoven
The Netherlands
31-40-791111

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United Technologies Corp.
100 Helen St.
Norwalk, CT 06856
203/852-4905

Optical Coating Lab. Inc.
2789 North Point Pkwy.
Santa Rosa, CA 95407-7397
707/545-6440

Optical Radiation Corp.
1300 Optical Dr.
Azusa, CA 91702
818/969-3344

Orwin Associates Inc.
88 Seabro Ave.
Amityville, NY 11701
516/842-7177

Ovonic Display System Inc.
1896 Barrett St.
Troy, MI 48084
313/280-1900

Panelvision Corp.
265 Kappa Dr.
Pittsburgh, PA 15238
412/963-9635

Penn-Tran Corp.
Rt. 144 North
Wingate, PA 16880
814/355-1521

Philips Electronics Ltd.
601 Milner Ave.
Scarborough, Ontario,
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416/292-5161 Ext. 2567

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Dorset BH16 5SJ UK
0202-632116

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Kollmorgen Corp.
3000 N. Hollywood Way
Burbank, CA 91505
818/843-6100

Photonics Technology
6967 Wales Rd.
Northwood, OH 43619
419/666-0033

Planar Systems Inc.
1400 NW Compton Drive
Beaverton, OR 97006
503/625-2006

Plessey Displays
Station Rd.
Addlestone, Weybridge
Surrey KT15 2PW, UK
0932-47282

PTK
Div. Emerson Electric Co.
1173 Los Olivos Ave.
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Los Osos, CA 93402
805/528-5858

Quantum Data Inc.
455 E. Kehoe, Suite 104
Carol Stream, IL 60188
312/668-3301

Racal Microelectronic
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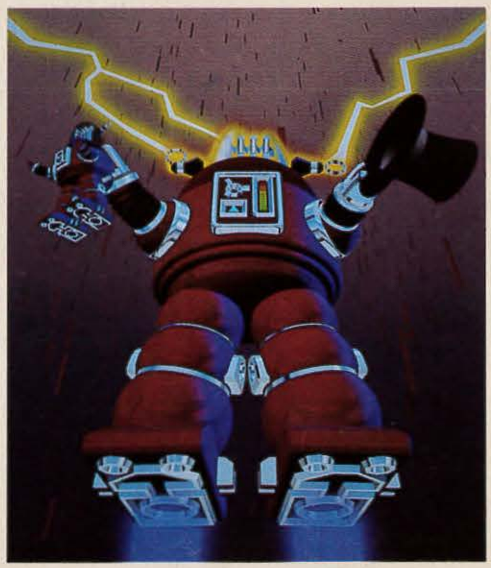

CELCO *Junior* saves time and makes money for animators: Data courtesy Pacific Data Images.

For further information call CELCO today.

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