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INFORMATION DISPLAY

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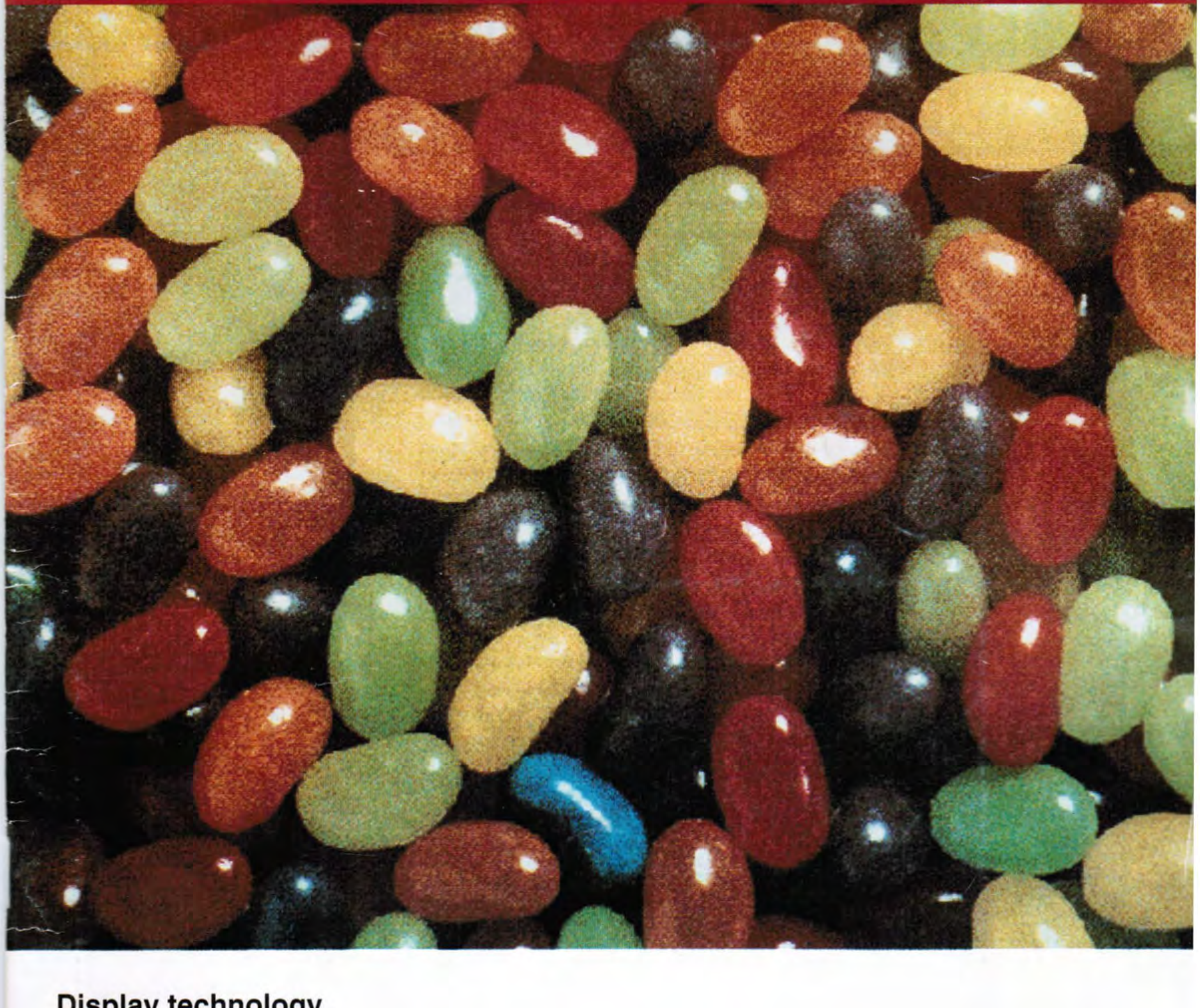
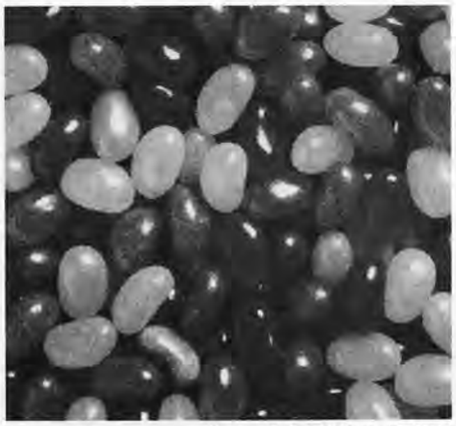
1994 TECHNOLOGY ROUNDUP ISSUE



Display technology
Display standards

Cover: A striking display development of 1994 was the impressively saturated colors of jelly beans (and anything else) shown on the current generation of dual-scan passive-matrix LCDs, such as this one made by Kyocera. Laptop-computer buyers supported the technology enthusiastically. Reportedly, only 15% of laptops sold in 1994 incorporated monochrome displays.



Kyocera Industrial Ceramics Corp.

Next Month in Information Display

CRT Issue
- Video electronics
- Measurements & standards
- IDRC '94 Review

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INFORMATION DISPLAY

DECEMBER 1994
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editorial

A Very Good Year

Makers of electronic displays and makers of the equipment for manufacturing those displays exchanged their depression for buoyant optimism in 1994. They deserve their happiness: it's been a rough few years. Furthermore, display makers don't have to worry (too much) about partying while Rome burns. If the global economy hangs together at all, long-term trends in communications, data processing, and consumer and industrial electronics all but guarantee strongly growing markets for display products. Even CRT unit sales continue to grow strongly, although the fortunes of custom and semi-custom CRT and CRT-monitor makers have become spotty as military budgets shrink and more new slots are designed for panels rather than boxes. (The color of your particular spot depends very much on which niche you're in.)

What keeps the display business endlessly entertaining is that success depends on much more than what color you make the "K" on the cereal box. It depends crucially on technical innovation and process improvements. In other issues of *Information Display*, we may focus on technologies and processes for their own sake, but in this annual December Technology Roundup Issue we focus on technical developments where they count: in prototypes that are shown to the technical community and in products that are put before the public. In the following pages, *ID*'s team of industry experts – Arlie Conner, Bob Donofrio, and Jane Birk – review 1994's developments in LCDs, CRTs, and emissive displays.

We also describe the crucial role of standards in product development and marketing. The Society for Information Display's (SID's) display standards activities are in serious trouble. Jim Greeson, chairman of SID's Definitions and Standards Committee, provides a brief update on global display activities and supplies a questionnaire so people who want to make sure that new standards don't obsolete their products and eliminate their jobs can sign up. (There are more altruistic reasons for participating in standards activities, but companies seem less able to support altruism these days than in the past.)

The new year will open with SID's Second Annual Display Manufacturing Technology Conference and Exhibition (DMTC '95). It was the inspiring optimism and enthusiasm of DMTC '94 that set the tone for the display community in the year that's now ending. DMTC '95 will provide our first communal temperature reading of 1995. I look forward to seeing you there.

Meanwhile, *ID*'s staff and advertisers wish you a happy and prosperous holiday season.

– Ken Werner

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INFORMATION DISPLAY

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president's message

by Andras I. Lakatos

"Hello. Society for Information Display. How may I help you?" This salutation is used many times each day, Monday through Friday, when answering the telephone at the offices of SID. The phones ring frequently, and the automatic fax machine comes to life with great regularity. Of late, messages addressed to socforinfodisplay@mci.com come in over the Internet to the computer screens located at each desk. I am happy to report to you that the new offices of your society are well used by our members, potential members, and individuals who simply want information about displays. I know this because a few days ago, a subcommittee of the SID Executive Committee participated in a review of the office's operations.

The new offices of the SID are located in Santa Ana, a busy suburb of Los Angeles, within a mile of the Orange County airport and less than an hour's drive from Los Angeles International Airport. The office park is beautifully landscaped. Inside, the offices are functional, bright, and comfortable. On the side wall of a small entrance hall are display cases full of recent SID publications. There are three small offices, a modest conference room, and a storage room where the publications are kept. The office is managed by Lauren Kinsey, executive director. She is aided by a small highly dedicated staff consisting of the membership coordinator Nancy Stafford and the publications manager Sepida Hosseini. Office hours are from 7:00 am until 6:00 pm, Monday through Friday, during which time someone is always ready to answer the telephone. The 11 hours are, of course, much longer than normal office hours in California. But the SID office is the central office of a worldwide society, and the extended schedule allows most of our Asian members to reach the office at the beginning of their workday and European members just before they close their offices. We encourage our members in these regions to take full advantage of these extended hours.

When we visited the office, the subcommittee was provided with a very thorough review of the office's day-to-day activities. This included a detailed description and demonstration of the all-important electronic database that is used for the maintenance of membership records. From this database, the office generates membership lists for all the chapters of the society in its three regions: Asia, the Americas, and Europe. The database is used to generate the mailing lists for our publications, for the Calls for Papers of the various society-sponsored conferences and workshops, and for our exhibitors. We were pleasantly surprised to learn that the second largest activity in the office, in terms of contact with our members, is the processing of 60-70 requests each week for various SID publications. We have a number of symposium proceedings which are close to being out of print, and at least some of our seminar notes are used regularly to teach professionals who are new to the field of electronic displays.

In addition to these incoming activities, the office is reaching out to recruit new members. Lauren Kinsey attends several meetings of sister professional societies, such as the Human Factors Society and the Society for Imaging Science and Technology, where she maintains a booth which offers SID publicity and publications. She is also involved in active recruitment of new sustaining members.

Despite these activities, the overall effectiveness and efficiency of the SID office needs improvement. We are well aware that some of our members have received less than satisfactory service in the past. First and foremost, the timeliness and accuracy of the membership database must be improved. The response time of the office to new members must be reduced to a two-week maximum from the day of receipt of a paid-up membership application.

To achieve these and a number of other goals, it was decided at the October meeting of the SID Board of Directors that president-elect Webster Howard and Lauren Kinsey will develop a long-range vision for the SID office's activities and a strategic plan to implement that vision. The plan will include improvement in effectiveness and efficiency. Turning toward more immediate needs, SID publications chair Aris Silzars and SID membership chair Lauren Palamateer will work with the members of the office staff to revise and improve the accuracy of the membership database and publication lists that are generated from this database. Both of these activities will be completed by January, 1995. Daily progress toward these objectives, along with everyday problem-solving by the office staff, will be aided by the SID office liaison Don Pinsky.

