≡ Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

January 1987
Vol. 3 No. 1

Automotive touch interactive display
Video/data projectors
Television displays for stadiums

Cover: *a prototype installation of the automotive touch interactive display described in Jan Olson's article (page 12)*

Next Month in Information Display

The Omega board at New York's Grand Central Station

Digital projection displays for planetaria

The psychology of perception as it relates to CRT design

Laser scanners: how to choose one for a specific application

SID: the first twenty-five years

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JANUARY 1987
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It took more than 2048 X 1536 addressable resolution before we called the GMA 201 Monochrome Display high performance. That's why it excels in *all* specifications. To assure 3,000,000 pixel addressability, spot size is just 0.19mm. Novel digital focus and astigmatism circuits maintain viewable resolution over the entire screen—and 256 displayable gray scale levels. For maximum image fidelity, geometric distortion is less than ±1%. For flicker-free viewing, refresh is 60 Hz non-interlaced (75 Hz optional).

No comparable monitor offers better imaging—or a better image—for your system. Fine details and dense graphics are strikingly discernable. In electronic publishing, you see large text pages in actual type fonts—without scrolling.

A monitor this good isn't made with off-the-shelf hardware. Tek designed and built its key components, fusing them in a synergistic design reflecting CRT technology leadership and the need for smooth system integration. Result: premiere performance and reliability at only 150 Watts with convection cooling.

Circuit boards detach for fast, low-cost service. OEMs can offer customers major world-wide regulatory compliance, and spare themselves certification delays: UL, CSA, IEC, DHHS, FCC* and VDE* are standard.

The GMA 201 is proven and ready to help sell your system now. The first in a new family of OEM raster monitors is backed by Tek's worldwide applications and service support. For details, and the name of your monitor specialist, please call: (503) 627-6868.

Tek Display Devices Operation: Trusted technology at the leading edge for systems builders.

 *Radiated and conducted emission compliance requires Option 23—cabinetry and power interface. Medical image courtesy of General Electric Medical Systems.

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INFORMATION DISPLAY

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editorial

This, the first issue of the new year, heralds a new publisher and new editorial direction for *Information Display.*

The Society for Information Display asked Palisades Institute for Research Services, Inc. to assume publication with the current issue. Palisades Institute has been running SID's annual technical symposia for ten years, has been publishing the *SID Proceedings* for eight years, and began managing the exhibit program with the 1985 Orlando meeting. So, the people at Palidades Institute know the Society's members and their interests. They also know that planning and assembling the editorial features for a technical society's general membership publication requires specialized skills, so they have acquired the services of Nutmeg Publishing Consultants. The Nutmeg staffers who are editing *ID* have among them over 40 years of experience in the editing and development of technical magazines, journals, and books. Each of them has a technical degree and practical engineering experience.

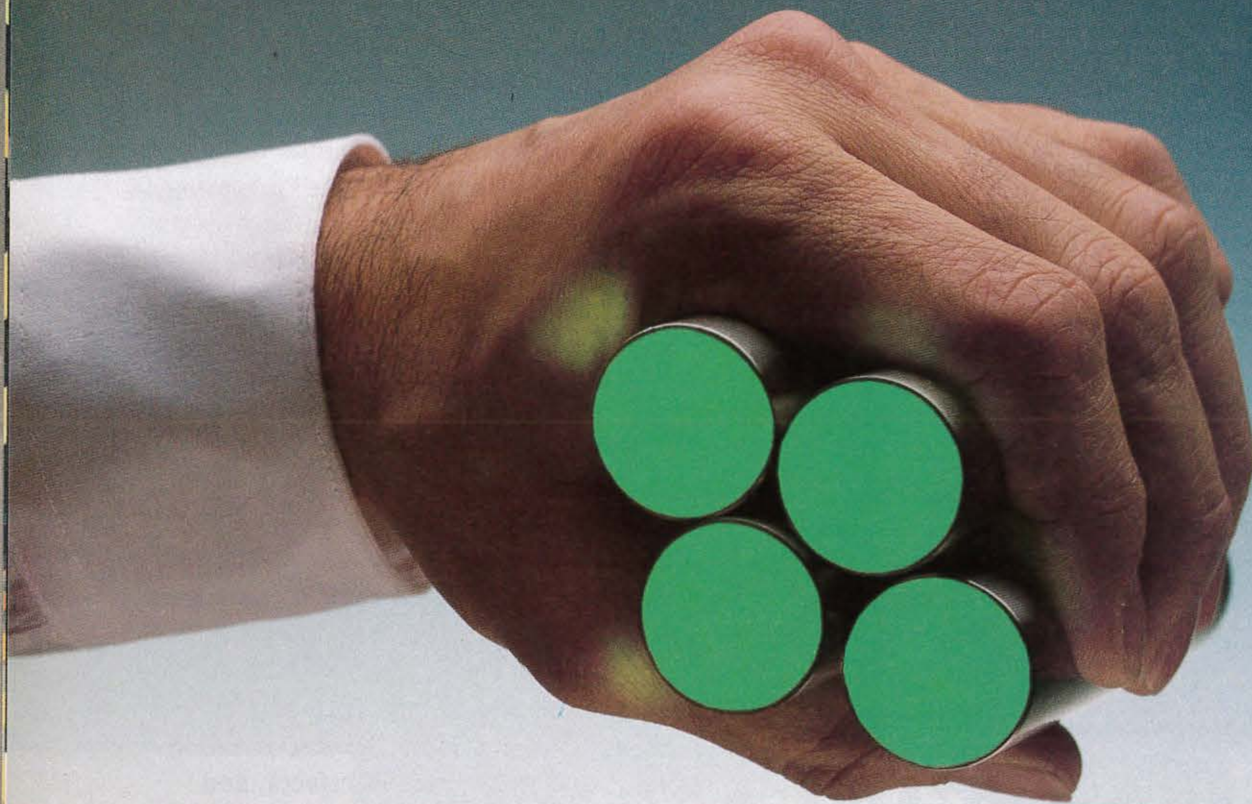
You will soon see a variety of editorial changes in *ID*, including a growing range of article subjects and styles. Included will be articles on design, applications, display principles, evolving display standards, and the subjective perception of display quality and its significance for display designers. There will be greater attention paid to hard-copy technology, and to systems, interfaces, and image and signal processing. In addition, there will be new coverage of consumer electronics, marketing, entrepreneurship, and management, all with a particular orientation to the display community. Because 1987 is SID's 25th anniversary, there will be special coverage of its history, beginning with an article in the February issue by Bob Knepper.

Two changes will be obvious immediately. First, there will be more editorial features pages—a total of a dozen in this issue—and the articles will have more technical depth. Second, the vast majority of articles will be written by recognized experts and will carry their authors' bylines.

To further this editorial approach, our staff will actively seek out SID members and other display specialists to write on specific topics, as well as for technical advice. However, because *ID*'s readers slightly outnumber the editorial staff (by about 3000 to 1), it may take us a while to get to you. Should you get impatient, please don't feel you have to wait. Article ideas, with either you or someone else as the proposed author, can be sent to The Editor, *Information Display*, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, N.Y. 10014.

We also welcome your general comments and criticisms. Our goal, after all, is that *ID* better serve you and the general display community.

Our new CRTs are quite a handful.



Introducing Litton's 1" tube.

Now let's see. What could you use a miniature CRT for?

How about a helmet-mounted display.

A compact film recorder.

A hybrid typesetter.

Or a compact display inside a crowded tank.

Litton's L-4272 cathode ray tube is the newest sub-miniature on the market.

And one of the best.

It's made by the leader of high resolution, high precision CRT's. Litton's reliable CRT products have been used in everything from advanced reconnaissance systems to sophisticated photocomposition machines.

The L-4272 is ruggedized, so it'll survive inside a tank, an aircraft or any vehicle using forward-looking infrared systems.

And it's a high performer. Spot size is 0.0008 inch. Brightness is 100 footlamberts with standard 525 line TV raster at 30 Hz filling the useful screen.

You can buy it as a stand-alone item or with a small coil and magnetic shield.

To get the small picture, contact Litton Electron Devices Division, 1215 S. 52nd Street, Tempe, AZ 85283. Phone (602) 968-4471. TWX: 910-950-0149.

Litton

Electron Devices

Circle no. 5

new products

Next-generation scientific calculator

Hewlett-Packard Company has introduced the HP-28C technical professional calculator, believed by its manufacturer to be the first calculator capable of performing symbolic mathematics.

The HP-28C features separate alpha and numeric keyboards and a 4-line by 23-character LCD display with 128K bytes of ROM. Complex numbers, matrices, vectors, lists, algebraic expressions, and other data types can be viewed, edited, and used in calculations as easily as ordinary numbers.

Equations can be entered and stored in the user's own terms with the calculation equation-solver capability. The HP-28C then solves an equation for any unknown variable anywhere in the equation. In addition, on-screen menus and soft keys give the HP-28C user keystroke access to hundreds of functions. The menus and soft keys provide high-level problem-solving capability without the need for programming.

The HP-28C can graphically depict any single-valued function and plot statistical data. Once an expression is plotted in the display, the user can locate an approximate root, press a key to record the coordinates, then use the equation solver to calculate the root with 12-digit accuracy. The calculator also contains a unit-conversion system for converting values between unit systems. The values of 120 units are built in; the user can have these in unlimited combinations.

When open, the calculator is 7.5" × 6.25" × 0.5" thick. It weighs 8 ounces. The list price for the HP-28C is $235. An optional compact printer, priced at $135, communicates with the calculator via an infrared beam. For further information contact Inquiries Manager, Hewlett-Packard Company, 1820 Embarcadero Road, Palo Alto, CA 94303. 800/367-4772.
Circle no. 6

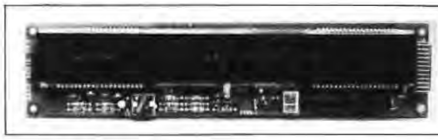
Light-emitting flat-panel terminal

A light-emitting flat-panel terminal from Emerald Computers, Inc. combines previously unutilized flat-panel benefits and conventional system access technology. The device has been designed to provide multiterminal users with a light, durable, compact alternative to conventional CRT terminals, without the disadvantages of electromagnetic distortion, mechanical vulnerability, eye strain, and ambient radiation.

The flat-panel terminal display occupies one-fifth the space of the CRT and may be easily plugged into any system. Employment of the RS232 communication mode, ANSI 3.64, and other standard terminal protocols combine to produce a ready compatability with the majority of host systems, from PC to mainframe. With complete internal communication circuitry, the display offers an 80-character by 25-line capacity of a 4" × 8" screen that requires a small desk surface. The overall display dimensions of 8½" (H) × 11" (W) × 2½" (D) produce a footprint of only 27.5 in.^{2}, compared to 140 in.^{2} for an average-to-small CRT. By comparison, flat-panel images are reported to be crisper and more readable at angles over 120°, with less flicker and distortion than CRT images.

For additional information, contact David Blass, Emerald Computers, Inc., 16515 S.W. 72nd Avenue, Portland, OR 97224. 503/620-6094.
Circle no. 7

Intelligent VFD module



The Industrial Products Division of IEE has added a new low-cost 5 × 7 dot-matrix 1 × 40 display to its FLIP™ line of intelligent vacuum fluorescent display modules. Designated as model 3601-84-040, this no-frills module is suited for high-volume OEM applications, such as copiers, point-of-sale terminals, and security systems. It displays a full 40-character line, yet is extremely compact, measuring only 9.45"(W) × 2.20" (H) × 0.77"(D). Characters are 0.2" (5.1 mm) high.

An on-board microprocessor controller handles all scan, refresh, and data I/O tasks, permitting easy interface to an 8-bit ASCII parallel data bus. Only +5 V_{dc} power is required for operation. The unit displays the full 96-character ASCII set of upper and lower-case letters, numbers, and symbols. Display characters are a bright, pleasant blue-green color that provides for comfortable short- or long-term viewing. A wide spectrum of color filters is available to fit almost any application.