We expect that, during the coming months, our members will see much improved communication from the SID office in terms of timeliness and accuracy. Even if many of you do not correspond with the office, we expect that you will benefit from the improved communications between the office, the chapters, and Palisades Institute, which handles the production and mailing of all the publications. If you have any suggestions or comments, please send them to my personal attention at the SID International Office, 1526 Brookhollow Drive, Suite 82, Santa Ana, CA 92705-5421; fax 714/545-1547; e-mail: socforinfodisplay@mci.com. I will answer each letter, fax, or e-mail received. In the meantime, I would like to encourage you to join the hundreds of SID members who are making very effective use of the services the SID office is currently providing. ■

The Tour Bus with a Thousand Eyes

by Aris Silzars

It was a typically cool and cloudy Saturday morning in London. It was early fall – a few years from now. The usual crowds of sightseers and locals were beginning to fill the streets. A group of enthusiastic young French grade-schoolers were crossing an already busy Trafalgar Square street joyfully shouting, "Allez! Allez!" At several of the more popular theaters, lines of hopeful ticket seekers were beginning to form. The streets were still damp and the air was fresh from the overnight London "mist," and although the sun was making occasionally serious attempts at cloud penetration, folded umbrellas (carried for insurance purposes only, I presume) seemed to be an integral part of everyone's attire.

The traditional red double-decker buses were well into their day's activities, shiny black taxis were bringing in the morning's latest Heathrow arrivals, and the sightseeing buses had started their first tours. All seemed quite normal – all except for one rather peculiar-looking tour bus.

Actually, this bus was quite ordinary as tour buses go. What was unusual was that instead of the normal complement of tourists looking and pointing from behind each window, there were instead four rows of approximately a dozen binocular-looking things lined up like birds on wire perches. Counting up all the windows, one could see that there must be at least 500 of these peculiar robot-like gadgets staring out from inside the bus. What was really weird was that these binocular-things were all moving apparently independently and in all different directions.

Meanwhile, the bus driver seemed oblivious to all this strangeness and was narrating the tour just like any other "normal" tour-bus driver. On his console, LED indicator lights were glowing above labels for a menu selection of languages – French, German, Spanish, Norwegian, and at least 20 others. An EL display occasionally blinked as if to acknowledge the words "Automatic Language Translators Activated."

It is mid-afternoon in West Windsor, New Jersey, on this same Saturday. Larry and his wife are sitting in their comfortably furnished, although modest, living room. Autumn is definitely in the air and the trees have begun their annual color show. Several weeks ago, Larry had decided that he and his wife would like to re-live their previous year's much-enjoyed vacation trip to London. After contacting his travel agent, he had signed up with "Experiential Tours" to have a 1-hour specialty tour of central London, including Trafalgar Square and the Piccadilly Circus area. And so far, the tour was living up to all their expectations.

They both hardly noticed the lightweight head-mounted glasses they were wearing. The wrap-around displays effectively closed out any peripheral view of their living room and, together with the stereo headphones, completely immersed Larry and his wife in their tour. What made this experience especially realistic was that they could independently look in whatever direction they wished. The recently improved head-trackers were so effective that there was no perceptible time delay between their head movements and the movements of the remote binocular cameras on that mysterious tour bus many thousands of

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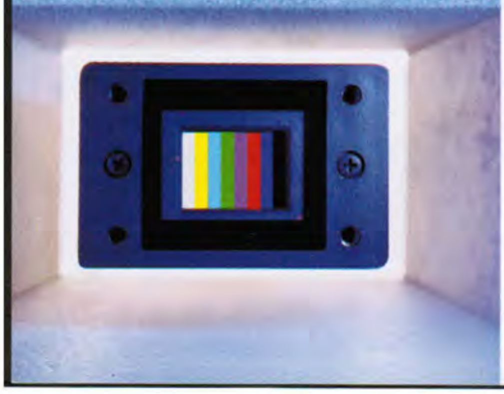

new products

Edited by JOAN GORMAN

Color PDP enters volume production

Fujitsu Microelectronics, Inc., Electronic Components Division, San Jose, California, has become the first flat-panel display (FPD) manufacturer to announce the commercial availability of a 21-in.-diagonal full-color ac-memory plasma display panel (PDP). Coinciding with the product's release is the New York Stock Exchange's purchase of over 1000 Fujitsu displays as part of its $125 million Integrated Technology Plan to introduce next-generation technology to the trading floor. Other primary applications include financial terminals, public-information boards in airports, teleprompters, ITD monitors, video-entertainment monitors on airplanes, and a variety of other applications for public information and entertainment in museums, galleries, and parks. Industrial, medical, video telecommunications, and various high-reliability markets will also benefit from the panel's thin profile, large color display area, and flexible video capabilities. Fujitsu's PDP offers over 260,000 colors (6-bit color per pixel) with 64 levels of gray scale and a 640 × 480 dot resolution. By using an interface board, it is capable of accepting either digital RGB or NTSC video signals, which enables the panel to display VGA video or standard television transmissions. The overall package dimensions, including the integrated drive circuitry, are 18.90 in. high by 15.75 in. wide by 1.26 in. thick, making it well-suited for space-limited environments. With an effective viewing area of 16.65 × 12.44 in., and a total weight of 11.16 lbs., several panels can be tiled together to form a larger viewing area for wall-hanging video conferencing or public-information display applications. A viewing angle of more than 140° also permits off-axis viewing without image distortion. The average brightness of the panel is 180 cd/m^2, which, when combined with its contrast ratio of 60:1, produces a clear image and enhances display viewability in a variety of ambient lighting conditions, such as those found in factories, foundries, and medical operating rooms. In addition, ac-memory plasma technology is immune to magnetic interference. Available immediately, the single-piece price for the FPF21C8060UA-02 panel is $10,000. Quantity discounts are also available.

Information: Fujitsu Microelectronics, Inc., Electronic Components Division, 3545 North First Street, San Jose, CA 95134-1804. 1-800-642-7616, 408/922-9000, fax 408/428-0640.

Circle no. 1

Monitor for color-critical applications

Barco, Inc., Kennesaw, Georgia, has introduced the 29-in. (27V) MegaCalibrator monitor that combines the largest high-resolution CRTs available, a maximum resolution of 2000 × 1600 non-interlaced pixels, highly automated convergence controls, and automatic color calibration. The MegaCalibrator is capable of displaying multiple full-size pages on a single screen, and provides more than twice the viewing area of a standard 20-in. monitor. It is ideal for color-sensitive applications such as electronic pre-press, photo re-touching, medical imaging, and other resolution-dependent graphics applications. With a horizontal frequency of 30–96 kHz, the MegaCalibrator is compatible with nearly every computer-based graphics system currently in use. It provides virtually unlimited connectivity through its built-in multi-scan frequency compatibility and offers an RGB bandwidth of 175 MHz. Barco has integrated its compact Optisense® on-screen optical sensor into the monitor housing for long-term color accuracy and automatic color calibration throughout the life of the monitor. An optional motorized tilt/swivel base is available.

Information: George Walter, Product Group Manager, Information Display Products, Barco, Inc., 1000 Cobb Place Blvd., Kennesaw, GA 30144. 404/590-7900.

Circle no. 2

On-line CRT-display alignment

Photo Research, a Division of Kollmorgen Instruments Corp., Chatsworth, California, has announced the PR-940G, a geometry adjustment system for assembly-line CRT-display alignment designed for high-throughput, multimode, and mixed-flow production-line applications, with adjustment cycle times as fast as 0.2 s. The PR-940G's stereoscopic imaging system extracts 3-D information from anywhere within a large volume of calibrated space with sub-pixel accuracy. Its two cameras eliminate the need for robotics or fixtures to position the CRT on the assembly line. Operator interaction and model-changeover time are also minimized by eliminating fixturing. The simple menu-driven calibration procedure uses NIST-traceable standards. The software allows simultaneous display of computation adjustment controls, which reduces operator adjustment time by eliminating crosstalk, and operator icons reduce training and skill-level requirements. Adjustment controls are "learned" by the system to optimize adjustment in minimum time. The system includes a controller, two cameras, a 486 PC, an illuminator, a calibration target, and a rigid camera stand. The PR-940G can also be completely integrated with the user's existing production-line system.

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CRTs

The Vigor of a Centenarian

As it approaches its 100th birthday, the CRT survives – and even prospers.

by Robert Donofrio

As THE CRT APPROACHES its centennial celebration, it continues to resist the onslaught of flat-panel displays. Its survival is the result of the technology's outstanding image quality, excellent performance/price ratio, and availability in many sizes and formats. CRT sales continue to expand, and there is a steady migration to larger screen sizes, particularly in consumer applications (Figs. 1 and 2).

Another reason for the CRT's continued success is that CRT technology presents a moving target. Far from stagnating, most of its components experience continual improvement, and manufacturers have been inventive in addressing environmental concerns. Foremost among these has been the disposal of old CRTs, with their leaded glass, in an environmentally acceptable way. Keeping the size of the glass particles relatively large when tubes are ground up can reduce the leaching rate of lead into the soil. Another approach is for the CRT manufacturer to send the glass to a lead smelter for salvaging both the lead and the silica. (Silica is normally used in the lead-smelting process.)

Contrast enhancement is a continuing goal of CRT manufacturers. A simple approach is to use glass faceplates with reduced optical transmittance. Dark glass panels of this kind give the viewer improved contrast with a more realistic picture, even under high-ambient-light conditions, and are therefore being used with increasing frequency. Contrast is also being increased by depositing a thicker aluminum backing over the phosphor screen. This further reduces the number of backscattered electrons that bombard the screen and makes the black areas of an image look even blacker.

Tricks such as using darker glass sacrifice luminance, which is often restored by increasing the electron-beam current or the anode voltage. The higher beam current has required designers to develop electron guns that are well focused at the higher currents. A higher-current beam also increases the heating of the shadow mask and, in extreme cases, can produce doming – a localized deformation of the mask that produces color distortions. Using a material with a low thermal coefficient of expansion – such as Invar™ – resists doming. Once reserved for high-performance tubes, Invar masks are migrating down through the CRT family tree. But Invar is expensive, so designers have also turned to special mask-suspension systems. Philips has developed a redesigned flat square 27V tube with an iron mask and corner suspension that performs well at the higher currents used with dark glass. The Philips "Corner Lock Suspension" and the Thomson/Zenith "Corner Sup-

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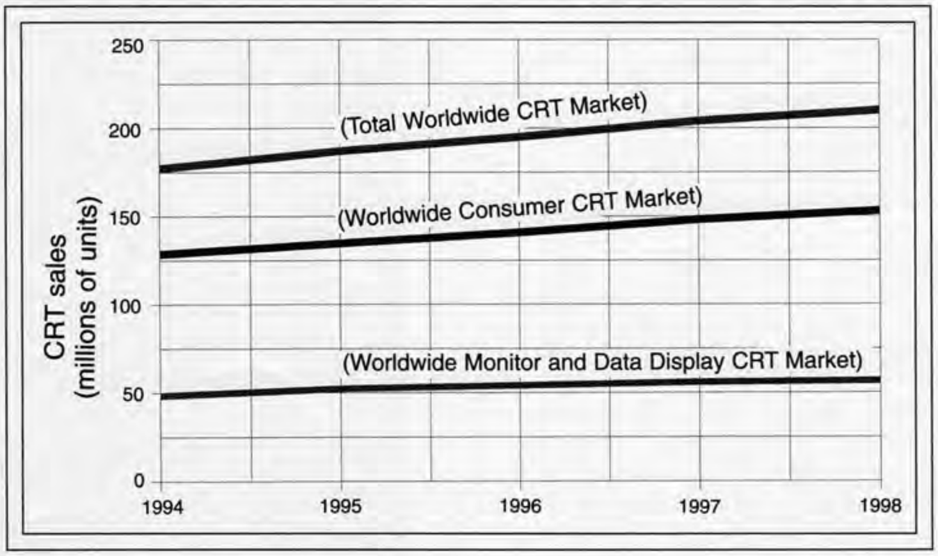


***Fig. 1:** Worldwide sales of CRT devices are still growing. (Figure based on data from J. A. Castellano, Ref. 1.)*

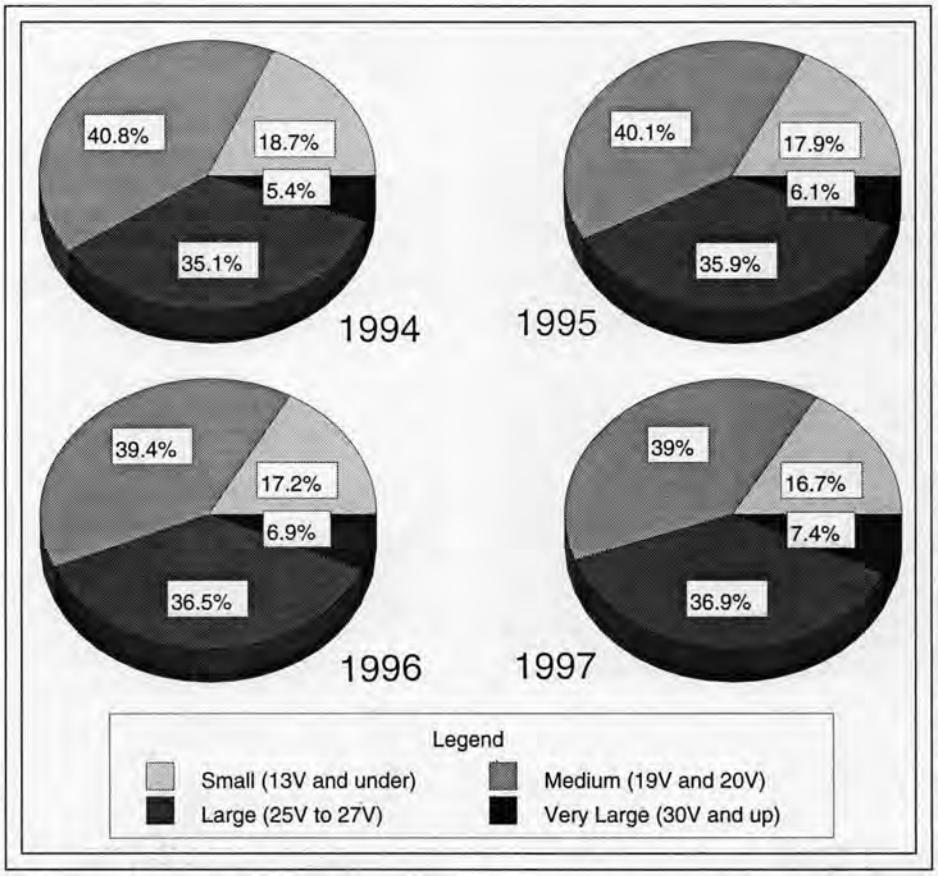


Fig. 2: CRT sales are slowly but steadily shifting to larger screen sizes, especially for consumer applications. (Figure based on data from Philips Display Components and the EIA.)

port" systems support the mask at the corners rather than at three or four points on the sides of the mask. These systems make the mask less prone to asymmetrical displacements, and the frame and mask generally have low mass, so they can respond more rapidly to thermal compensation. The corner suspension systems are particularly effective in large 16:9 tubes.

Another approach to increasing contrast, which was demonstrated by Toshiba at the Consumer Electronics Show in Chicago last September, uses a filter between the panel glass and the phosphors. There is an accompanying increase in luminance because the filter permits the use of a faceplate glass with higher transmittance. Toshiba said its technique was similar to one described previously by Sony, which leads to the supposition that the system uses an unpigmented phosphor and a pigmented matrix filter along the lines of the filters used in color LCDs.

Cathodes and Electron Guns

The demands made on tubes for diagnostic medical imaging and other high-performance applications continue to require greater luminance and smaller beam spot size than are readily available. Dispenser cathodes permit several times the beam current per unit area – and therefore more luminance – than do conventional oxide-coated cathodes, while retaining good service life. Like Invar masks, dispenser cathodes are premium components, but they are no longer exotic.

Reducing the spot size requires increasingly sophisticated electron guns and electron optics, which have been forthcoming thanks to sophisticated computer-aided design tools.

Even people without direct knowledge of product design and development (D&D) understand that the need for improvements in performance drives development. It is less well understood that the need for improvements in product quality – that is, consistency and uniformity throughout a production run – and manufacturability drive a substantial proportion of D&D efforts. Philips, for example, introduced a new glass mounting structure multiform early in 1994. The "Eiffel Tower multiform" – its shape suggested the outline of the Eiffel Tower to Philips' designers – is being used in Philips 25V, 26V, and 27V color picture tubes, not to improve the optimum performance but to supply a more rigid mounting for the electron gun. This improves the uniformity of completed CRTs by enhancing the mounted gun's resistance to rotation and aiming variations produced by routine inhouse handling.

Lower, Wider, and Bilingual

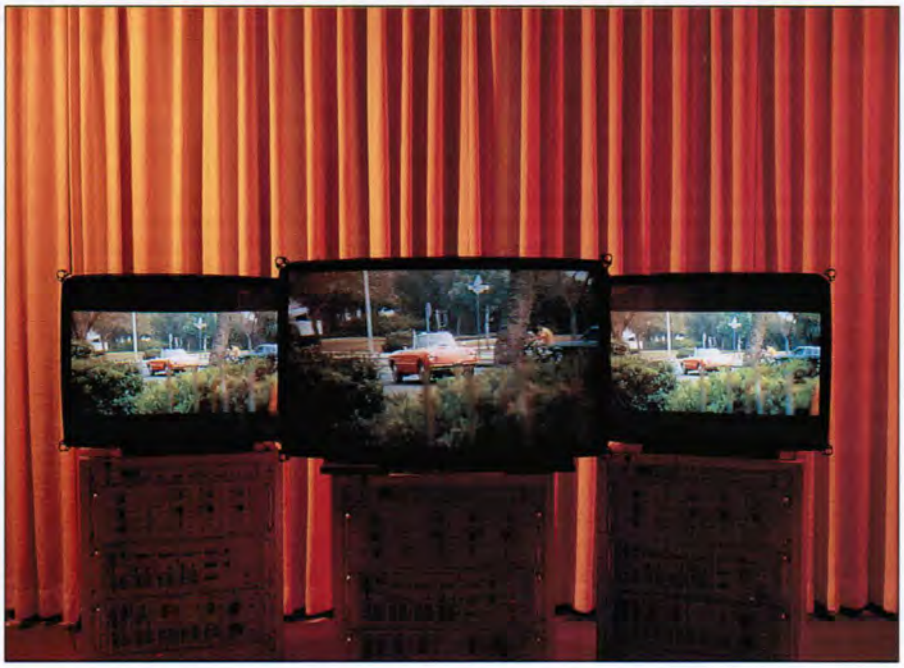
CRTs with a lower, wider aspect ratio of 16:9 are being developed for the new high-definition television (HDTV) receivers that may start appearing in late 1995 or early 1996. But some 16:9 TV sets are being sold – particularly in Japan – that stretch the current NTSC picture to fill the screen or display CinemascopeTM images from videodiscs without resorting to letterboxing – putting an image with one aspect ratio on a screen with another aspect ratio by placing black bars above and below the image (Fig. 3). The new aspect ratio is inspiring some innovative deflection-yoke designs.

Usually, television CRTs are specifically made for use in either NTSC receivers (used in North America, Japan, Taiwan, and parts of South America) or in PAL receivers (used in most of western Europe, Australia, mainland China, parts of South America, and parts of Africa). In 1994, Philips started making a 27V CRT that can be used for either NTSC or PAL reception without exhibiting moire interference patterns.

Ergonomics, Coatings, and Flatness

Limits on the weak electric and magnetic fields produced by CRT monitors that have been proposed by the Swedish MPR and other agencies have become a *de facto* standard. Tubes, circuits, and deflection yokes have been redesigned to comply with these limits, generally with little if any effect on the prices charged for completed CRT monitors.

Conductive coatings for CRT faceplates are needed to keep electrostatic fields within the MPR recommendations. R&D on these coatings continued in 1994, including work on



Philips Display Components

Fig. 3: A number of CRTs with an aspect ratio of 16:9 appeared in 1994 for use primarily with processed NTSC or recorded video programming. Here, a 16:9 (wide-aspect-ratio) CRT is flanked by two 4:3 CRTs showing "letterboxed" images.

what has turned out to be a tradeoff between abrasion resistance and conductivity. Several manufacturers combined anti-static and anti-reflection properties in a single coating.

Philips' vacuum-deposited anti-reflection anti-static (ARAS) coating was being used on the large-monitor public-information displays in three international European airports this year. The anti-static properties keep the screens of the high-mounted monitors from becoming dusty, so frequent cleaning is no longer necessary. Several companies are now using spin- or spray-applied coatings, which are generally less expensive than vacuum-deposited coatings.

The Energy Star program in the U.S. and equivalent programs in Europe have focused attention on energy conservation in computer peripherals, including CRT monitors. Systems that reduce the power to their specially designed CRT-based monitors after a specified period of inactivity became increasingly common in 1994.

The momentum toward higher resolution, higher refresh rates, and larger screen sizes slowed in 1994 because of soft economic conditions around the world. Cost-containment became a watchword. Zenith reportedly curtailed R&D on its flat-tension-mask (FTM) CRT. End users and systems integrators will be the losers because FTM is an attractive technology with excellent image quality and the anti-glare characteristics of a truly flat screen. Tension masks were in the news on another front. Tektronix sold its tension-mask CRT business to Planar, the manufacturer of electroluminescent flat-panel displays.

Flat-CRT technology, once moribund, rebounded in 1994. News was made by two categories of devices: field-emission displays and the matrix-addressed CRT as realized in Matsushita's "Flat Vision." Clearly, CRT technology is still kicking as it approaches its 100th birthday. And the HDTV era, which is expected to further invigorate the industry, is not yet upon us.

Notes

[1]J. A. Castellano, "The CRT Display Market: Strategies and Trends in the 1990s," *SID Intl Symp Digest Tech Papers* **25**, 215-218 (1994). ■

Active Matrix, Passive Matrix ... or Something in Between?

LC disciples are looking toward the future and seeing a world covered with liquid-crystal displays.

by Arlie R. Conner

ACTIVE-MATRIX liquid-crystal displays (AMLCDs) became more available in 1994, with supply almost satisfying demand – at least for the less cost-sensitive applications. Passive-matrix devices flourished, especially since the typical image quality increased so dramatically. And the continuing exploration of other addressing methods and new electro-optical effects produced many other newsworthy items during the year.