The 3601-84-040 is priced at $91 (quantities of 100); availability is stock to 4 weeks, ARO. For additional information, contact IEE, Industrial Products Division Sales Office, 7740 Lemona Avenue, Van Nuys, CA 91409-9234. 818/787-0311, ext. 418.
Circle no. 8

Night vision and sunlight readable lenses

The Computer Products Division of General Instrument Corporation has developed night-vision green and sunlight readable lenses to add to its Clare-Pendar family of military lenses meeting military specifications for chromaticity and illumination. The night-vision green color range is intended to be used in aerospace cockpits where the pilot is using light-intensifying goggles for night flight. At the other end of the light intensity spectrum, the sunlight readable lenses are appropriate for cockpit applications subject to bright sunlight conditions. All lenses are designed for front-panel lamp replacement and are available in single- or multiple-lamp configurations.

For further information contact Bill Haushalter, General Instrument Corporation, Computer Products Division, 1401 Lomaland, El Paso, TX 79925. 915/592-5700.
Circle no. 9

Miniature P-package inverter

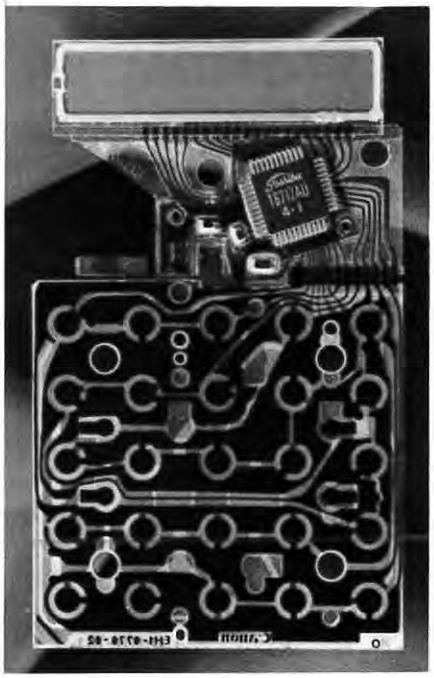
The miniature P-Package Inverter from Endicott Research Group is engineered to provide the output voltages and frequencies of most E600 and LPS Smart Force™ Inverters, while remaining compact. These compact units are suited for powering EL lamps to backlight LCDs and membrane switches in portable hand-held instruments and field equipment.

P-series inverters are fully encapsulated for environmental protection, PC mountable, and conform to the same general operating specifications as the standard E600 and LPS inverters. Units will power from less than 4 to as many as 60 in.^{2} of electroluminescent material, depending upon type of EL lamp, dc input voltage available, and required brightness level. P-Series Smart Force™ Inverters are available with low dc inputs, including 5, 6, 9, 12, 15, 18, 24, or 28 V_{dc}.

Price: LPS "P" Package—$5.49 ea.; E600 "P" Package—$6.12 ea. (quantities of 250).

For more information contact Michael Foldes, Endicott Research Group, Inc., 2601 Wayne Street, P.O. Box 269, Endicott, NY 13760. 607/754-9187. TWX: 510-252-0155.
Circle no. 10

Flexible circuitry with SMT



Elform's new flex circuitry does not require solder to make the attachments. Components are temporarily held in place by using heat and pressure. The conductive traces are heat activated and hold the parts in place prior to encapsulating the parts with a 1/2-mil heat-activated film laminate. The flex circuitry can be custom built from engineering drawings with heat-sealing edges for attaching solar cells or LCDs. It can also be an integral part of the membrane switch keyboard. For more complex designs, thru hole vias can be used for two-sided circuitry. The electrical traces can be either graphite or silver covered with graphite. The film laminate SMT is designed to eliminate all the problems associated with solder.

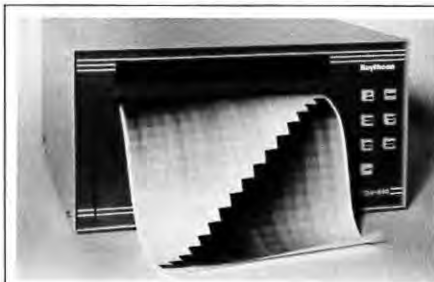
For more information, contact Roger R. Reinke, Elform, Inc., P.O. Box 7362, Reno, NV 89510. 702/356-1734. Telex: 170037. Fax: 702/356-1742.
Circle no. 11

Optically transparent heater

UCE has announced the availability of transparent heaters that provide "light clear" uniform high-efficiency thermal transfer to flat substrates. A typical application includes heaters for LCDs. Connections are easily made to solderable tabs or wire at the edge of the substrate. The heaters feature clear conductive coatings for transparency; flatness for integral application to the substrate to be heated, offering efficient thermal transfer; vapor-deposited metalization over the entire heating surface for uniform heating; simple solderable connection; a wide variety of voltage inputs, watt density, and physical size for custom application-specific heaters; and environmental protection for harsh environments.

For further information contact UCE, Inc., 24 Fitch St., Norwalk, CT 06855. 203/838-7509.
Circle no. 12

Thermal hard-copy recorder



Raytheon Ocean Systems Company has developed a high-performance thermal hard-copy recorder which retails for less than $5,000. The TDU-850 Thermal Display Unit is reported to produce true gray scales at high speeds and with high resolution, generating recordings of near photographic quality. It can produce full tonal images or display digital data in graphic or alphanumeric form. Applications include alphanumeric/graphic printing, spectrum analysis, surveillance and facsimile transmissions, medical electronics, and radar and sonar recordings.

The instrument uses a linear array thermal head in a direct printing process that is without toners. The head is 8.5" wide and has a total of 1728 addressable elements, resulting in a dot density, or resolution, of 203 dots/in. Line printing is controlled and driven electronically. The recorder is quiet and maintenance free because there are no moving parts associated with the printing of data.

Price is from $4,950, depending on interface and application. Additional details and a TDU-850 product data sheet are available from Raytheon Ocean Systems Co., 1847 West Main Road, Portsmouth, RI 02871-1087. 401/847-2054.

Circle no. 13

High-resolution communication and display system

Model CT 2000 from DataBeam is a high-resolution communication and display system equipped with a control tablet and a transportable console. Images of written or graphic materials and computer-generated data in point-to-point or multipoint environments are transmitted via standard telephone lines or high-speed digital circuits. The system incorporates a patented cathodochromic CRT light-valve display, which produces a brightness of 5-10 times that of conventional projection video with greater resolution on a 4 × 4 ft. screen. Features include a laser printer for hard copies, facsimile or digital scanner for document input, system storage of documents for immediate recall, a graphics tablet for command entry, on-line pointers with interactive annotation, and a 2,048 × 2,048 line-resolution display.

For further information contact Peter G. Gammon, DataBeam Corporation, 3256 Lochness Drive, Lexington, KY 40503. 606/273-3204.

Circle no. 14

NIH grant goes to Lucitron for large flat-panel development

The National Institutes of Health (NIH) has awarded a 6-month $50,000 grant to Lucitron, Inc., Northbrook, IL, for work on a new kind of very big flat video display panel to be used for medical images. Successful completion of this Phase I award will allow the company to apply for a Phase II grant of up to $500,000. Lucitron will use the NIH grant to further work on its 35-in.-diagonal FLATSCREEN® panel, which is 5 in. thick and as flat as window glass.

Potential uses in medicine for these large flat panels include the display of computerized X-rays, CAT scans, magnetic resonance imagery, and ultrasonics, as well as the training of medical and nursing students. The big bright display screens will make it possible for groups of doctors and technicians to work with larger-than-life images in operating theaters and lecture rooms.

Alan Sobel, Vice President, Operations, Lucitron, Inc., stands in front of the FLATSCREEN® panel on which is displayed a picture of Michael deJule, Vice President, R&D. The image on the panel comes from an IBM personal computer.

Computer publishing event cancelled

NCGA's Computer Publishing '87, scheduled for Sept. 29–Oct. 1, 1987, has been cancelled, according to National Computer Graphics Assn. President Dr. Phillip Mittleman, "because the marketplace is saturated with computer and electronic publishing events at this time."

Rivals in engineering drawing conversion sign OEM agreement

Metagraphics, Inc., Woburn, MA, and Shantek Corp., Warren, NJ, once considered arch-rivals for the engineering drawing conversion market, have signed an original equipment manufacturer (OEM) agreement. Metagraphics will buy selected hardware and software scanning products from Shantek to achieve broader capability in the scanning, digitizing, and conversion of large engineering drawings. Metagraphics will then integrate these Shantek components into its M-4200 system, an Apollo Computer-based drawing conversion system that reads manually-created hardcopy drawings, corrects errors in geometry, and converts the drawings' information into an intelligent database for CAD/CAM systems. Customers will benefit, says Metagraphic's Vice President of Engineering, Thomas E. Bailey, Jr., by being able "to get a complete integrated solution for all their drawing conversion needs from one vendor."

Adage and Raster Technologies reach out-of-court settlement

Adage, Inc., Billerica, MA, and Raster Technologies, Inc. have reached an out-of-court settlement of a suit filed in January 1985 concerning the alleged infringement of a Leixdata Corp. patent by Raster Technologies, Inc. Lexidata, since acquired by Adage, received U.S. Patent No. 4,475,104 for the "Z-Buffer" technology embodied in its SOLIDVIEW® three-dimensional display system. The companies did not disclose the terms of the settlement except to note that the agreement provides Raster Technologies with a license to produce products incorporating the technology covered by the original patent and a subsequent one.

Executive changes: Conrac, Optical Radiation, Toshiba

Conrac Corp., Stamford, CT, has elected **Hans E. Mitthof** Vice President with direct operating responsibility for Conrac's newly formed Display Products Group. Mr. Mitthof, who for the past seven years has been President of Conrac's European subsidiary Conrac Elecktron GmbH, will now be based in Stamford. Conrac has named **Jose Aparicio** General Manager of its new Singapore plant for volume production of computer graphics monitors, Conrac Singapore Pte Ltd.

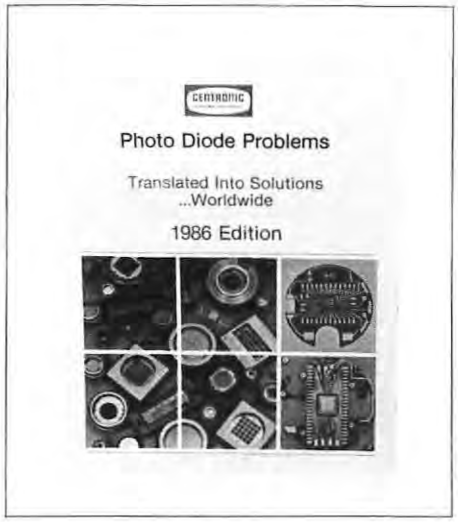
Optical Radiation Corp., Azusa, CA, announces the following executive appointments: **R. Richard Geatty,** Vice President of the Scientific and Industrial Products Group; **Jules Schneider,** Vice President of the Electronic Products Division; and **Adrian Sabater,** Director of Marketing for the Electronic Products Division.

Toshiba America, Inc. has appointed **Robert P. Lawrence** Vice President, Sales, for its Disk Products Division in Santa Clara, CA.