A top story was the rise of "dual-scan color" supertwisted-nematic (STN) LCDs. In prior years, there were a few makers of color STN-LCD panels, each making annual improvements and each increasing manufacturing capacity. But this year, there were at least six vendors, each offering models – in a wide range of shapes and sizes – that offer astounding performance (Fig. 1). At first glance, these passive-matrix displays are nearly indistinguishable from their color thin-film-transistor (TFT) active-matrix cousins!

Many of the important features that are now "equivalent to a TFT" include the overall package dimensions, the diagonal measure, and the measurable color qualities. Most analysts would agree that the STN-LCD does not compete in terms of viewing angle, contrast ratio, or response speed, but the performance gap is certainly narrowing. For notebook-computer applications, the lack of full-motion video is usually not critical, and the lower cost of the STN-LCD is an important market factor.

The single-scan VGA-pixel-format LCD, with its 480:1 multiplex ratio, still shows some crosstalk problems and suffers from relatively low contrast values and relatively long response times. In order to improve performance to an acceptable level, designers adopted the *dual-drive* or *dual-scan* format, which splits the electronics of the LCD into separate top and bottom halves. The dual-scan improvement increased the manufacturing cost, since the number of column drivers is doubled. And the manufacturing process is

Kyocera

Fig. 1: *The color quality of current-generation passive-matrix dual-scan LCDs is excellent. This panel is from Kyocera. Earlier passive-matrix panels from all manufacturers suffered from crosstalk artifacts – a problem that has now been solved.*

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more difficult, since bonding of drivers to glass is harder when the interconnection pitch is halved. Nevertheless, the price of the dual-scan color panel remains less than one-half the price of an AMLCD.

Sanyo and Kyocera had dual-scan panels as early as 1992, but this year the popularity and availability of this LCD category blossomed. Color STN panels are being produced over the full range of LCD sizes. At one extreme, Citizen is making a color 0.7-in. STN panel for viewfinder applications. At the other extreme, large-format color XGA panels are now in development.

It's an "Active" Market!

Perhaps the biggest surprise for 1994 was the lack of major price reductions in color AMLCD panels, and the lack of increased availability to meet the demand. Most of the populace seems to be aware of the distinction that "Active Matrix Inside" implies when purchasing a notebook computer – even if they aren't aware of what LCD stands for!

While there was certainly an easing of allocations, and even a small pull-back in the laptop market early in the year, the prices just didn't plummet as had been predicted. We predict that demand will continue to outstrip supply, especially if LCD prices continue to fall, however gently.

Hitachi and Sharp excitedly announced that they had squeezed their 10-in. LCDs into 8.4- and 9.5-in. package outlines, using the thinnest of microchip packages. Now the OEM can easily change LCD models within the same notebook-computer case, since the overall dimensions are nearly identical among each LCD vendor's three or four offerings, including their passive color and monochrome panels.

By the middle of '94, even the smallest of laptop-computer makers had a product in the market with an AMLCD, and the lifting of U.S. Government tariffs helped stimulate the demand for this product relative to monochrome STN displays. This represents the biggest change from last year: fewer than 25% of notebook computers use monochrome STN-LCDs, while more than 33% reportedly use active-matrix color!

What's under the Hood?

For active-matrix computer displays, 1994 was the year of 4096 colors. The internal workings of this type of product revolve around 3-bit drivers. The extra bit needed for 16 shades per primary, or 4096 colors, is obtained by building an "FRC" shading circuit into the display.

Although panels capable of displaying even more colors were in full production by Sharp and NEC, the 3-bit driver was just fine for 256-color VGA computer displays, and thus became a standard in the industry. A rash of 6-bit-capable panels are set to be introduced before the end of the year to enable true multimedia and more natural color reproduction (Fig. 2). With a modest amount of shading circuitry, these LCDs can portray 24-bit (16.7-million-color) images.

FPD – the joint venture of Philips, Sagem, and Thomson – advanced the cause of active-matrix panels using relatively simple two-terminal active devices by introducing a monochrome 9.5-in. model. The display uses a newly developed 8-bit driver to provide 256 gray levels and the ability to show "photorealistic" images. NEC introduced a full line-up of "natural-color" panels using their special "analog driver" technology. Among these is a 13.1-in. 1280 × 1024 TFT that caught my eye at every show where it was exhibited (Fig. 3).

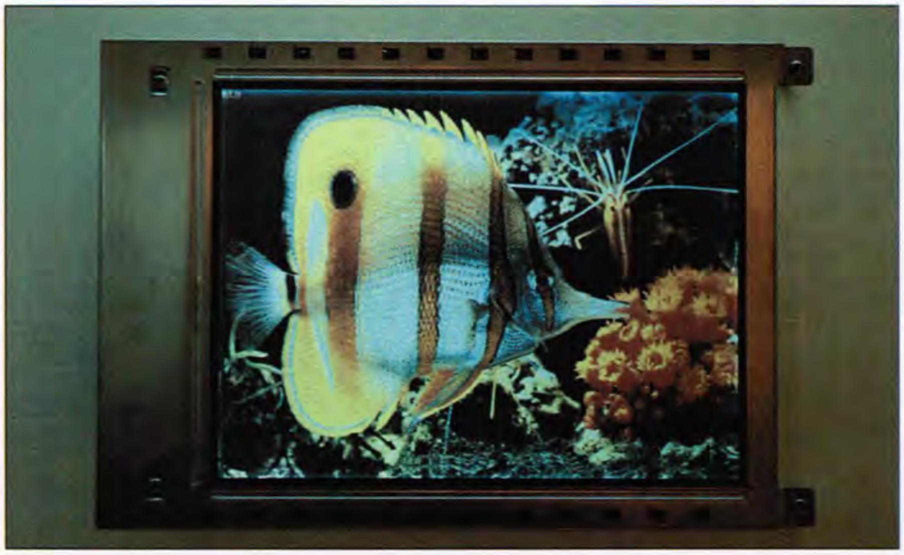
The "multimedia" trend is continuing. Both 6- and 8-bit drivers are now available from four or five chip makers, so high-color capabilities should soon be standard. Vivid even announced a 9-bit driver that uses a standard 5-V CMOS process. This driver may enable even higher color quality in the next generation of AMLCDs.

Top of the Line

As far as the high end goes, we saw the shipment of a significant number of high-resolution LCDs – 1024 × 768 pixels and up. Although nary a laptop was shipped with such a display, some workstations got more portable.

Silicon Graphics introduced the "Indy Presenter," which pairs a 12-in. color XGA (1024 × 768-pixel) LCD monitor with a specially developed overhead projector so that portable presentations can now be made with the company's low-priced workstations.

In Focus, nView, and Proxima introduced overhead-projection panels using 10.4-in. XGA TFTs, so now everyone can show and tell using the now-standard higher-resolution graphic format of 1024 × 768 color pixels. The trend in these products is exemplified by Proxima's announced ability to show images created in 1280 × 1024 format, with the higher-resolution images displayed via interpolation on XGA-format LCDs.



Hosiden

Fig. 2: Many manufacturers are introducing "full-color" or "multimedia" LCD panels that can display 64 shades per color primary for a total of 262,144 colors. With a modest amount of shading circuitry, these LCDs can portray 24-bit (16.7-million-color) images. This 9.5-in. full-color TFT display is from Hosiden.

NEC Electronics

Fig. 3: *NEC's 13.1-in. 1280 × 1024 "natural color" AMLCD has been an attention-getter on the show circuit.*

Sharp topped the size list by demonstrating a 21-in.-diagonal color TFT-LCD, outdoing their own previous impressive announcement and demonstration of a 17-in. panel. In the 21-in. panel, Sharp chose to fabricate only 640 × 480 color pixels, thus positioning the largest panel ever for use as a real "hang-on-the-wall" TV.

Besides FPD's pioneering efforts in two-terminal devices, other active-matrix constructions flourished. Toshiba and Sharp showed LCDs based on thin-film diodes, and each had refined device structures promising much higher transmission and lower front-surface reflectance for backlit models, and much higher reflectance for front-lit (ambient-lit) models. The characteristic should make these units especially suitable for smaller hand-held instruments. Seiko-Epson improved their metal-insulator-metal (MIM) panels, now calling them "Super-MIM."

New Addressing Schemes for Passive LCDs

Motif and Optrex continued their pioneering efforts to bring fast response speeds to the world of STN-LCDs, and both announced the availability of samples during 1994. At SID '94, we got to see this technology in action. The results were impressive, even though these panels did not yet equal the performance of AMLCDs elsewhere on the show floor. (Motif was courageous enough to have a competitor's AM panel next to its own passive panel for a direct comparison.)

Asahi and Motif signaled their intent to cooperate in commercializing their Multi-Line Selection (MLS) and Active Addressing™ (AA) techniques (Fig. 4). These varieties of passive LCD threaten to take a bite out of the middle of the market, if the promises of full-motion video with better contrast and gray-shading can be delivered in a timely fashion. Motif announced relationships with several other makers of STN panels that will allow the makers to purchase the AAICs that enable the Active Addressing method without requiring a license agreement. All of the vendors expect to be shipping in volume in '95.

Another Industry about to Emerge

A whole industry seems on the verge of sprouting to support new applications made possible by phase-change and polymer-based LCDs, especially those targeted to purely reflective modes of operation. Even though the personal-digital-assistant (PDA) products such as Apple's Newton™ did not take off quite as fast as predicted, there are still an uncountable number of hand-held digital devices that need the lowest possible power consumption. Bistable and purely reflective modes of operation are the technical frontrunners for filling the needs of these low-power applications.

We also saw an increase in the available types of passive panels. Ferroelectric LCDs once again became commercially available from Canon, GEC, and Thorn EMI after many years of laboratory work and materials advances. Displaytech is now offering a color shutter based on ferroelectric cells, and GEC has a custom-FLC program tailored to niche markets.

The Long-Term View

Another big story, continuing in 1994, was the sizable investment in LCD factories, especially those to make AMLCDs, using what is now considered the conventional process utilizing amorphous-silicon TFTs. The U.S. Government promised almost $600 million worth of advanced display-development matching funds, but of this amount only a modest $50 million was earmarked to equip the actual manufacturing lines.

Several companies have invested their own dollars, so that the total U.S. investment as of this writing is estimated to be in the $1-billion range, somewhat less than the Japanese equivalent of $4.3 billion. One noteworthy example is Sharp's new factory in Mie, expected to cost $500 million and produce annual revenues of almost the same amount within a few years.

For the established manufacturers the yields are up, the capital purchases are being paid for with some good revenue streams, and the

Optrex

Fig. 4: Multi-Line Selection (MLS) and Active Addressing™ (AA) techniques use application-specific integrated circuits to generate addressing waveforms that allow passive-matrix displays to achieve video speeds and wide viewing angles. This MLS-addressed unit is from Optrex, the Mitsubishi-Asahi Glass joint venture. (Screen image © Second Nature Software; used with permission. Photograph by John Murray.)

prices are coming down. Large panels – 10.4 in. on the diagonal and up – still command a premium, but the smaller sizes are now available, at least in larger quantities, for less than $1000.

The overall market continues to be dominated by Sharp – which claims more than 50% of the AMLCD market by revenue – but other companies have snagged some market share, and there is more diversity in product offerings than ever before.

In fact, 1994 was dominated by LCDs from Japan. The next few years may shift some emphasis back to local suppliers who will challenge Japan's total dominance. FPD, Goldstar, and Samsung have begun to supply LCDs. Singapore and Taiwan have been supplying large quantities of small TN displays for some time but are now able to ship a limited supply of AM samples as well. The Taiwan Government announced an investment program in conjunction with several manufacturing organizations, including some European participation.

Good Things in Small Packages

Epson, Matsushita, and Sony have been quietly improving their polysilicon (p-Si) TFT capabilities for several years. Now, others are promising to make this a very exciting new category, with higher-resolution devices in development. Tiny, low-resolution displays previously developed for camcorder viewfinders will now find their way into head-mounted displays (HMDs) for virtual-reality, navigation, and other important applications.

Epson announced a stunning achievement: the development of a full-VGA-resolution color LCD in a 1.3-in. format. Hitachi announced and began shipping samples of a 1-in. monochrome panel, along with a color-filtered high-resolution television panel having 345,000 total dots.

A new joint venture between David Sarnoff Research Center and In Focus Systems was formed to commercialize the former's extensive knowledge of p-Si device physics and transistor design. We can expect this venture – along with Xerox's efforts to make low-temperature p-Si-on-glass LCDs and Kopin's unique single-crystal TFT devices – to result in a flourishing of high-density displays in the near future.

Almost everyone seems to agree that large displays – greater than 40-in. on the diagonal – will be hard to achieve with a direct-view technology. The magnification, via projection, of these small high-performance LCDs is expected to fill the demand for large-screen television and HDTV applications until 80-in. direct-view panels actually become manufacturable. ■

Please send new product releases or news items to Joan Gorman, Departments Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.

Emissives Get Brighter – with Colors

Plasma display panels and electroluminescent displays made substantial strides in the last 12 months.

by Jane D. Birk

A NUMBER OF exciting developments over the past year in electroluminescent (EL) displays and plasma display panels (PDPs) can best be summarized in two words: bright and colorful. This year's crop of EL displays is brighter than ever, and we have seen demonstrations of color displays in both EL and plasma technologies ranging from relatively simple eight-color models to those boasting over 16 million colors.

Plasma Displays

Many industry watchers have said that the success of hang-on-the-wall large-screen television and HDTV will depend on the development of a viable color flat-panel technology capable of achieving large diagonals. The color plasma panels shown at SID '94 last June in San Jose, California, indicate not only that plasma technology will be a leading contender for hang-on-the-wall TV, but that this long-promised application may be close to reality.

Japanese companies continue to maintain their lead in color dc plasma technology. Two such displays showing full-color full-motion video images were featured at SID '94: Japan Broadcasting Corporation's (NHK's) 40-in.-diagonal HDTV display and an 18-in. NTSC TV display from Matsushita Electronics Corporation. Both of these dc plasma displays feature a 0.65-mm pixel pitch and are capable of displaying 16 million colors. The appearance of these displays is impressive, and so are their underlying structures. Both companies are working with Dai Nippon Printing to develop a sandblasting fabrication process that produces barrier ribs that are approximately 50 μm wide.

In addition to developing high-resolution displays, Matsushita has developed a line of

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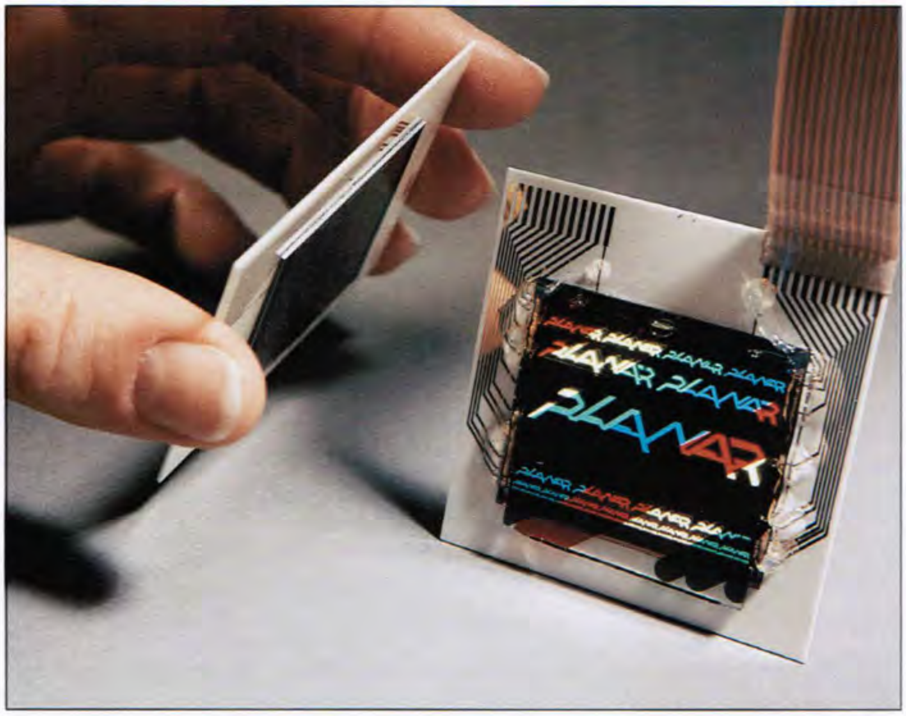
Joe Danieli

Fig. 1: Plasmaco surprised the cognoscenti by introducing its first color ac plasma-display prototype at SID '94 after a remarkably short 5-month development effort. Shown on the 21-in. 640 × 480-pixel display is a full-color image produced by the panel's 24-bit drive electronics.



Planar Systems

***Fig. 2:** Two complementary trends could be seen in display development during 1994: making displays with larger screens, and making displays with smaller screens but higher pixel densities. This is Planar Systems' prototype of a 1.5-in.-diagonal 1000-lpi color EL display for head-mounted applications.*

lower-resolution eight-color displays. Using a large 3.3-mm pixel pitch, these panels can display graphics as well as characters, and provide a full-color, bright, wide-viewing-angle image for public-information applications in train stations, airline terminals, stores, and hotel lobbies.

New developments keep coming in color ac plasma technology too. Photonics has demonstrated a 30-in.-diagonal color display that has the largest number of pixels of any color ac PDP shown to date. It features 1024 × 768 (XGA) resolution and can display 18-bit color. The company also exhibited a 19-in. 640 × 480 color display capable of displaying 256K colors and full-motion video.

The Thomson Tubes Electroniques booth at SID '94 featured a panel with the highest pixel density of any color plasma display by virtue of its 0.4-mm RGB pixel pitch. This 13-in.-diagonal VGA-format plasma panel features 512 colors and should be released as a product early in 1995.

Fujitsu continues to manufacture and ship its 21-in. 640 × 480 display – the only volume-production color ac plasma product announced to date. This display has been incorporated into a flat-panel NTSC television set. Although the panel is not currently being marketed outside Japan, informed industry sources indicate that Fujitsu is contracting with a major U.S. company for a high-volume high-visibility application – an opportunity for color plasma technology to put its foot in the mainstream.

In a surprising move, Plasmaco introduced its first color ac plasma-display prototype at SID '94 (Fig. 1). The 21-in. 640 × 480-pixel panel displayed a simple color-bar image. However, the prototype was produced in a remarkably short 5 months by a design team led by Dr. Larry F. Weber, the company's acting chief executive officer. Plasmaco's technical staff is now developing 24-bit drive electronics for the panel, which will allow the panel to display a full 16 million colors. The display is being designed so that buyers can use it as a second source for the Fujitsu display.

While color is clearly the wave of the future for plasma technology, monochrome plasma is still alive and marketable. All of the major plasma manufacturers are continuing to manufacture and market monochrome PDPs in a wide range of sizes, pixel dimensions, and features. Plasmaco announced new interfacing options in 1994 for its 21.3-in. flat-panel monitor, including an accelerated PC adapter card and an X-terminal interface that fits completely within the monitor's standard 1.75-in.-thick housing. Electro Plasma continued to ship displays, including a 30-in.-diagonal landscape display for CAD applications and models featuring surface acoustic wave (SAW) touch controllers.

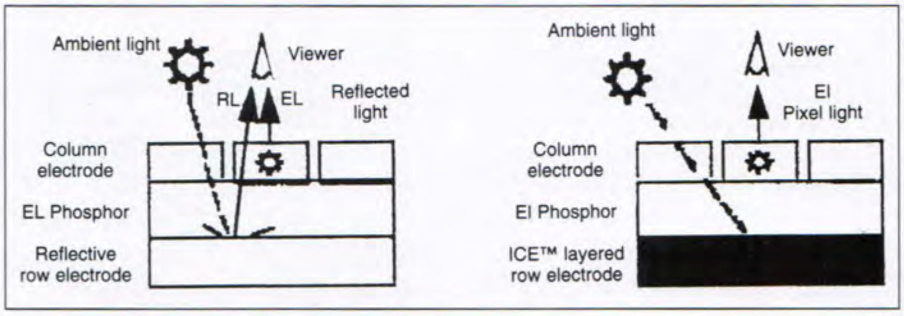


***Fig. 3:** During 1994, Planar Systems introduced a new fabrication process it calls Integral Contrast Enhancement (ICE™), which significantly improves the EL display's contrast and character crispness. In a conventional EL display (left), ambient light reflects off the aluminum row electrodes and degrades contrast. In an ICE display (right), a gradient-index film deposited between the dielectric layer and the row electrode absorbs the ambient light.*

In addition to developing large color displays, Photonics offers displays built to military and commercial standards in a variety of sizes, resolutions, and interfacing options.

Electroluminescent Displays

While plasma-display manufacturers are concentrating on large displays, Planar Systems is currently developing a line of very small displays, and is prototyping a 1280 × 1024 active-matrix monochrome EL display with an amazing 1000 lines per inch (lpi). The display, which is being produced under an ARPA contract, measures a little more than 1.5 in. on the diagonal, and will be used for head-mounted displays. The company has plans to produce similar displays with 2000 lpi, as well as full-color models (Fig. 2).