Survey of Desktop Publishing

According to a new 170-page study from the consulting firm of International Resource Development, Inc. (IRD), most of the computer-based technical electronic publishing (TEP) systems currently on the market are sorely deficient in output resolution. Many applications require a resolution approaching typeset-quality text of at least 1,000 dots/in., but very few laser printers offer better than 300–400 dots/in. resolution. A bifurcated market already exists, the IRD report maintains. While the personal computer manufacturers are fighting for each $10,000 sale of low-end TEP systems, Xerox Corp. is quietly bagging orders for hundreds of millions of dollars worth of its high-end 9700- and 8700-based systems, each selling for $200,000 to $800,000. Most of these high-priced systems, according to the IRD report, are going to the in-plant market, where technical manuals are the principal application. Will end-to-end high-quality TEP systems ever penetrate the office automation market? That depends on how far and how fast the high-resolution laser printers come down in price. Says Jean Buffham of the IRD staff, "It would not be reasonable to expect this to happen before the next century." Copies of Report No. 717, *Technical Electronic Publishing—Pre-Press & Paper-Based*, are $1,650.00. For a free table of contents and description, write: IRD, 6 Prowitt St., Norwalk, CT 06855. 203/866-7800, Telex: 64 3452.
Circle no. 16

1986 Photodiode Catalog



Centronic Electro-Optics, Inc., a newly formed division of Centronic, has published its short-form photodiode catalog for 1986. The catalog lists performance and packing specifications for the entire product line, consisting of: photo-transistors, hybrids, quadrants, bi-cells, infrared LEDs, photo-darlingtons, photo-interrupters, and photo-voltaic diodes.

For more information and a copy of the catalog contact Jim McVea, Centronic Electro-Optics Inc., 1101 Bristol Road, Mountainside, NJ 07092, 201/233-7200, Fax: 201 233-6092 or Frank Scott, Centronic Electro-Optics Inc, 1829-B DeHavilland Drive, Newbury Park, CA 91320, 805/499-5902, Fax: 805 499-7770.
Circle no. 17

1985 IEEE Index

The *1985 Index to IEEE Publications* is now available. The volume indexes all papers and books published by the IEEE during 1985, including articles from 55 periodicals, papers from 143 conferences, 64 new standards, 14 IEEE Press books and other items. Author and subject index. $200.00 per copy. IEEE order no. JH78287. Order from IEEE Service Center, Publication Sales, 445 Hoes Lane, Piscataway, NJ 08854-4150. 201/981-1393.

Case study: the first automotive-display touch panel

BY JAN B. OLSON

WHEN a major U.S. automaker decided to add a CRT with a touch screen to the dash panel of its premier model, adapting existing touch-screen technology seemed like the easiest part of the job. But the environmentally harsh and aesthetically demanding automotive environment had been underestimated. Solving the problems took aerospace technology and treating the touch screen as an integral part of the display system.

Even when the difficulties appeared insurmountable, the automaker steadfastly supported the project, and for good reasons.

Automobiles have become increasingly complex and technically sophisticated machines in recent years. Normal progress, driven by competitive pressure, has been greatly accelerated by federally mandated requirements for improved fuel economy, reduced emissions, and greater safety.

Microprocessors and computers are playing an important role in this automotive evolution. Computerization often permits dramatic leaps in functional capability and user options that, unhappily, are accompanied by increased complexity of operation. This has definitely been the trend with the modern automobile.

Additionally, the same government constraints that are forcing rapid technological advancement are also restricting the automakers' traditional competitive weapons—styling and performance. In an effort to differentiate their product from their competitors', and their top-of-the-line models from the very-similarly sized and styled—but less expensive—stablemates, automakers are offering more and better bells and whistles in the passenger compartment. These include complex music systems with tape decks or compact disc players; graphic equalizers and speaker balance controls; trip and mileage computers; on-board diagnostic capability; malfunction and service advice; warning systems; memory seat controls; mobile telephones; and soon, navigation and map display.

Jan B. Olson is currently Vice President of Business Development, The Sierracin Corporation, Sylmar, California. While President of the company's Transflex Division, he was directly responsible for the development of the touch panel described in this article.

Dashboard crowding a problem

These factors have contributed to "dashboard overpopulation," where too many switches compete for too little space. This problem is most acute in top-of-the-line models [Fig. 1], where the number of features is greater than on lesser models, but the amount of dashboard space is about the same. In addition to its user unfriendliness and its adverse impact on styling, this situation causes concern that drivers may become confused and distracted while searching for the right button among too many alternatives.

The instrumentation industry has responded well to these challenges, and rather advanced digital and graphic electronic displays using various technologies, such as LED, LCD, VF and EL, are rapidly replacing their analog antecedents. These are capable of supplying more information more clearly and in less space than dedicated analog panels with comparable information content.

Control system input devices, however, have undergone few changes except for downsizing and proliferation. Conventional mechanical switch controls of all types including push button, rocker, toggle, slide, and rotary knob are seen in increasingly bewildering profusion. As dashboard "real estate" becomes more scarce, some multifunctional switches are being employed, which further adds to the confusion. Consider the semi-annual process of setting the clock forward or back on models in which time and radio-frequency indication share the same display. This process that formerly involved only twisting the obvious knob under the clock can now require revisiting the owners manual to discover which illogical radio switches must be pressed.

The touch-screen solution

These factors that are plaguing the automotive industry are not uncommon in other high-technology fields. The common factors driving this technical revolution include increasing sophistication and control options (usually accelerated by computerization) in equipment operated by someone who is not a trained computer specialist, and where the ease, accuracy, and speed of operator-machine interaction is important. In addition to vehicular operation, activities in which these factors are present to a high degree include medical diagnostics and patient monitoring, air traffic control, machine tool operation, process control, laboratory analysis, telecommunications, and the use of military weaponry.

These latter fields have been leaders in adopting a relatively new technology that is aimed at resolving this dilemma. That technology is known by a variety of unofficial terms, the most descriptive of which is "touch screen" (commonly just plain "touch"), but more properly, "direct touch interaction with displayed information."

Simply described, direct touch interaction is accomplished by placing a transparent position-sensitive switch across the display, then linking it via a computer to the location of information on the display. This creates a reconfigurable switch array that lends itself to menu-driven selection. Such a system can be combined with the display of data and can provide static or dynamic visual feedback of the selection made or results attained, if desired.

While the automotive application possesses, to a very high degree, all of the conditions that would make it ripe for "touch," it also has some unique constraints that have prevented this conversion. These constraints include an uncontrolled and wide-ranging thermal and humidity environment, a moderately severe shock and vibration exposure, high intensity directly impinging and reflected

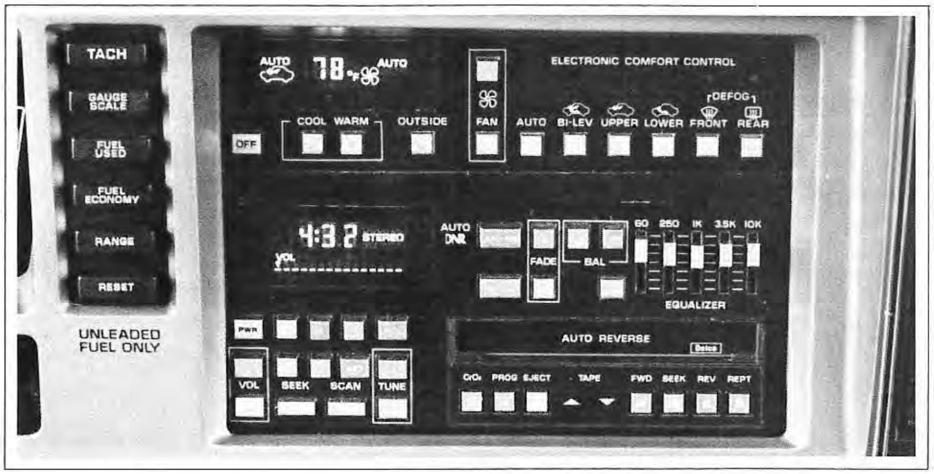
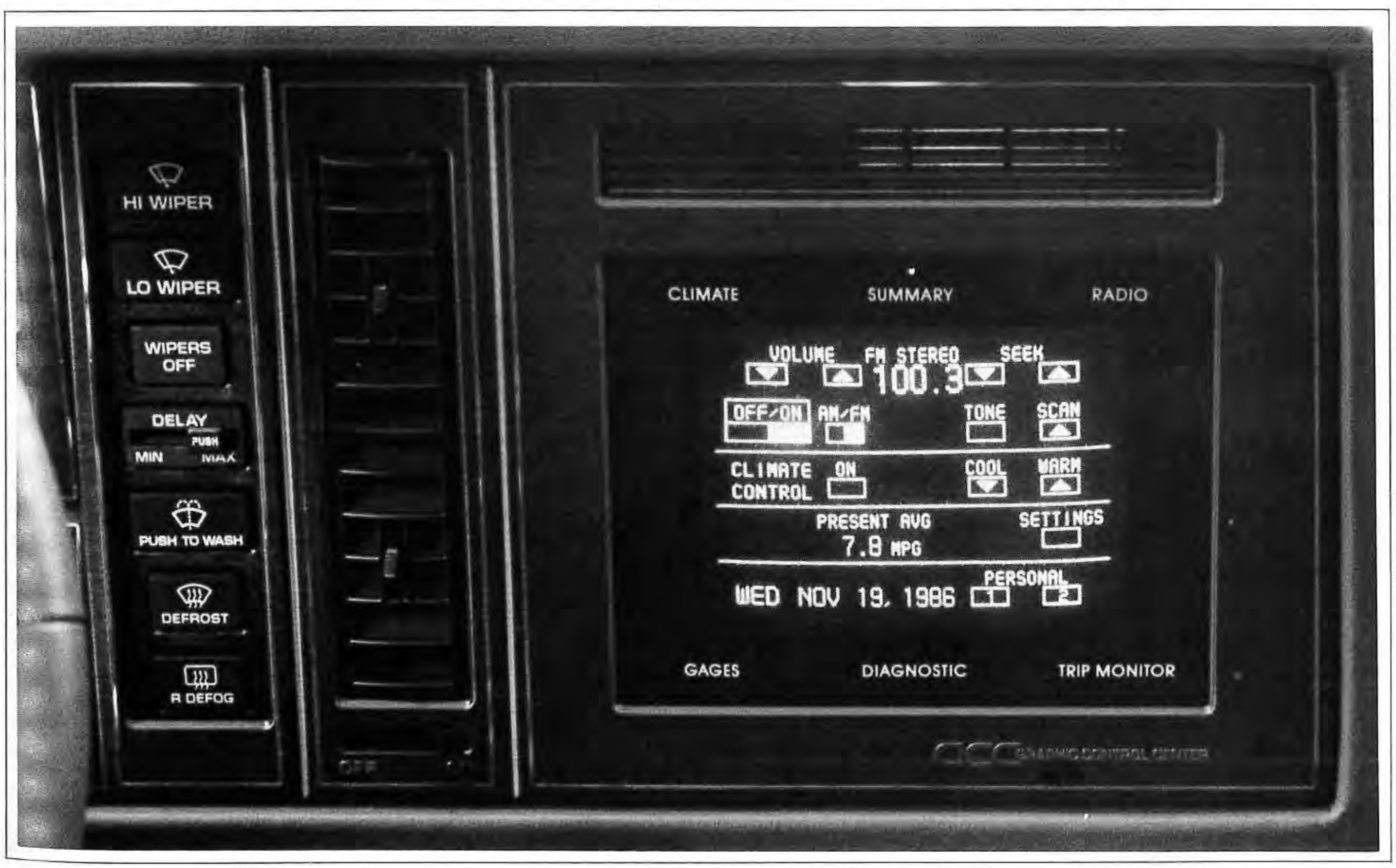


Fig. 1: A conventional top-of-the-line automobile dashboard, above, uses pushbuttons that are dedicated to controlling a single function. More features mean more crowding on the dash panel. Fig. 2: The touch interactive graphic control panel, below, uses touch-panel-over-CRT to provide simplified, reconfigurable switching. Summary "page" of the display is shown, one of 39 available to the driver; additional diagnostic pages can be accessed by a service technician.

sunlight, crash worthiness, system cost limitations, high-rate and inflexible production demands, variable maintenance discipline, and very demanding quality, cosmetic, and reliability considerations.

One U.S. auto company, however, has aggressively and tenaciously pursued the adaptation of touch-interaction technology to the automobile. The dramatic result is that a CRT-based touch-screen system [Fig. 2] was introduced on



one popular top-of-the-line car as standard equipment beginning with the 1986 model. Rather uncommonly, this manufacturer has beaten its Japanese counterparts to the market on Japan's home court of displays and related devices, and pioneered the use of touch-screen technology in consumer products.