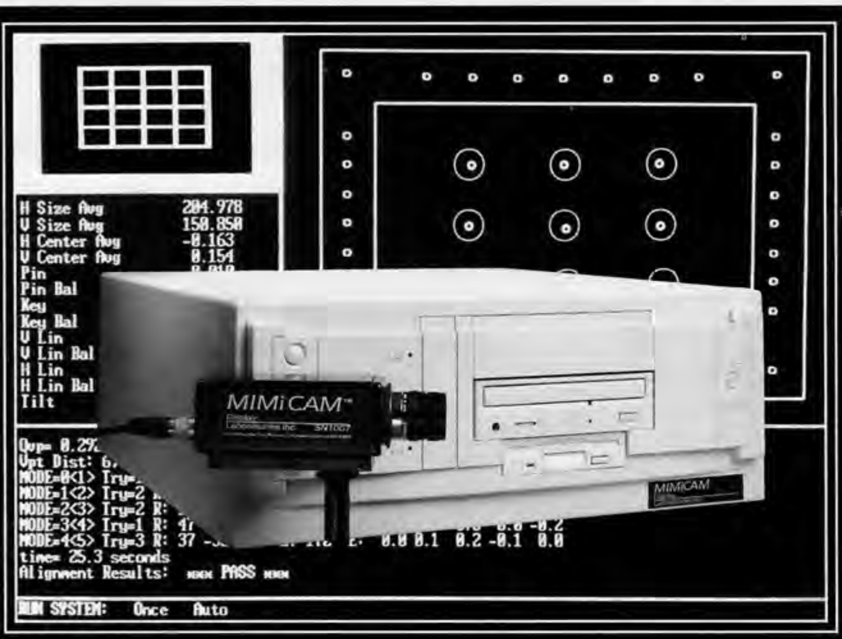
Planar also introduced a new fabrication process it calls Integral Contrast Enhancement (ICE™), which significantly improves the EL display's contrast and character crispness. Side-by-side comparisons of ICE and non-ICE EL panels clearly show the advantages of the new technology. The ICE process involves depositing an additional light-absorbing layer between the dielectric layer and the aluminum row electrode (Fig. 3). This layer is a gradient-index optical film that exhibits the optical characteristics of the EL structure at the surface, gradually changing to those of the aluminum electrode. The gradient index reduces reflections from the metallic electrode structure, which degrades contrast and crispness in conventional EL displays, and eliminates the need for an optical contrast- or color-enhancement filter.

In addition to improved monochrome displays, Planar has commercially introduced an eight-color 9-in. display with 640 × 350 pixels. A version with 640 × 480 pixels is planned for introduction early in 1995. At SID '94 the company exhibited a full-color EL display featuring a vivid blue. (The lack of a blue phosphor with good luminous efficiency has traditionally been the limiting factor in the development of full-color EL displays.) Planar indicated that a full-color product with a 320 × 256-pixel format will be introduced by mid-1995. The color EL displays are expected to be competitive in price with TFT-LCDs and will offer EL's traditional advantages over LCDs, which include undegraded performance over extremes of temperature and a very wide viewing angle.

Sharp – Planar's only major competitor in the technology – continues to market both standard and high-brightness EL displays. Sharp's high-brightness displays utilize a split-screen drive method that doubles the display's refresh rate, and therefore the brightness, without requiring additional power. High-brightness models are available in sizes up to 17 in. on the diagonal, the largest EL panel currently in production. In addition, Sharp offers a high-resolution 1280 × 1024 display with a 13-in. diagonal. The company has not announced any plans for development of color EL panels.

And Wait 'til Next Year

This has been an exciting year in terms of the number, variety, and quality of the emissive FPDs introduced. But even as this article is being written, development continues. We think that 1995 will bring with it larger and brighter displays, with higher resolutions, more colors, and improved features. We eagerly anticipate SID '95, to be held at the Walt Disney World Dolphin Hotel in Orlando, May 21-26. The displays may even dim the nightly fireworks over Snow White's Castle. ■



Display Standards in Trouble

Those who make the standards make the rules of the game. If SID members and their employers don't support standards activities, the benefits of being the standard makers will go to those who do.

by James C. Greeson, Jr.

THE SOCIETY FOR INFORMATION DISPLAY (SID) standards program is a program in trouble. Participation became so inadequate in 1994 that the program is threatened with termination. Meanwhile, nationally and internationally, standards that influence our industry are actively and aggressively under development. While standards are by definition voluntary, they are increasingly being cited in regulations. Therefore, standards are often best thought of as conditions of business.

But standards are more than annoying facts of technological life. They can and should earn the support of your organization because of the benefits that accrue. Who should have a personal role in the development and use of standards?

Why Standards?

Vendor/manufacturer viewpoint. Standards are about commerce. If your company markets a product or service, it is simply good commercial practice to make the appropriate standards integral to your operations. When they are well designed and well implemented, appropriate standards help the provider of goods and services by improving efficiency in three areas:

- *Marketing efficiency.* Two examples tell the story. A vendor can describe the interface of a video card in detail – timing, voltage levels, and sense, etc. – or cite conformance with VESA Local Bus. Which description makes it easier for the customer to make a buying decision?

  A salesman can explain the ergonomic characteristics of a display – flicker, character design, etc. – to a potential user line by line, or he can simply cite conformance to ISO 9241-3, 7, and 8. If the standards are doing the right job, the salesman benefits by focusing the sales call on the differences between his product and the competition rather than on a line-by-line discussion of the qualities of the product.
- *Manufacturing efficiency.* Generally, standards specify uniform test methods. Using stable test platforms across product lines and pre-accepted quality-control methods improves manufacturing efficiency.
- *Engineering efficiency.* If the right standards exist at product-development kick-off, those standards represent the base line for product specification. If make/buy decisions are made, the right standards package can quickly communicate product minima to potential vendors.

Buyer/end-user viewpoint.

- *Base function guaranteed (even if not completely understood).* A buyer, especially a commercial buyer of modest quantities, cannot be an expert on every product he needs. But the non-expert buyer can purchase with increased confidence if the product conforms to a standard that represents expert opinion on what the product should be.
- *Side-effects are under control.* Safety, machine-to-machine interaction, and incompatibilities do not need line-by-line review if the appropriate standard is in place.
- *Mechanical fit.*
- *Manufactured quality.* Conformance to ISO 9000 is important evidence in some markets that the product is manufactured with appropriate quality controls in place. The net result is that the buyer can concentrate on product quality and value – issues that differentiate your product from alternatives – rather than on the essentials of function, fit, safety, and base quality that your product presumably shares with the products of reputable competitors.

Kinds of Standards

There are many kinds of standards, which are needed to fill different roles. The existence of competing standards opens the possibility of inconsistency. Inconsistency is worse than inappropriateness. With inconsistent standards, instead of assuring a potential customer that your product conforms, you must explain why it conforms to one standard and not the

James C. Greeson, Jr., is the chair of SID's Standards and Definitions committee and the Technical Advisor to ANSI on electro-optical devices. He serves on the ISO committee on display ergonomics, where he is editing ISO 13406-2 on flat-panel ergonomics. He is on the output-devices subcommittee of the committee revising HFS 100, the ANSI display workplace ergonomics standards, and is President of Ergonomic Solutions Incorporated (ESI), which supports clients on EMC and electro-magnetic immunity standards.

other. Potentially, SID could fill an important role: participating in display standards sufficiently to identify inconsistencies before standards formally issue.

In-house standards. Most larger companies write their own standards, in addition to using public standards. There are several good reasons for this. A public-standards document cannot designate specific tools for testing. But results can vary from tool to tool – as it does, for example, with misconvergence measurements on a color CRT. This variation is always undesirable and may not be acceptable inside a company. A company standard can specify specific brands and model numbers for test equipment.

Other motivations for company standards include the desire to write standards that anticipate the state of the art or that provide guard bands to ensure production units comply with existing public standards in function or quality.

Such company standards can be a tool for efficient product planning, multiple-site manufacturing coordination, and efficient tooling procurement.

Industry standards. VESA, SEMI, IEEE, EIA, and other organizations write industrial standards that are not sent through a national or international consensus process. Such standards are appropriate when limited consensus is acceptable and speed is of the essence. Explicit standards – for electrical interfaces, for example – are needed early in a product cycle and must change quickly with the state of the art. An industry group is the best forum for instituting such standards.

National standards. Broader consensus – including quasi-governmental bodies and all "materially affected" parties, such as buyers, vendors, and interest groups – is the key reason to move to a national standard. In the U.S., the American National Standards Institute (ANSI) provides various structures for developing standards – such as the ANSI HF(E)S-100 standard for display ergonomics. It takes more time to achieve the "face trustworthiness" conveyed by the successful issuance of such a standard. By policy, a guiding principle of all ANSI standards is international harmonization to ensure that standards do not become a trade barrier.

International (multinational) standards. These standards are promulgated by two central organizations: the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) (see "International Standards Organizations: A Thumbnail Sketch"). Well-known examples of such standards include ISO 9241, the IEC IECQ series, and CEN multinational and EN 29241. These standards must earn the acceptance of two-thirds of voting countries and be rejected by no more than one-quarter of voting countries. Each participating country has a national committee charged with voting and commenting on standards as they develop. This process can be even more difficult than the one for developing national standards.

All standards are voluntary, but international and national standards such as the ISO 9000 series can be a marketing switch – a condition of business. When HFES 100 is issued, it may well be cited in regulations or even in laws. In the European Union, the multinational Euro-Norms are likely to be cited in directives and become mandatory. This has happened in EMC standards.

These standards have the best strategic face validity because most countries have harmonization agreements.

U.S. Activity Drops below Critical Mass

SID members support standards that affect display and display-system technology at every level – in-house, industrial, national, and international. SID itself co-sponsors with EIA a number of activities: JT-6, JT-20, and JT-32 on various CRT issues and JT-33 on flat panels. JT-33 is also the technical advisory group on the flat-panel quality specification series being developed by IEC. A potential new role for SID is to establish a coordinating committee to deal with the standards consistency problem.

There are standards committees at all levels developing display standards for all direct-view displays, and spanning all issues from interfaces through ergonomics. But the participation of the display and display-integration industries in North America is waning. So few people are involved that it has become impossible for the JT-33 committee to do a responsible job as U.S. representative to the IEC.

The U.S. display industry apparently has a distorted view of the utility of standards in business. The pull of enhanced efficiencies from well-designed standards and the need to resist the promulgation of inappropriate standards – which may then be cited in regulations

International Standards Organizations: A Thumbnail Sketch

International Organization for Standardization (ISO)

- Since 1946:
  - 166 technical committees,
  - 2300 subcommittees,
  - 7100 issued standards.
- Scope: virtually every area of technology except electrotechnical (see IEC).
- The official standards bodies of 91 countries are members.
- The ISO's European counterpart is the European Committee for Standardization (CEN), which includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

International Electrotechnical Commission

- Since 1906, jointly with ISO since 1947:
  - 88 technical committees,
  - 100 subcommittees,
  - 41 countries (representing 95% of electrical consumption).
- European counterpart is the European Committee for Electrotechnical Standardization (CENELEC), with the same membership as CEN except for Iceland and Luxembourg.
- Both CEN and CENELEC often endorse ISO/IEC standards (89% success at last count) as ENs (Euro-Norms).
- The 18 European countries are required by the EU (European Union) to harmonize country standards.

SID Standards Questionnaire

At a time when its participation is more important than ever before to the international health of the display industry, SID's flat-panel standards work is in crisis. If you are interested in participating in this essential activity, please return this questionnaire. Unless a few good men and women do return it, SID/EIA flat-panel standards activities will not continue. Please write in any comments that you think may be helpful, and please sign this questionnaire.

Mail the completed questionnaire to James C. Greeson, Jr.,
SID Standards and Definitions, 6025 Bedfordshire Dr., Raleigh, NC 27606.
Mr. Greeson can also be reached by phone/fax at 919/851-8289 or by e-mail at 71204.624@compuserve.com.