Autos—a tough environment for touch

One of the most critical, and as it turned out, most difficult components of the CRT touch-screen system to adapt to automotive use was the touch panel itself. This adaptation proved to be a much more ambitious project than anyone anticipated, and resulted in an intensive two-year development and verification test program. However, it also dramatically advanced the state of the art for touch panels, which will benefit the industry generally. The remainder of this article deals with the touch-panel concept, the new materials and capabilities that had to be developed before panels could function reliably in the difficult automotive environment, and some of the improvements resulting from this development that have broadened the applicability of touch-panel technology and improved its performance in other applications.

Resistive overlay vs. infrared interrupt

As a first consideration, there are several technologies competing in the touch interaction device market. (It is not proper to call them all touch panels because at least one is not a panel at all, but a peripheral frame.) Each of the available technologies has its own virtues and drawbacks, and most will find their niche markets. These technologies include resistive, optical, capacitive, and acoustic systems, and some of these technologies have more than one implementation. The two most popular technologies were serious contenders for the automotive application.

The first of these was resistive overlay, a transparent membrane switch in which two conductively coated transparent elements are assembled with the conductive surfaces facing each other, and suitably separated to prevent inadvertent contact. These elements can each be patterned into rectangular array and assembled to form a switch matrix, which is called the "matrix panel" approach [Fig. 3]. Alternatively, each can have opposing bus bars which are orthogonal to those on the other element to create linear potentiometers in the X and Y axes. When a voltage is impressed on each element alternately, the voltage division at the contact point, as sensed by the other element, produces X and Y voltages that are analogous to the X and Y contact positions. An analog-to-digital converter then translates the signal to computer-readable form. This is the "analog panel" approach [Fig. 4].

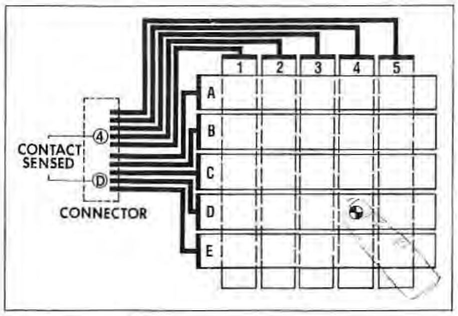
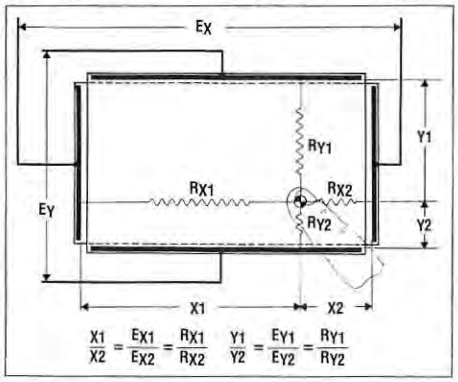


Fig. 3: Typical matrix touch-panel circuit.

Fig. 4: Typical analog touch-panel circuit.



Principal advantages of the resistive-overlay panel, either matrix or analog, are that it is simple and inherently inexpensive at the system level, is highly reliable and stable, gives tactile feedback (with the actuation force being a controllable design parameter), can be shaped conformally to the display face, and lends itself to optical enhancement of the display (an important factor in the automotive application).

Among its disadvantages are that it substitutes a more vulnerable plastic surface for glass, has finite thickness that can add to parallax error, can introduce its own optical characteristics into the display system, and can contribute to the reflectance and consequent reduction of light transmittance. Each of these disadvantages can be reduced to levels of no consequence in most applications, or even used to advantage, by proper design with a good understanding of the human factors involved.

Infrared interrupt was the second contending technology. Here a peripheral protruding "frame" contains closely spaced infrared LEDs in two of its adjacent sides while the opposing sides contain IR photodetectors aligned to specific emitters. This is a matrix-type switch in which electronics sense the interruption of one or more invisible IR beams in each axis, thus sensing finger location (but not the touch itself).

Among the advantages of this system are that no extraneous optical elements are superimposed on the display face and the glass display surface is retained as the exposed surface.

Disadvantages include generally higher system cost and the straight-line nature of light beams, which can cause significant parallax on large non-flat CRTs. Also, the devices are somewhat sensitive to dirt, dust and other light-obscuring build-up, and are subject to false signals from flies and the like. Significant disadvantages in the automotive application are the lack of tactile feedback and the operator's inability to rest and move his finger on the surface prior to "poking in" the input—a major consideration when driving along a rough or rolling highway.

After evaluating all technologies, the automaker selected the matrix-type resistive overlay touch panel as offering the best combination of important attributes, including maintenance-free reliability, appropriate human factors aspects, styling latitude, technical maturity, and cost effectiveness.

The complexity of simplification

In the final design, the central transparent area is a 5 × 5 matrix yielding 25 potential switch locations. This provided sufficient design latitude, as no single "page" requires more than 20 switches—a substantial simplification over the number of choices available on the conventional dashboard [compare Figs. 1 and 2].

This transparent central area is surrounded by a non-transparent border that contains six dedicated or "hard" switches used to call up the entry pages for the major systems or routines. These entry pages are used to access subordinate more-detailed pages for a total of 39 pages containing 162 switches (including several switch functions that repeat on different pages). The manufacturer has said it would take 91 dedicated conventional switches to manage the functions controlled by this system.

Some pages are dedicated to providing information instead of control, like those that pictorially depict such conditions as which lamp is burned out or which door is ajar, and one called "GAGES" which provides a tachometer and oil pressure, system voltage and coolant temperature gauges to augment the traditional "idiot lights." There is also a "service mode" that taps the car's on-board diagnostic system and displays many additional pages providing technical readouts to a mechanic, and frees him from depending on a plug-in shop computer console.

The construction of this particular switch [Fig. 5] is more complex than the usual touch panel because the application presents some unusual requirements:

- *Contrast enhancement filter* to reduce the high-intensity reflected ambient light to increase the CRT's contrast ratio and to provide color bias to match the monochromatic CRT's color to that of the vacuum fluorescent instrument panel. This requires very close tolerances on color coordinates and density.
- *Critical human factors,* including the consideration that the intended operators represent a broad cross-section of age, education, and experience levels, and may completely lack previous computer experience. But whatever their degree of computer ignorance and computer shyness, they will not be undergoing a training period. In addition, the operator will be off-axis relative to the nonrotatable CRT's centerline, so parallax error is a significant consideration.
- *Severe environmental exposure* to temperatures between −40 and +85°C, and relative humidity to 95% at +65°C. When tested up to 500 hours at these conditions, the panel must maintain faultless operation throughout the exposure, and retain pristine cosmetic appearance afterward. This requirement invalidated virtually all materials conventionally used for touch screens.
- *Maintaining rigid cosmetic quality* of the required complex laminate after severe environmental exposure. This was made more difficult by coefficient-of-expansion mismatches and potential thermoplastic behavior of some of the materials employed. Both polycarbonate and acrylic are optically bonded to the respective switch elements, which are patterned conductive indium tin oxide (ITO) on polyester terepthalate (PET).
- *Predictable high-volume manufacturability* in quantities to thousands per month was absolutely essential in order to satisfy the automakers' car building schedule. This was a monumental challenge as no one had previously produced panels even approaching this level of complexity at these high production rates.

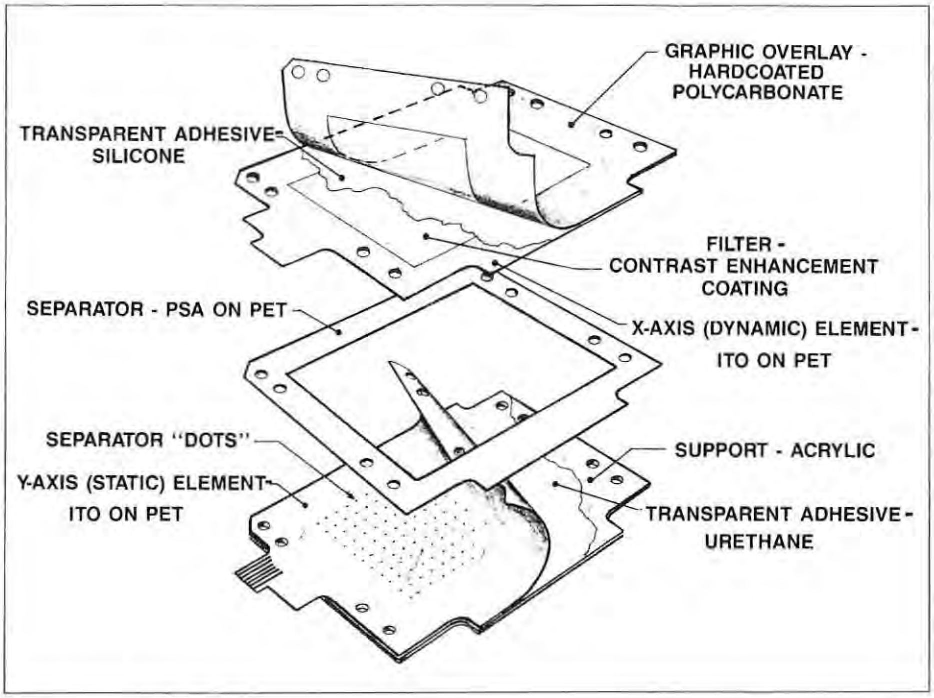


Fig. 5: Construction of the first-generation automotive touch panel is more complicated than meets the eye.

The Transflex Division of the Sierracin Corporation (since consolidated with Sierracin's Thermal Systems Division in Bell, California), the developer and supplier of this touch panel, had been a pioneer in the industry, but had never before encountered such technically demanding requirements. Fortunately, as a second-generation technological spin-off from Sierracin's Sylmar Division, a leading producer of high-performance aircraft windshields and windows, Transflex had access to some very sophisticated transparent materials and expertise. Moreover, the first-generation spin-off is Sierracin/Intrex, which manufactures the conductively coated film which is the basis of the touch screen. Both of these close associations proved vital to meeting the stringent technical demands of this automotive application, and consequently advancing the state of the art of this product.

Many improvements required

The first major hurdle in the development of a satisfactory automotive touch panel was overcoming the sunlight problem. Direct sunlight, if not filtered, would illuminate the full-phosphor face of the high-intensity monochromatic CRT at the expense of contrast ratio, upon which legibility depended. Lower-elevation sources of illumination, such as light-colored clothing that reflected sunlight onto the panel surfaces, also destroyed contrast ratio. Transflex was able to draw on the specialized optical expertise developed in the Sylmar Division, and provided a solution employing a contrast-enhancement filter coating at the proper level in the laminate together with a first-surface anti-glare coating. The resultant panel achieves good CRT legibility under the most adverse sunlight conditions, and provides precise instrument panel-matching color bias, which was needed to meet styling requirements. These in-house capabilities have become available on conventional panels. Custom contrast-enhancement filters "tuned" to the wavelength of a given display are now routine, as are neutral filters of any desired density.

The solution to most of the human factors considerations lies in enlightened programming. Here the automaker did an excellent job by programming pushbutton-sized and -shaped icons rather than a checkerboard touch pattern. The manufacturer also retained familiar layouts for radio pushbuttons, air conditioning, and the like, and used graphically descriptive legends for less traditional functions. The net result is a system that, while very complex, is unintimidatingly familiar to most drivers, and one in which user comfort and proficiency is almost immediate. The potential parallax problem was eliminated by designing all switch icons to be considerably smaller than the corresponding active area of the touch panel. This ensures that when a finger is aimed at the image from any reasonable seating position, contact will be made with the appropriate X and Y electrodes.

The next series of technical challenges was created by the high operating and storage temperatures and steamy humidity requirements, coupled with dissimilar and somewhat marginal materials. Virtually every material normally used in this type of panel for less-demanding indoor applications proved inadequate, and an upgraded substitute had to be found or developed. Once again, Sylmar Division's experience was called upon, this time to provide high-temperature transparent adhesives. It was necessary to replace conventional pressure-sensitive-adhesive optical laminating materials with high performance thermosetting adhesives, one a totally elastic silicone needed to maintain cosmetic perfection in the outer surface after thermal exposure. This requirement is similar to the need to maintain good optical quality after high-temperature exposure on the windshields of such high-performance aircraft as the F-111, F-16 and B-1, for which this specialized silicone material was developed. The other adhesive selected is a urethane which provides a strong elastic bond to the acrylic support to prevent warpage, and is similar to those used on high-strength lightweight aircraft windshields.

In addition, the materials and processes normally used in the non-transparent conductors or "traces" had to undergo an upgrade, as did the ink and process used in the dedicated-switch graphic area. The transparent conductive coating process also required modification to produce an ITO coating capable of meeting the stringent demands of this application, and the close working relationship with Sierracin's Intrex Division was called upon to develop the exceptionally stable film used on the product. These improved performance materials are available for other less demanding applications, resulting in quality and reliability benefits.

Probably the most difficult challenge of all was to bring this novel combination of materials and processes, which had been developed at the eleventh hour, out of the laboratory and into high-volume predictable production in a short period of time. Novel production processes, handling methods, and automated inspection techniques were developed exclusively for this program. As with the other improvements necessitated by this product, these producibility breakthroughs are also available to other lower volume programs, with resulting economic and quality benefits.

A giant step for touch

The demands of the automotive environment are probably as stringent as any likely to be encountered by touch panels, and in some cases more severe than the requirements for aircraft components (+85°C vs. +71°C, for example). They have been met and the solutions placed in production in this ambitious pioneering application, and transposed as appropriate to the more conventional touch-panel product lines.

While this development program was a very costly and at times painful experience, it can now be looked upon as a coming of age for the touch-panel concept. It marked the debut of touch panels to consumer products and can be viewed as another milestone in the continuing quest to optimize the man-machine interface. ■

Video/data projectors

BY PAUL W. ZIMMERMAN

MICROCOMPUTERS are essential business tools, and their output tends to be voluminous, but to convey this information to a group in a conference room is not easy. When the computer is set up for a meeting, the monitor that seemed quite adequate on the desk causes the attendees to crowd around one end of the conference table and squint. A larger conference room monitor only partly addresses the problem. The ideal solution is a video/data projector with a 72- or 100-in.-diagonal image that can be viewed easily by a large group of people.

Once the decision has been made to invest in a video/data projector, the prospective buyer will be faced with a bewildering array of products and systems. At least 43 models from 26 different manufacturers currently crowd the market, and their prices range from under $4,000 to over $110,000 (Table 1). The selection process is further complicated by the lack of specification standards on the part of projector and computer manufacturers. The buyer who simply compares vendor spec-sheets, looking for the unit with the best specs at the lowest price, may be courting disaster, because no two spec-sheets describe the same parameters. To combat this problem, several major vendors have formed a Task Force on Video Projection Standards, which is part of the Accredited Standards Committee PH7, National Association of Photographic Manufacturers. Any resolution by this committee is at least 2 years away; until then, let the buyer beware – and let him insist on a demonstration.

Technology determines price

The basic video projector is a monochromatic single CRT. It has relatively low resolution and brightness because of the single CRT. The next step up is a higher-resolution black-and-white or green CRT system, but the single CRT still limits display brightness. Higher priced color projectors have three CRTs in either a refractive or reflective system. Most are of the refractive type, with three multi-element lens assemblies. Each of the red, green, and blue CRTs is a high-resolution monochrome unit, and many are liquid cooled. The image on each CRT is focused on a screen through its own multi-element lens. Reflective systems incorporate a mirrored rear surface in each CRT that reflects images from the focal-plane phosphor and bounces them back to the projection lens. Each of the three CRT lenses is a single integrated unit.

The highest priced systems use light-valve technology, with most incorporating high-brightness arc lamps (usually xenon) and an oil film. The arc lamp shines through slits in the rear of the light valve and projects the image created on the oil-film surface through a refractive lens assembly. Light-valve systems provide the brightest image, but their cost – starting at over $38,000 – is more than four times that of CRT projectors. There are some

Table 1: Common Video/Data Projector Types

Type	Cost ($)	Features
Monochrome CRT	4,000	Low resolution and low brightness; monochromatic
Monochrome CRT	24,000	High resolution and high brightness; monochromatic
RGB CRTs reflective refractive	6,000–15,000	High resolution and medium brightness; color
Light Valve	30,000–110,000	Highest resolution and brightness; color
Liquid Crystal	. . .	Low resolution and high brightness; monochromatic

Paul W. Zimmerman is Marketing Manager, Display Products, for Sony Corporation of America, Video Communication Products Division, Park Ridge, New Jersey, with responsibility for professional video monitors and projection systems.

liquid-crystal projectors, but they are monochromatic and do not produce the resolution demanded by most applications.

How brightness is measured

In choosing a projector, brightness is usually a major consideration [Fig. 1]. Unfortunately, brightness is the most easily misunderstood and misrepresented of the performance parameters. Some manufacturers measure peak brightness; others, average brightness. Some measure in lumens; others, in footcandles. To avoid damage to CRTs, some machines have a peak white clipping circuit that does not allow the projector to go to full-white brightness (and full white is, of course, unusable).

With all the difficulties, brightness is the factor most people use when selecting a system, and explanations of the more commonly used terms should make reading and comparing spec-sheets more meaningful. Projector brightness can be measured using three different units:

- *Lumens:* The total amount of light output from the projector itself (from all lenses).
- *Foot lamberts:* How bright the image is on the screen. It is related to screen gain and throwing distance.
- *NITs:* 3.426 NIT equals 1 foot lambert.

Brightness itself can be measured in different ways.

- *Peak brightness:* The measure of the brightness with a white window projected on a gain 1 screen. The window size varies from manufacturer to manufacturer.
- *Average brightness:* The measure of the brightness on a gain 1 screen using color bars, white field, or monoscope pattern (a standard television test pattern). The choice of measurement technique depends on the manufacturer.

The relationship between lumens and foot lamberts is

$$\text{lumen} = \frac{A \times (\text{foot lambert}) \times C^2}{S},$$

$$\text{foot lambert} = \frac{1}{A} \times \frac{\text{lumen} \times S}{C^2},$$

where $A = 0.003333081$, C is the screen diagonal (in inches), and S is the screen gain [Fig. 2].

Some manufacturers measure light output as soon as a system is turned on, because light output decreases and stabilizes at a lower level after a unit has warmed up. Until all manufacturers apply the same standards, the temptation will remain to specify light output using the highest number possible. And this kind of specification does not necessarily mean that the unit has the qualities the user seeks. In any case, brightness numbers are just for reference. A more realistic measurement would be obtained using a modulated signal or a standardized test pattern displayed on the screen. It should be noted that, measured this way, light output would probably be only about 65% of peak white brightness.

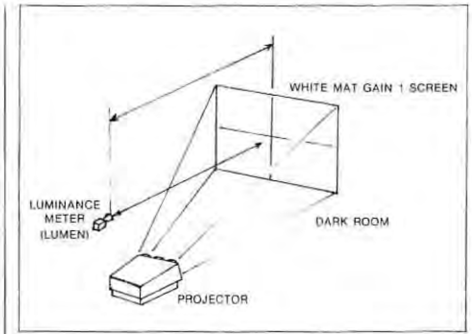
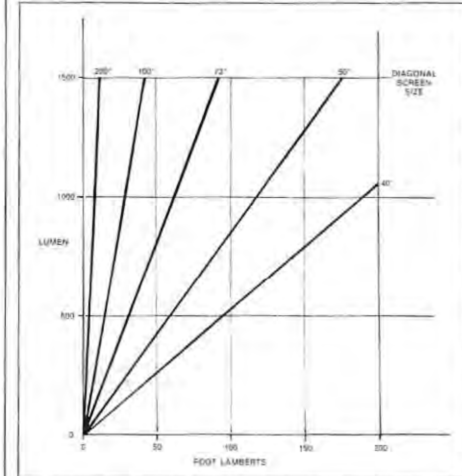


Fig. 1: Measurement of brightness.

Fig. 2: Relationship between lumens, foot lamberts, and throwing distance (screen size). Screen gain = 1.



Set-up time is important

Set-up time and adjustment controls are additional important considerations. A quick set-up procedure is more critical for portable projectors, less so for permanent installations. The user should consider whether the projector will be permanently mounted on the ceiling or in a rear-projection room, or whether it will be shuttled from conference room to conference room, needing readjustment every time.

The number of controls involved in setting up can vary drastically. Portable table-top projectors intended for use with a standard flat screen generally have only four controls (horizontal and vertical centering for red and blue), making set-up simple. More sophisticated units that can be adjusted for either front- or rear-screen projection, mounted either on a table or from the ceiling, and used with either flat or curved screens (and most units have this much flexibility) may have almost 50 controls that need adjustment. This large number of controls allows precise focusing and registration of the three lenses for all sections of the picture. Generally, the center of the picture is adjusted first, then the corners. Adjustments are made in each color, horizontally, vertically, and at the corners. As long as this procedure can be done quickly, the effort involved is worth it, as an out-of-focus or out-of-registration corner can mar an otherwise sparkling presentation.

Well-designed projectors offer well-laid-out controls and a logical systematic approach to adjustment. A well-designed unit can be completely set up in about 5 min. One that is poorly designed can require more than 30 min. of set-up time. The stability of the unit once it has been adjusted is also a critical factor. Some units drift so much that by the time the adjustment procedure is complete the process must be repeated. Other problems to watch for include displays that are fuzzy unless the brightness is turned way down, inaccurate color rendition, and focus that continually drifts.

Computer interface can be a problem

Once a video projector has been purchased, many users connect it to a computer. Once again, the lack of standards can create problems. The computer connection to the monitor varies dramatically not only from manufacturer to manufacturer, but even within a given manufacturer's line of products. For example, IBM offers four different display cards for its IBM-PC series of machines, and each one has a different vertical scanning frequency and a different connector pin configuration. The monochrome card output is 18.4 kHz, the standard color graphics adapter (CGA) card output is 15.7 kHz, the extended graphics adapter

(EGA) card is 21.8 kHz, and the professional graphics adapter (PGA) card is 30.5 kHz. As long as a computer is connected to an appropriate monitor, there is no problem. The trouble arises when users of several different computers or different display cards meet in the conference room and expect all of the equipment to connect to the same video projector. This situation requires a multiscan projector capable of interfacing with a variety of computers or interface cards. There are several projectors that can be adjusted to lock onto the appropriate scanning frequency, and some units, such as the Sony VPH-1030 Q1 VideoGraphic, automatically lock onto the incoming signal [Fig. 3].

The vertical and horizontal scan rates are only part of the problem, however. The retrace or blanking time (the time it takes for the electron beam to turn off, travel from the right side of the screen to the left, then turn back on for the next line) is also non-standard, varying from 5 to 15 μsec. Some projectors' retrace times are too long, resulting in the last few characters being cut off the edge of the display. There is no way to predict this problem from a specification sheet. A demonstration is the only way to detect it.

The user will encounter further problems if the computer has a digital rather than an analog display output. Again, this is not a problem as long as the computer is connected to an adjacent monitor, but it becomes one when the video projector is connected. In general, digital displays use TTL signals with relatively high impedence levels, which limit their drive capability to less than 6 ft. Trying to go farther than 6 ft. without special buffering results in crosstalk, noise, and bandwidth limiting. With a special TTL buffer interface, these signals can go up to 50 ft. The best solution is to convert the TTL digital signals to analog signals, which can go well over 100 ft. This conversion is particularly important with ceiling-mounted or rear-screen projectors. Several companies sell computer interface boxes designed for TTL buffering or digital-to-analog conversion. One company offers a monitor breakout cable with a piggyback connector that provides a pin-compatible connection from the buffer or converter to some of the more popular video projectors; the cable is available for a wide variety of specific computer connection configurations [Fig. 4].