No.	Question	
1.	Name: ______ Organization: ______ ______ Address: ______ ______ ______ Telephone: ______ Fax: ______ e-mail: ______	
2.	What percent of your time do you currently (1994) spend in standards activities of any kind?	In-house standards: __ % Industrial standards: __ % National standards: __ % International standards (including voting and commenting for U.S. positions on these standards): __ % Total: __ %
3.	Expected relative support from your organization for these activities, with 1994 as a base year.	☐ Increase in 1995 ☐ About the same in 1995 ☐ Decrease in 1995 ☐ Discontinue in 1995
4.	Does your organization use display standards in day-to-day business operations?	☐ Yes ☐ No
5.	If the answer was "YES", list the standards that you use or expect to use.	
6.	SID's role in standards development:	☐ Should increase ☐ Is about right ☐ Should decrease ☐ Is unnecessary
7.	In 1995, check those activities that interest you. This will generate correspondence to inform you how to get and/or stay involved.	☐ Industrial standards, circle any that apply: EIA, IEEE, VESA, SEMI, Other (please write in) ☐ National Ergonomic Standards (HFES -100 canvass committee) ☐ International Ergonomic Standards ☐ National Engineering Standards ☐ International Engineering Standards

No.	Question	
8.	Check all areas of interest/ expertise (use the space below for any comments, modifiers, or additional areas of interest):	☐ CRT technology ☐ Flat-panel technology ☐ Display measurements ☐ Display workplace ergonomics ☐ Display systems or subsystems ☐ High rendition quality images ☐ Quality/sampling plans for displays ☐ Projection ☐ Head-mounted displays ☐ Multimedia ☐ Data compression of images
9.	Remove my name from the following lists:	☐ JT 6 ☐ JT 20 ☐ JT 32 ☐ JT 33 ☐ SID STANDARDS AND DEFINITIONS ☐ All
10.	My organization is likely to support the following business travel for standards development or voting/comment.	☐ Air travel (number of U.S. trips ____) ☐ Hotel days (number of days ____) ☐ International travel (trips ______)
11.	I can expect time and company resources to pursue this work.	________ days/year
12.	I have an interest in a leadership role in display-standards development.	☐ Yes ☐ No
13.	I can attend a one-day SID standards organization meeting in the fourth quarter of 1994.	☐ Yes ☐ No
14.	Should SID have a standards coordinating committee? This committee should be charged with oversight of SID/EIA activities and related, possibly overlapping, work at HFES, VESA, SEMI, ASTM, etc.	☐ Yes ☐ No
15.	If question 14 was answered yes, should this committee have project approval for all SID/EIA standards projects?	☐ Yes ☐ No

and laws – have been insufficient to draw support from corporate America. The level of support within my own company is expected to fall 60% in 1995.

SID is at a turning point. The flat-panel standards work has fallen to the point where it must be reestablished from zero. Our current mailing list will be replaced with the names of the *Information Display* readers who respond to the accompanying questionnaire. We need your active participation at this time, when ISO, IEC, and ANSI – as well as industry groups such as VESA and SEMI – have active standards programs that affect all aspects of display technology. ■

To participate as an exhibitor at DMTC '95 in Santa Clara, please call Erika Suresky, Exhibit Manager, Palisades Institute for Research Services, Inc., at 212/620-3375, fax -3379.

display continuum

continued from page 6

miles away. (The newest head-trackers had optical sensors that analyzed eye movements as a precursor to head motion, in addition to the usual motion sensors.)

The overall experience was so close to being there that Larry decided he would do this from now on for any new location that they were planning to visit. It was great to have this kind of personalized overview. Now, when they arrived in person, they would no longer have to wander around for several days finding the locations and activities that they most wanted to experience. Not only that, this was an inexpensive way to find out about new destinations and, of course, to review previous good experiences as they had just done. The cost of the tour had been less than for an in-person bus ticket, and the interconnect time had recently been reduced to $50 per hour, so this was becoming a rather manageable expense for a Saturday afternoon – perhaps even cheaper than a trip into New York, by the time one added a cab ride or two to the train fare.

The following Monday, as Larry was describing his exciting new discovery to some of his colleagues, he learned that these "virtual tours" had also become quite the rage with pre-newlyweds in Japan. "Experiential Reality" buses were regularly plying the streets of Honolulu and the main roads of Maui to preview, for these young Japanese couples and even their parents, what they would find when they arrived at their favorite honeymoon destination.

As Larry learned more about this new technology, he discovered that head-mounted displays with remote sensors, together with high-performance head-trackers, had found all kinds of new applications. For example, on the same Saturday that he was taking his tour of London and the Japanese couples were previewing Honolulu, out in the Atlantic Ocean a remotely piloted undersea vessel was searching for a sunken submarine. The pilot of this remotely guided vessel was sitting in a surface ship several thousand feet above wearing a head-mounted display that also tracked head movement and provided a high-resolution 3-D picture as clear and sharp as he would be able to get by being there. In this case, being there would not have been a very pleasant experience, with the many-atmosphere high-pressure environment inside the deep-undersea vessel.

In yet another part of the world, an active volcano was being explored with a robotic walker guided by an operator wearing a similar head-mounted display that gave her the same view as the robot was getting. Here again, the key was the wide field of stereoscopic vision, the full-color high-resolution display, and the ability to reproduce head and eye movements as well as could be done by being there. In spite of knowing the unpredictability of the situation, it took the operator several hours to recover emotionally from the sheer terror she felt when the volcano unexpectedly erupted and destroyed the robot observer she was guiding.

There are many other scenes like these for us to imagine and construct. They will generally be based on simulating a variety of learning experiences; previewing events that are too scary, too unknown, too uncomfortable, or too unaffordable to experience in person; exploring hazardous or non-survivable environments; exploring locations where a human being would be too big or too intrusive; engaging in detection and security activities – and the list grows longer and longer.

And, we don't want to forget ENTERTAINMENT. The possibilities here seem nearly limitless. Anything from remotely piloted model airplanes and rockets to real race cars to water-skiing to skydiving. And maybe even calmer activities such as concerts and tours of art galleries. In other words, anything that can (and sometimes cannot) be done by a real person can be recreated to be experienced by one or many people remotely.

If you are a regular peruser of this column, you already know that virtual reality has "arrived." About a year ago (October '93), I wrote that there is now a popular magazine with that title. Since then, all sorts of publications have picked up on "VR" and made it ***the*** popular new topic. However, a recent news article that warned of the ***health hazards of virtual reality equipment*** really clinched it! This article was describing problems such as the dangers of motion-sickness and disorientation, and asserted that the technology has moved too quickly without time to analyze its environmental and health aspects. It mentioned the "product liability" issues and how the manufacturers would soon realize that they could be sued for injuries resulting from disoriented people bumping into things, such as with their cars, after playing a VR game or having some other yet unspecified VR experience. THAT'S IT! With that kind of "endorsement," we can now say for sure that VR is here to stay.

The major product opportunities for the display community will be in small, lightweight, high-resolution display modules and in head-motion and eye-movement sensors. The technologies that are being developed using high-resolution active-matrix addressing of LCDs and EL panels should be readily applicable to such products. The newer FEDs could also be interesting once their performance capabilities are further developed.

What I find especially interesting about all this is that there are so many new applications yet to be discovered. Most other display markets are relatively mature, the needs are well understood, and the technological possibilities are quite predictable. But not here. Thus, while the large flat full-color hang-on-the-wall display still remains the "holy grail" of the display industry, the growth of some of these other product applications could be just as exciting – and **very** interesting from a business-opportunity and business-growth perspective.

If these small and very-high-resolution displays are to become reality, they will need new processes and new materials to make them happen. In recognition of this, in this month's industry segment we feature an update on the work that is being done in the U.S. to improve phosphor technology.

For many display technologies, whether small or large, the availability of high-quality phosphors continues to be vital to success. This is the reason that the **Phosphor Technology Center of Excellence** was established. The Center recently completed its first year review at **Georgia Tech**. Currently, the Center supports over 25 professors and 40 graduate research students on six campuses and in several companies. The member organizations are: **Georgia Institute of Technology, University of Georgia, University of Florida, Oregon State University, Pennsylvania State University, David Sarnoff Research Center,** and the companies of the **American Display Consortium. Chris Summers** heads up the Center from his base at Georgia Tech. Some of the new developments of this past year are: The formation of a fast-track program to respond to industry needs in electroluminescent and field-emission-display phosphors; an EL program focusing on the development of a brighter blue phosphor through the development of new phosphor and insulator materials; the synthesis and testing of new materials and smaller-particle powders that have the potential to improve FEDs; and work to develop efficient phosphors that are suitable for use in an FED environment to enable CRT-quality flat-panel displays at low cost.

In other industry news, **BARCO, Inc.** of Kennesaw, Georgia, has hired **Brian Overy** as Market Development Manager for Simulation. Brian, who will manage simulation and life-critical applications, brings 13 years of experience in electronic systems and flight-simulation technologies to the company. He joins BARCO from Lockheed's Fort Worth division, where he spent 7 years working as Chief of the Flight Simulation Laboratory and lead technical consultant of the Aircraft Flight Simulator Program.

Photon Dynamics, Inc. of Milpitas, California, has announced several new appointments in their executive ranks. **Howard M.**

Bailey has been named the new CFO. He joins the company after serving as CFO and/or operations director of several companies, including Plus Logic, MicroPhoretic Systems, and MegaVolt Integrations. The company also appointed **Gino Addiego** as Vice President and General Manager of the new Test and Repair Division, and **Jeff Hawthorne** as Vice President and General Manager of the Inspection Division. Dr. Addiego was most recently VP of R&D at Photon Dynamics. Jeff Hawthorne managed the optical, hardware, and metrology algorithm designs for Photon Dynamics. Photon Dynamics designs, manufactures, and supports a complete line of advanced test, inspection, and repair systems for FPDs. The company recently completed a new round of investment, raising over $3 million from a group of venture funds.

Tektronix, Inc. of Beaverton, Oregon, is continuing on its path of divesting all display operations. As previously announced, the Avionics Business Unit under **Al Herman** has now become **Planar Advance**. The Display Products (monitors) group under **Rich Hockenbrock** may also be nearing some kind of buyout or acquisition opportunity. Some of the color shutter technology has migrated to Planar Advance, some is still in the Display Products group, and Tektronix will apparently continue to manufacture some for its own needs and also for these two groups. The remaining CRT operation is currently managed by **Robin Burnham** with the expectation of a phase-out in early 1996. Outside vendors are being evaluated to take care of the remaining future needs. One-time builds are also being contemplated for some of the lower-volume and older products. **Ken Hawken** and **Conrad Odenthal**, two long-time SID members, have the unenviable task of helping to make this phase-out happen.

In Focus Systems, Inc. of Tualatin, Oregon, and the **David Sarnoff Research Center** of Princeton, New Jersey, are in the final stages of completing an agreement to form a new company called **Sarif**. A letter of intent has been signed and negotiations are expected to be completed soon. **Steve Hix**, the founder of In Focus Systems, will be the Chairman and CEO of this new joint venture. Sarif will be in the business of developing polysilicon technology for projection displays.