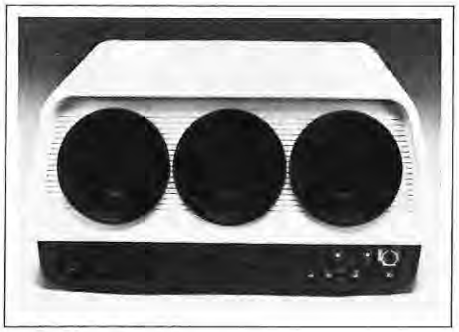


Fig. 3: Sony's VPH-1030Q1 VideoGraphic Projector automatically locks on to horizontal scanning frequencies ranging from 15.75 to 32 kHz.

What's in the future

Once the problem of differing standards is resolved, users will be able select the projector best suited to their needs, based upon meaningful specifications. With further research, tomorrow's video projectors will be brighter and have better resolution. Many computer manufacturers are designing graphic display cards whose scanning frequencies exceed 32 kHz – and there is talk of going beyond 64 kHz. Generally, these very high scanning frequencies will be used in display boards for CAD/CAM systems, which are certainly a market for video projectors. Newer technologies, especially liquid-crystal light valves, promise lower costs and higher brightness in projector systems. ■

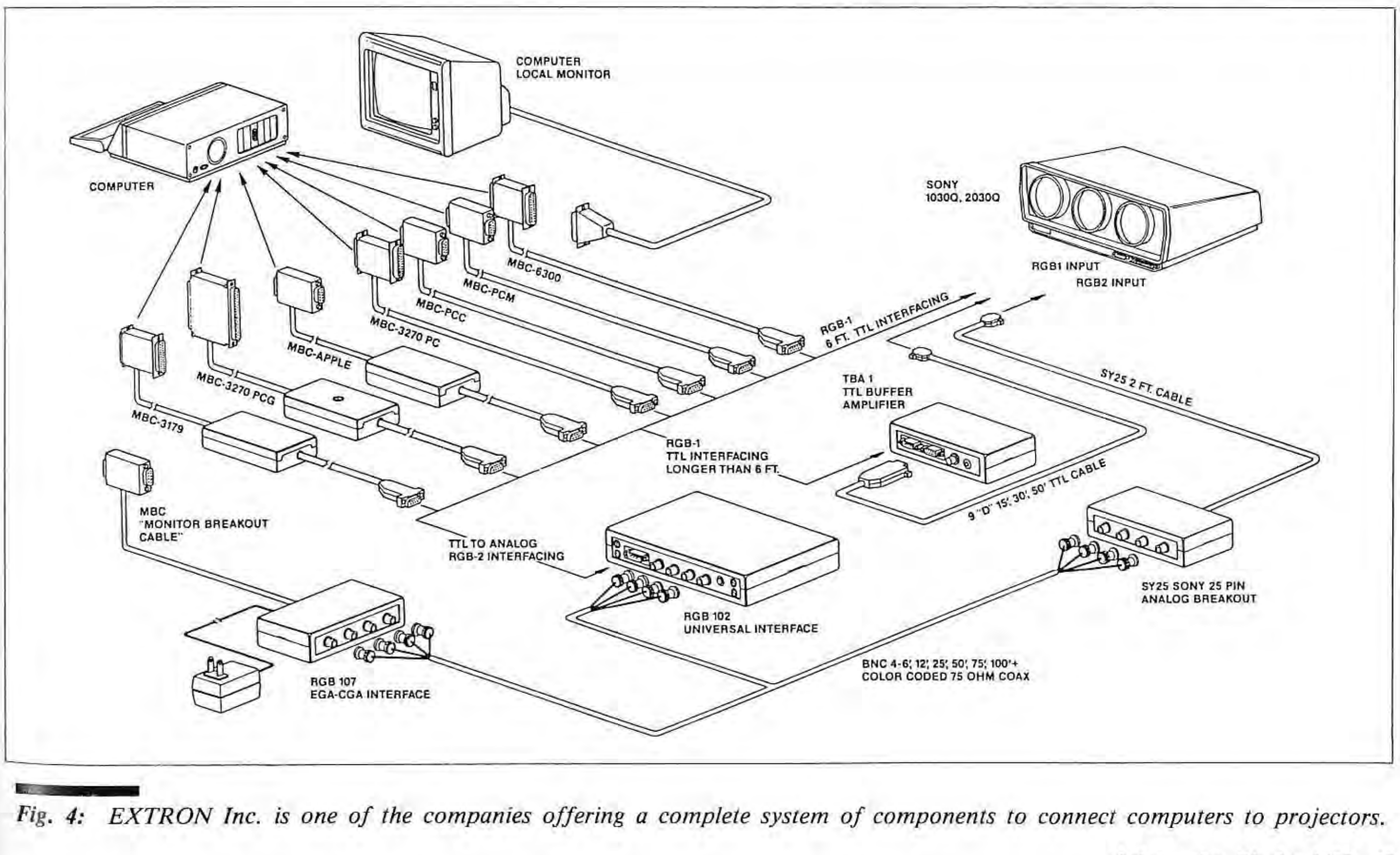


Fig. 4: EXTRON Inc. is one of the companies offering a complete system of components to connect computers to projectors.

Suppliers of Video/Data Projection Equipment

Editor's Note: The following list of vendors was supplied by ICIA (International Communications Industries Association), 3150 Spring Street, Fairfax, VA 22031.

Projection System Equipment

Arcturus
50 Beharrell Street
West Concord, MA 01742
617/369-5360
Ron Therrien

Aydin Corporation
700 Dresher Road
Horsham, PA 19044
215/657-8600
Mike Hamanko

Bell & Howell
7100 McCormick Road
Chicago, IL 60645
312/673-3300
Don Newhall

D.O. Industries
317 E. Chestnut Street
East Rochester, NY 14445
716/385-4920
Julien Goldstein, Exec. VP

Dwight Cavendish Displays, Ltd.
2117 Chestnut Avenue
Wilmette, IL 60091
312/256-0937
Marshall Ruehrdanz, President

Electrohome, Ltd.
809 Wellington Street, North
Kitchener, Ontario N2G 4J6
800/265-2171
Victor Luther

Electronic Systems Products, Inc. (ESP)
1301 Armstrong Drive
Titusville, FL 32780
305/269-6680
Diane Borders

General Electric Company
Electronics Park
Syracuse, NY 13221
315/456-2152
Jerry Gundersen, Int'l. Sales Mgr.

Hughes Aircraft Company
1901 W. Malvern
Fullerton, CA 92634
714/732-1535
Warren J. Hendrickson

Hughes Aircraft Company
6155 El Camino Real
Carlsbad, CA 92008
619/438-9191
Dick Stults

Ikegami Electronics (USA) Inc.
37 Brook Avenue
Maywood, NJ 07607
201/368-9171
John Chow

Image Amplification
P.O. Box 699
Pine Brook, NJ 07058
201/882-0584
Marius Brown

Inflight Services, Inc.
485 Madison Avenue
New York, NY 10022
212/751-1800
Phillipe La Pierre, Director of R&D

Information Display Systems
1710 Goodridge Dr.
McLean, VA 22102
703/827-4935
Scott Williams

JBL Incorporated
P.O. Box 2200
Northridge, CA 91329
818/893-8411
John Wilson

Kloss Video Corporation
42 Fourth Avenue
Waltham, MA 02154
800/KLO-SS33
Steven Jackson

National Viewtech
60 West Avenue
Patchogue, NY 11772
516/758-6400
Earl Evans

NEC America Inc.
1255 Michael Drive
Wood Dale, IL 60191
312/860-9500
Fred Erdmann

Panasonic Industrial
1 Panasonic Way
Secaucus, NJ 07094
201/348-5200
Rob Mahon

Pulsar Video Systems, Inc.
7732 Clairemont Mesa Blvd.
San Diego, CA 92111
619/278-4318
Ronny Zagayer

Runco Video Corp.
1162 Chess Dr., Suite J
Foster City, CA 94404
415/349-7459
Jeff Mahan

Sony Corporation of America
Video Communications Products Div.
Sony Drive
Park Ridge, NJ 07656
201/930-1000
Paul Zimmerman

Trident International, Inc.
Central Florida Research Park
Orlando, FL 32826
305/282-3344
Deborah Day

TRW, Command Support Div.
5205 Leesburg Pike, Suite 1106
Falls Church, VA 22041
202/845-3812
Paul Graf

United Ventures, Inc. Tandom Div.
P.O. Box 180
Richmond, IL 60071
815/675-2277
A. Howard Shambough

Vivid Systems, Inc.
41752 Christy Street
Fremont, CA 94538
415/656-9965
Michele R. Solomon

Zenith Electronics Corp.
1000 N. Milwaukee Avenue
Glenview, IL 60025
312/391-8160
Teresa Sepulveda

Computer Interfaces for Video Projectors

VIDCO, Inc.
2400 W. 10th Place #4
Tempe, Arizona
602/966-2221

Extron Electronics
12362 Beach Boulevard
Suite 2
Stanton, California 90680
714/891-6174

Television displays for stadiums

BY WILLIAM E. GLENN

TELEVISION viewing of sports events provides the viewer with many features not available to live spectators. To provide these features, stadiums have installed television displays so that their attendees can see close-up views, slow-motion replays, and other features available to the television audience.

The requirements of television displays in stadiums are, indeed, severe. Stadiums need bright images on large screens that can be viewed in high ambient illumination. These requirements far exceed the capability of conventional CRT projectors. To meet these requirements, a number of displays have been developed. This article will review commercially available displays and describe the technology currently under development that will lead to more advanced displays.

Light-valve displays

The current generation of high-resolution stadium displays uses light valves. In these devices, light is generated by an arc light as in a film projector. The film, however, is replaced by a light modulator controlled by a video signal. To provide the necessary light-modulating surface, an electron beam scans a deformable fluid. The application of Schlieren optics allows this deformed surface to modulate the light intensity of the arc and produce a projected image. In a Schlieren optical system, changes in intensity are produced on the screen by refraction or diffraction of light in the image plane of the projector. The light-controlling surface is transparent. It controls the intensity by deflecting light past a series of stops in the optical path rather than by absorbing the light, as in a film projector. Displays based on light valves are actually quite efficient and can produce a projected image with about the same optical efficiency as a film projector.

The original television light valve, invented by F. Fischer of the Swiss Federal Institute of Technology, Zurich, Switzerland, was called the Eidophor.[1] A version of this device is currently being produced by Gretag A.G. in Zurich, Switzerland. It uses an electron gun which is placed off-axis of the raster area to scan the surface of an oil film placed on a rotating spherical reflector [Fig. 1]. The electrostatic forces on the surface of the oil produce deformations with amplitudes that correspond to the intensity of the light to be displayed on the screen. An arc light illuminates the raster area by light reflected from a series of mirrors referred to as Schlieren bars placed just ahead of the projection lens. The spherical mirror reflects these light sources back onto themselves. In this way, if the oil film is not deformed, the

Dr. William E. Glenn invented the Talaria projector while at the General Electric Research Laboratory in Schenectady, New York. He is currently Director of the New York Institute of Technology's Science and Technology Research Center in Dania, Florida, where work is continuing on a solid-state light-valve projector.

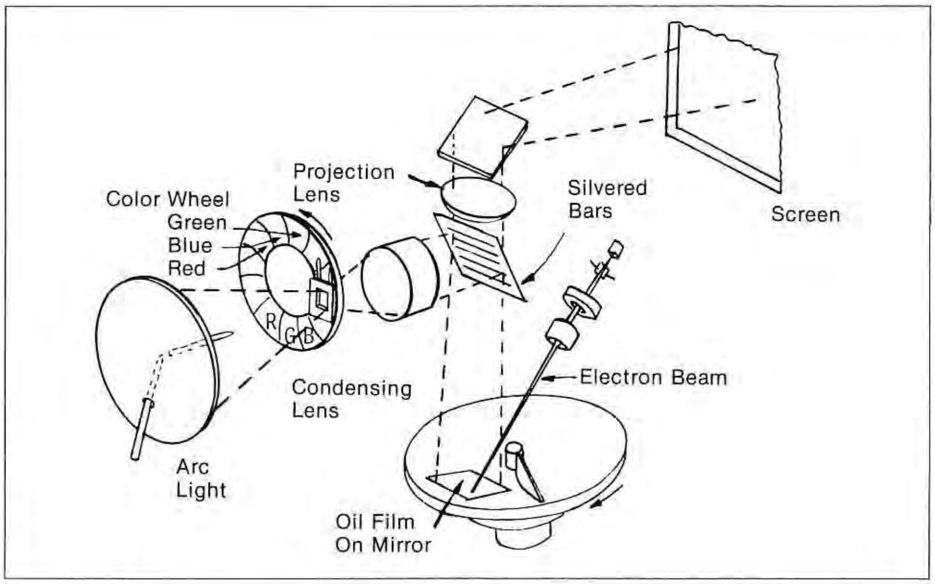


***Fig. 1:** The first television light valve was the Eidophor, invented by F. Fischer of the Swiss Federal Institute of Technology.*

light from the smooth areas does not reach the projection lens, and these areas appear black on the screen. Deformed areas will refract or diffract light between the bars and appear as light areas in the image. The Eidophor achieves color simply by superimposing three projected images on the screen. The image for each primary color originates from one of three light valves. The Eidophor employs a vacuum system that is continuously pumped by both mechanical and diffusion pumps. It uses replaceable tungsten cathodes and requires considerable maintenance. Because of its very large light-modulating area, this projector has the highest light output of any light-valve projector, as demonstrated in a typical stadium installation [Fig. 2].

A different version of the light-valve projector was invented by the author at the General Electric Research Laboratory in Schenectady, New York.[2,3] W. E. Good and T. T. True at the General Electric Projection Display Products Operation in Syracuse, New York subsequently developed the system into a commercial product called Talaria[4] [Fig. 3]. Like the Eidophor, it uses an electron gun to deform a fluid surface. However, the electron gun is coaxial with the optical path and uses a high-brightness cathode in a sealed-off vacuum envelope. As a result, it has relatively low maintenance.

The Talaria controls intensity and color by using a special optical system in which all three colors are produced by the complex modulation of a single electron gun. Green light is diffracted vertically by the modulated raster lines. A vertical wobble of the green-light spot at a high frequency is used to control the amplitude of a diffraction grating formed by the raster lines. This controls the intensity of the green light in the image. This light is diffracted to pass the set of Schlieren bars oriented horizontally. The corresponding input set of bars is illuminated with green light. Another set of Schlieren bars is placed in the optical path orthogonally to these and is illuminated by magenta light. The same electron beam that forms the green grating forms two superimposed gratings that diffract light horizontally in each picture element. One of these gratings has a spacing that diffracts red light through the magenta Schlieren bars, while the other diffracts blue light. Because a single electron gun produces all three colors, the three colored images automatically register correctly.

Fig. 2: The Eidophor light-valve projector in a typical stadium installation.

By using a lenticular plate to focus the light source through the input Schlieren bars, the optical efficiency of this system is quite high.

Both the Eidophor and Talaria have been produced with 1125-line high-definition-television (HDTV) format projected images. The efficiency of these light valves is typically 0.5–1.0 lumens/W. With projected images, screens are frequently used which distribute the light only in the area where there are viewers. As a result, the brightness of the screen appears higher than it would if the light were simply scattered at random as with a flat white screen. This increase in apparent brightness is referred to as screen gain. Since screens are normally used with light valves that have a gain of about 2, the overall efficiency is equivalent to about 1–2 lumens/W.

Matrix displays

Frequently, stadiums require color television displays that can be viewed in sunlight. In these cases, the high brightness required is achieved with matrix displays. A bright light source at

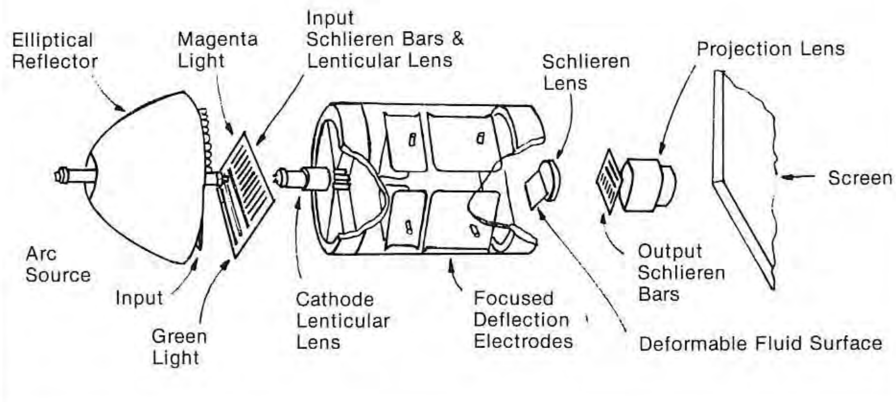


Fig. 3: For somewhat smaller displays, General Electric's Talaria light-valve projector offers certain advantages over the older design of the Eidophor.

each pixel is controlled by its own drive circuit. The light sources are typically either colored incandescent light bulbs or electron-excited fluorescent phosphors. The switching matrix must control the intensity of each color in each pixel of the display. For television, this must have a continuous grey scale. Because of the cost and complexity of providing individual control of each pixel light source, these displays have somewhat lower resolution than those using light valves.

One such matrix display, called Astrovision, by Panasonic, a Division of Matsushita Electric Corporation of America, Secaucus, New Jersey, uses incandescent light sources. Available in a portable version [Fig. 4], this type of stadium display can provide a screen brightness of up to 300 fL. The optical efficiency, however, is low.

Both Diamond Vision, by Mitsubishi, Marunouchi, Tokyo, Japan, and the Jumbotron,[5] by Sony, Tokyo, Japan (see cover, *Information Display,* May 1985), use electron-excited phosphors in a switched matrix to generate the light. This light source is much more efficient and has both higher brightness and faster response time than incandescent sources.

System comparisons

In the accompanying table only systems that have been used in stadiums or other public exhibitions are compared. In this table the resolution given is the value that would be obtained by viewing a resolution test chart. For matrix displays the television line resolution is assumed to be 0.7 times the number of scan lines or pixels in the picture height. Known as the Kell factor, this number represents the ratio of the resolution, as determined by viewing a test pattern, to the number of raster lines.

The table makes clear that for color television images with a 300–800 television line resolution, it is necessary to use light valves to produce the images. These devices typically produce highlight brightnesses of 25–50 fL, which is quite adequate for indoor use or outdoor use at night. For displays that must be viewed outside in daylight, screen brightnesses of 300–3000 fL are required. In such cases, only the bright matrix displays will suffice.

Future systems

Projection screens. Projection screens are normally white. Therefore, they cannot produce a good black level in the image in the presence of ambient light. For televisions projectors, higher ambient light can be tolerated if the screen is black by reflected light. Screens can be made black, but still have good efficiency if the light incident on the screen is focused through small holes in a black surface by an array of small lenticular lenses. Several lenticular screen designs have been produced experimentally that have screen gain, good efficiency, and good ambient light rejection. Further development of this approach for stadium use would be desirable.

Another approach uses optical fibers in a black matrix. As in the lenticular screen, light emerges from holes in a black surface by an array of small optical

Table 1: Currently Available Stadium Displays

Display	Manufacturer	Light Output (Lumens)	Resolution (TV Lines) Vert./Horiz.	Screen Size (ft.)	Screen Brightness (fL)	Screen Gain	Power Consumption (kW)	Efficiency (Lumens/W)
Eidophor 525-Line	Gretag A. G. Zurich, Switzerland	7,000	375/800	20×26	21	1.6	16	0.44
Eidophor 1125-Line	Gretag A. G. Zurich, Switzerland	4,200	800/1000	10×17	54	2.6	16	0.26
Talaria 1125-Line Arenavision	General Electric Co. Schenectady, N.Y.	1,350	325/750	9×12	25	2.0	1.75	0.77
2LV Talaria 1125-Line Arenavision	General Electric Co. Schenectady, N.Y.	2,300	800/850	9×12	40	2.0	2.5	0.92
Astrovision	Panasonic Div. of Matsushita Secaucus, N.J.	183,000	200/200	21×29	300	--	880	0.2
Diamond Vision	Mitsubishi, Tokyo, Japan	80,000	200/200	11.6×17.3	400	--	200	0.4
Jumbotron	Sony Tokyo, Japan	32,000,000	260/170	82×132	3000	--	1,000	32.0

fibers. The input and output fibers are incoherent arrays with the output area much larger than the input. This system has good efficiency and good ambient light rejection. It also eliminates the need for a long "throw," or space behind the screen for the projector. Prototype screens of this type have been produced by the author.[6] Advanced Displays Technologies, Inc., Golden, Colorado, is developing a stadium display screen, called Fibervision, that uses a similar design.

Television projectors. High-brightness television projectors will probably use either more advanced light valves or laser scanners in the future. The author is currently developing a light-valve projector using a deformable light modulator that is addressed by a solid-state chip. Control of the light is achieved in much the same way as in the Eidophor or Talaria. This device uses a Schlieren optical system. The optical efficiency is high because the light intensity remains at full brightness for the duration of one television field. As a result, optical efficiency of more than 2 lumens/W is possible. (Electron-beam-addressed light valves must decay in brightness during a field to produce adequate motion rendition.)

Laser scanners are also being used to display color television. Dwight Cavendish Displays Ltd., Cambridgeshire, England, and Advanced Display Technologies, Golden, Colorado, are developing laser-scanner projectors. Laser scanners typically produce about 0.03 lumens/W. Consequently, large high-brightness displays using laser scanners require very large lasers and have very high power consumption.

***Fig. 4:** Matrix displays, such as Panasonic's portable Astrovision, are currently the only displays bright enough for use in direct sunlight, but their resolution is not as good as that of light-valve projectors.*

Conclusion

Current stadiums place a premium on image size, contrast and resolution under high-ambient-light conditions. The hours of display operation are relatively short, and the income from each sports event is very high. Consequently, reliability and the costs of maintenance, installation, and operation tend to be secondary considerations. As display technology advances, however, these secondary considerations will become more important.

As high-definition television becomes more prevalent, stadiums will demand larger displays with TV line resolutions of approximately 700 (1020 or more pixels in the vertical dimension). Ultimately, solid-state-driven light-valve projectors will probably provide the most efficient and most maintenance-free high-brightness high-resolution image sources.

Advances in screen design using fiber-optic or lenticular screens can improve the contrast ratio and efficiency of projection screens under high-ambient-light conditions.

Matrix displays will probably continue to be the display of choice under full-sunlight ambient illumination. ■

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president's message

With this issue of *Information Display* we begin a new chapter in our on-going efforts to upgrade our journal and to bring you the important technological and product news you want on a regular, monthly basis. We have contracted with Palisades Institute for Research Services, Inc. to take over the responsibility for the Journal from MetaData, Inc., starting with this issue. I do not want to dwell here on all the reasons for this change, but I would like to tell you why we are confident that *Information Display* will become an even stronger, more relevant technical publication in the future.

Many of you will of course recognize the name "Palisades" as the folks who have been managing our International Symposia, Seminars, and Technical Exhibits for a number of years. Maybe somewhat less visible to you have been their equally important efforts in publishing the *Digest of Technical Papers* for the Symposium, the organization and printing of the programs, their vital help in organizing domestic and foreign IDRC's (International Display Research Conferences), and their responsibility for publishing the *SID Proceedings*.

Our ties to Palisades have grown over the years because they have carried out each new assignment in an effective, professional manner. In the course of the years they have developed a thorough understanding of the information display business and technology. The current depth and breadth of the Palisades staff in our field of interest convinces me that *Information Display* will benefit tremendously from this new venture. I also believe that the advertisers, SID sustaining members, and Symposium exhibitors will all find that *Information Display* is the most effective way to share product news and new developments with all the members of the display community.

The responsibility for the technical content of the journal has been assigned to Nutmeg Publishing Consultants whose staff has more than 40 years of practical experience in writing and publishing technical articles. I am confident that you will immediately notice an improvement in the caliber, depth, and relevance of the technical articles which should add to your monthly reading enjoyment. Of course, if you have ideas, comments or suggestions for future feature articles, by all means send them to The Editor, *Information Display*, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014. To paraphrase one of our previous presidents, with your continued help and support "this will be a dynamite journal." So let's hear from you!

Sincerely,

chapter notes

Canadian Chapter

The Canadian Chapter met November 12 at Philips Electronics, Ltd., in Scarborough, Ontario. Guest speaker **Mr. Thomas C. Maloney** of **Litton Panelvision**, recently returned from a trip to Japan, gave members on overview of the display work being done in Japan today. CRTs, TFEL, plasma, and LCDs were some of the display technologies covered. Mr. Maloney reported that while advances are being made in every area, the most impressive developments are in color LCDs.

Delaware Valley Chapter

The Delaware Valley Chapter met November 20 at Spitz Space Systems in Chadds Ford, PA, to see a demonstration of a new type of planetarium display called the "Space Voyager." **Dr. George Reed**, noted author and astronomer, and **Mr. G. David Millard** of **Spitz Space Systems** explained the workings of the Space Voyagers which they helped to develop: complex, display oriented models of the solar system which, unlike classical planetaria, employ no clockwork or mechanical analogs. Their projectors, incorporating over 10,000 lenses, are controlled entirely by three datalinked digital computers. These machines, unique in the world, are manufactured in the Delaware Valley. The model demonstrated at the chapter meeting is now on its way to the Singapore Science Center.

At the same meething, the Chapter installed new officers: Chairman, **Richard E. Seifert**; Vice Chairman for External Affairs, **John W. Parker III**; Vice Chairman for Internal Affairs, **Charles P. Halsted**; Secretary, **Nathan Rubin**; Treasurer, **Karl D. Quiring**; and Academic Liaison Officer, **Randall C. Pyles**. **Stephen M. Filarsky** continues as Regional Director.

Editor's note: Dick Seifert was so impressed with Dr. Reed's presentation that he recommended the subject to ID*'s editors. As a result, the February issue will carry a feature article on Space Voyagers.*

Japan Chapter

A special joint meeting of the Japan Chapter officers and the officers of SID was held in Tokyo on September 30. The purpose of the meeting was twofold: to review the Chapter's 1987 budget and to agree on a proposal to make SID membership fees payable in Yen. Both objectives were accomplished.

The Chapter held an executive committee meeting November 12 in Kanazawa. The Japan Chapter will take on the major responsibility for organizing the 1989 IDRC, which will be held either in Japan or in China.

Participants at the special joint SID-Japan Chapter executive meeting in Tokyo. Left to right: T. Kojima; C. Suzuki; I. Chang; L. Tannas, Jr.; J. van Raalte; P. Pleshko; S. Kobayashi; W. Goede; and S. Mikoshiba. Not in picture: K. Arai and M. Yokozawa.

Mid-Atlantic Chapter

The Mid-Atlantic Chapter met at the IBM Building in New York City on November 11 to hear a panel of experts review the Sixth International Display Research Conference (Japan Display '86). Panelists included **Webster Howard** and **Vernon Beck** of **IBM Corp.** and **Allan Kmetz** of **AT&T Bell Laboratories.** The panelists reported that LCD technology dominated the conference, accounting for over a third the papers (more than twice the number of CRT papers). New phenomena in ferroelectric LCs raised questions about the rate of their development. Ever larger (foot-square) and more complex TFT-LC prototypes lead a hypothetical product development shadow by a mere two to three years. Novel CRT work such as large screen (43-in.-diagonal) direct-view monitors was also reported.

Chapter Chairman **Ron Feigenblatt** already has his schedule of meetings planned for the next six months. Tentative dates and speakers are as follows:

Jan. 15. "A Review of Flat Panel Displays," Allan Kmetz, AT&T Bell Laboratories

Feb. 10. "Soft Touch Sensitive Screens," Thomas Schwartz, AT&T Information Systems

Mar. 3. "Laser Beam Imaging," Leo Beiser, Leo Beiser, Inc.

Mar. 31. "Real-Time Computer Holograms," S. Benton, Polaroid (joint meeting with SPSE)

Apr. 30. To be announced

June 2. Annual SID-MAC Banquet

San Diego Chapter

On November 14, the San Diego Chapter met at the **North Island Naval Air Station** in San Diego, where **Lt. Cdr. Michael Fackerell, U.S.N.**, demonstrated the Navy's 2F64C Motion Base Flight Simulator.

UK & Ireland Chapter

At its October 29 business meeting, the UK & Ireland Chapter voted to donate a £100 award for the best paper at Eurodisplay '87 (Sept. 15–17, 1987 in London), and will ask the Program Committee to judge. It was reported at the same meeting that the Department of Trade and Industry has asked the Chapter to help run a seminar to report on its LCD Technical Mission to Japan.

Following is a tentative schedule of future meetings.

Jan. Imperial College, "Government Support for Displays," A. Woolard

Feb. IBM, Winchester, "Computer Displays" (joint meeting with the British Computer Society Displays Group)

July 6&7. Trevelyan College, Univ. of Durham, "Display Market Trends." Visit to Mullard CRT factory at Durham on July 6 and special event in the evening; technical meeting July 7.

calendar

January

20th Hawaii International Conference on Systems Sciences. Ralph H. Sprague, University of Hawaii, College of Business Admin., R-303, Honolulu, HI 96822. 808/948-7430.
Jan. 6-9 Kallua-Kona, HI

O-E/LASE '87: Optoelectronics & Laser Applications in Science and Engineering. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
Jan. 11-16 Los Angeles, CA

Picosecond Electronics and Optoelectronics. Optical Society of America, 1816 Jefferson Pl., N.W., Washington, DC 20036. 202/223-8130.
Jan. 14-16 Incline Village, NV

Eighth Annual Computer Graphics Conference. Carol A. Every, Frost & Sullivan, Inc., 106 Fulton St., New York, NY 10038. 212/233-1080.
Jan. 14-16 San Diego, CA

OFC/IOOC '87: Optical Fiber Communications Conference/International Conference on Integrated Optics and Optical Fiber Communication. Optical Society of America, 1816 Jefferson Pl., N.W., Washington, DC 20036. 202/223-8130.
Jan. 19-22 Reno, NV

SYSCON: OEM Computer Peripherals Subsystems Conference & Exposition. Multidynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701. 213/402-1610.
Jan. 20-21 Los Angeles, CA

February

International Symposium on Pattern Recognition and Acoustical Imaging. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
Feb. 1-6 Newport Beach, CA

21st Television Conference. Anne Cocchia, SMPTE, 595 W. Hartsdale Ave., White Plains, NY 10607. 914/761-1100.
Feb. 6-7 San Francisco, CA

IEEE 1987 Aerospace Applications Conference. Warren A. Schwarzmann, 4 Aurora Dr., Rolling Hills, CA 90274. 213/973-1121.
Feb. 7-14 Vail, CO

Fundamentals & Applications of Lasers—Short Course. Laser Institute of America, 5151 Monroe St., Toledo, OH 43623. 419/882-8706.
Feb. 9-13 Orlando, FL

Electronic Imaging '87: International Electronic Imaging Exposition & Conference. Ed Martin, MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02115. 617/232-EXPO.
Feb. 16-19 Anaheim, CA

CSC '87: 1987 ACM Computer Science Conference. Association for Computing Machinery, CSC-87-PR, 11 West 42nd St., New York, NY 10036. 212/869-7440.
Feb. 17-19 St. Louis, MO

COMPCON Spring '87. IEEE Computer Society, 1730 Massachusetts Ave. N.W., Washington, DC 20036. 202/371-0101.
Feb. 23-26 San Francisco, CA

Flat-Panel and CRT Display Technologies—Short Course. (Sponsored by UCLA and SID.) UCLA Extension, Short Course Program, 10995 Le Conte Ave., Los Angeles, CA 90024. 213/825-1295.
Feb. 23-27 Los Angeles, CA

March

Office Automation Conference. AFIPS, 1899 Preston White Dr., Reston, VA 22091. 703/620-8900.
Mar. 9-11 Dallas, TX

1987 Technical Symposium Southeast on Optics, Optoelectronics. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
Mar. 17-22 Orlando, FL

Computer Graphics '87. Bob Wancy, National Computer Graphics Association, 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031. 1-800/225-NCGA.
Mar. 22-26 Philadelphia, PA

Advances in Semiconductor and Semiconductor Structures. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290. Telex: 46-7053.
Mar. 23-27 Bay Point, FL

SOUTHCON '87. Dave Litherland, Electronic Conventions, Inc., 8110 Airport Blvd., Los Angeles, CA 90045. 213/772-2965.
Mar. 24-26 Atlanta, GA

4th International Symposium on Optical and Optoelectronic Applied Science and Engineering. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290. Telex: 46-7053.
Mar. 30-Apr. 3 The Hague, Netherlands

ADEE WEST: Automated Design and Engineering for Electronics West. Wendy Geller, ADEE WEST, Cahners Exposition Group, 1350 Touhy Ave., P.O. Box 5060, Des Plaines, IL 60017-5060. 312/299-9311, ext. 2486.
Mar. 31-Apr. 2 Anaheim, CA

April

ELECTRO '87. Dave Litherland, Electronic Conventions, Inc., 8110 Airport Blvd., Los Angeles, CA 90045. 213/772-2965.
Apr. 7-9 New York, NY

IEEE Computer Society Symposium on Office Automation. Vincent Lum, Dept. of Computer Science, Naval Postgraduate School, Monterey, CA 90045. 408/646-2449.
Apr. 27-29 Gaithersburg, MD

CLEO '87: Conference on Lasers and Electro-Optics. Optical Society of America, 1816 Jefferson Pl. N.W., Washington, DC 20036. 202/223-8130.
Apr. 27-May 1 Baltimore, MD

IQEC '87: International Quantum Electronics Conference. Optical Society of America, 1816 Jefferson Pl. N.W., Washington, DC 20036. 202/223-8130.
Apr. 28-May 1 Baltimore, MD

calendar

May

37th Electronic Components Conference. Doug Loerscher, Sandia National Labs., Div. 2123, P.O. Box 5800, Albuquerque, NM 87185. 317/261-1306.
May 11–13 Boston, MA

EICO '87: 4th European Conference on Integrated Optics, Electro-Optics, and Sensors. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
May 11–13 Glasgow, Scotland

SID '87: Society for Information Display International Symposium, Seminar and Exhibition. Palisades Institute for Research Services, Inc., 201 Varick St., Suite 1140, New York, NY 10014. 212/620-3388.
May 11–15 New Orleans, LA

SPSE '87: 40th Annual SPSE Conference and Symposium on Hybrid Imaging Systems. Pam Fornas, SPSE, 7003 Kilworth Lane, Springfield, VA 22151. 703/642-9090.
May 17–22 Rochester, NY

CG Int'l '87: Conference on Computer Graphics in Japan. Prof. Tosiyasu L. Kunii, Kunii Laboratory of Computer Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-Hu, Tokyo 113, Japan. (03) 812-2111.
May 25–28 Karuizawa, Japan

June

International Conference on Computer Vision. Azriel Rosenfeld, University of Maryland, Center for Automation Research, College Park, MD 20742. 301/454-4526.
June 8–11 London, England

National Computer Conference. Marketing Department, AFIPS, 1899 Preston White Dr., Reston, VA 22091. 1-800/NCC-1987.
June 15–18 Chicago, IL

Munich Laser Show. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
June 22–26 Munich, West Germany

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