As always, I am pleased to hear from you in person or by correspondence. I can be reached by phone at 609/734-2949 or by fax at 609/734-2127. E-mail works well also, aris_silzars@maca.sarnoff.com. Or if you still like the U.S. mail, send your comments and news releases to Jay Morreale c/o Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014. Merry Christmas and Happy Holidays to all, and to all a spectacular New Year! ■

To participate as an exhibitor at DMTC '95 in Santa Clara, please call Erika Suresky, Exhibit Manager, Palisades Institute for Research Services, Inc., at 212/620-3375, fax -3379.

Circle no. 30

continued from page 11

Information: Sue Mesecher, Photo Research, 9330 DeSoto Avenue, P.O. Box 2192, Chatsworth, CA 91313-2192. 818/341-5151.

Circle no. 3

ICE Plus™ doubles brightness and contrast

Planar Systems, Inc., Beaverton, Oregon, has announced the production availability of the first member of its ICE Plus™ family of high-performance monochrome flat-panel displays (FPDs). The 640 × 400-format EL640.400-CE1 (CE1) display doubles brightness and contrast through two technological breakthroughs. Planar's Integral Contrast Enhancement (ICE™) technology results in crisp characters, eliminating the "blooming" exhibited by display pixel elements being driven at high luminance levels. In addition, ICE Plus™ displays incorporate electronics that offer selectable modes for double brightness or low power consumption. These technological advances increase the display's luminance contrast, drastically improving performance in high-ambient-light environments and eliminating the need for expensive contrast filters. This daylight-readable performance breakthrough will particularly benefit outdoor applications. ICE Plus™ technology incorporates Planar's low EMI design and a variety of interface options to make integration of the CE1 as easy as possible. The CE1 can be driven by a standard VGA card (via the feature connector), by standard FPD controller ICs, or by using a normal interface (using vertical-sync, horizontal-sync, data, and clock). The CE1 provides FPD users high levels of environmental and electrical performance; namely, a viewing angle of 160° in both vertical and horizontal planes, the widest flat-panel operating temperature range available, from –25 to +65°C, and much better reliability than backlit LCDs.

Information: Troy Severson, Planar Systems, Inc., 1400 N.W. Compton Drive, Beaverton, OR 97006. 503/690-1100, fax 503/690-1493.

Circle no. 4

LCD module with built-in controller

Seiko Instruments USA, Inc., Torrance, California, has introduced its new Series G324E 320 × 240 black-and-white LCD module with built-in controller, which incorporates cathode fluorescent (CFL) edge-lighting and film supertwist (FSTN) technology. The CFL edge-lighting consists of a single CFL mounted on the side of the module. A proprietary diffusion process provides even light distribution and excellent contrast, and the edge-lighting system reduces the weight, thickness, and power consumption of direct electroluminescent backlighting methods, yet offers the same dot size and viewing area. The CFL brightness is 100 cd/m^2. The module measures just 166 (H) × 134 (V) × 15.1 (T) mm and weighs approximately 300 grams. Dot size is 0.32 × 0.39 mm, dot pitch is 0.36 × 0.43 mm, and the 6-in.-diagonal display provides a 128 (H) × 110 (V) mm viewing area and a 70° viewing angle. The module's power requirements are +5 V @ 23 mA and –24 V @ 6 mA, the operating temperature is 0° to +50°C, and the duty cycle is 1/240. The G324E modules are ideal replacements for small CRTs in POS, test instrumentation, and medical and industrial equipment applications, where compact size, even light distribution, and excellent contrast are necessary. The G324E is available in black and white (FSTN) negative mode with an optional built-in controller chip that simplifies the software interface. The price with controller is $261.50 in sample quantities (under 99 pieces). Samples of the new module are available now, with production quantities scheduled for availability in December, 1994.

Information: Brian Platt, Seiko Instruments USA, Inc., Liquid-Crystal Display Dept., 2990 W. Lomita Blvd., Torrance, CA 90505. 310/517-7771, fax 310/517-7792.

Circle no. 5

High-voltage CRT amplifiers

M. S. Kennedy Corp., Cicero, New York, has introduced a new series of high-voltage transimpedance amplifiers for cathode and grid drive of high-resolution CRT monitors. The MSK 640 and 641 operate from positive supply voltages of up to +75 and +100 V, respectively, with corresponding output swings of 55 and 85 V peak to peak. The MSK 642 operates from a supply of up to –75 V and will swing 55 V peak to peak. Transition times of 2 ns into 8.5-pF loads are possible with all three amplifiers, making these parts ideal for driving high-resolution monitors and displays with 10-ns pixels and resolution in excess of 1280 × 1024 lines. The MSK 640 Series is intended for use in military and aerospace applications, and is packaged in hermetic single in-line nine-pin packages with mounting holes for heat-sinking purposes. These parts are pin-compatible with discontinued military versions of the LH and CR 2424 Series of amplifiers. Fully compliant QML versions are available, as are industrial grades. MSK offers a full line of video amplifiers for ultra-high-performance CRT applications, as well as custom video signal-processing circuits for CRTs and flat-panel displays.

Information: Greg Overend, Sales Manager, M. S. Kennedy Corp., 8170 Thompson Road, Cicero, NY 13039. 315/699-9201, fax 315/699-8023.

Circle no. 6

Smart touch system

MicroTouch Systems, Inc., Methuen, Massachusetts, has announced the ClearTek 2000, the newest generation of its analog capacitive touch screens that improves touch-system accuracy 75% over previous models, while also providing increased touchdown speed of 8–15 ms and new remote diagnostic capabilities. MicroTouch's new Smart Touch Screen technology involves a redesign of their entire analog capacitive controller line. The new 2000-series controllers now include advanced firmware that allows correction values derived from a multipoint factory touch-screen calibration procedure to be stored on a unique non-volatile memory (NOVRAM) chip which is part of the controller. The calibration data is used by the controller to provide highly accurate touch coordinates to the host system – with an offset of less than ±1%. In addition, the ClearTek 2000 controller generates up to 270 touch points/s at 19.2K baud, making it well-suited to applications using drag and drop techniques or other actions where a touch screen replaces the mouse. Other touch technologies, with slower point speeds, will not allow the user to smoothly drag the cursor or icons across the screen. The ClearTek 2000 includes new diagnostic software and a diagnostic LED on the controller which, in addition to running troubleshooting tests, can update parameters on the controller via modem, thus eliminating the need to remove the controller from the monitor for return to the factory when such service is needed. The ClearTek 2000 provides high accuracy, high-resolution 1024 × 1024 touch points, fast touchdown speed, and the ability to detect the lightest touch. Single-piece pricing for a ClearTek 2000 touch-screen kit, which includes an etched or a polished touch sensor, a 2000-series controller, software drivers, and all necessary cables, begins at $495; volume discounts are available. All MicroTouch touch screens include a 5-year parts and labor warranty.

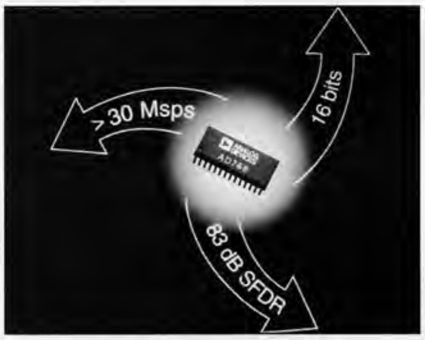
Information: Annette Petagna, MicroTouch Systems, Inc., 300 Griffin Park, Methuen, MA 01844. 508/659-9000, fax 508/659-9100.

Circle no. 7

High-speed DAC

Analog Devices, Inc., Norwood, Massachusetts, has introduced the AD768, a 16-bit 30-Msps digital-to-analog converter that delivers the highest resolution and accuracy of any high-speed DAC, with a spurious-free dynamic range (SFDR) of 83 dB at 1 MHz and a settling time of only 25 ns (to 0.025%). High-speed applications include direct digital synthesis in communications systems, signal generators and instrumentation, and imaging and video displays. It is already being used in basestations for GSM digital cellular telephony and ADSL. The AD768 is a current-out DAC which incorporates a precision 2.5-V reference and draws 500 mW. In addition to its accuracy error, the AD768 offers an extremely low glitch (35 pV-s) and operates off a ±5 V supply. Operation is specified over the –40° to +85°C temperature range. The AD768 is priced at $19.95 in thousands and packaged in a 28-pin SOIC. Delivery is from stock.

Information: Analog Devices, Inc., 181 Ballardvale Street, Wilmington, MA 01887. 617/937-1428, fax 617/821-4273.

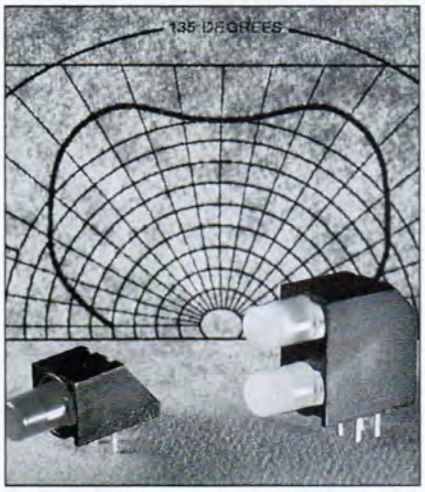


Circle no. 8

Flat-top LEDs

Dialight Corp., Manasquan, New Jersey, has expanded its circuit-board indicator (CBI®) product line with the addition of two new types that incorporate 4-mm flat-top LEDs. These CBIs are manufactured to accommodate flush front-panel designs without sacrificing either direct or peripheral viewing angles. The new indicators include the single high 550-6x07 and the bilevel 552-60xx-200, both available in red (635 nm), green (565 nm), and yellow (583 nm), with mixed color combinations available in the bilevel version. The new devices feature a total viewing angle of 135°; typical luminous intensity of 7 mcd (red and green) and 10 mcd (yellow); and typical forward voltage of 2.2 V (red and green) and 2.3 V (yellow). The CBIs are encased in black housings (made with UL94V-0-rated material) that enhance the contrast ratio and assure consistent lead alignment and positioning of the LEDs. Pricing in 1000-piece quantities is $0.47 for the 550 and $0.92 for the 552. Current lead times range from 3 to 5 weeks, with samples available now.

Information: Dialight Corp., 1913 Atlantic Avenue, Manasquan, NJ 08736. 908/223-9400, fax 908/223-8788.



Circle no. 9

Projector series expands

Hughes-JVC Technology Corp., Carlsbad, California, has announced the expansion of its Series 300 Image Light Amplifier® projection systems with the introduction of Model 310E, which utilizes a reduced-aperture liquid-crystal light-valve technology delivering up to 2000 lumens of light output, image sizes up to 35 ft. wide, and a 150:1 contrast ratio at a significantly reduced price of $59,500. Like all Series 300 ILA projectors, the Model 310E uses a patented image light-amplifier technology which enables super high brightness for applications where high ambient light and image size are a concern. It features a horizontal-scan frequency from 15 to 90 kHz, making it ideal for video, HDTV, computer data, and high-resolution graphics applications demanding up to 1600 lines of resolution. Other members of the Series 300 include Model 320 ($70,000), which provides up to 2300 lumens of light output and a 200:1 contrast ratio, and Model 335 ($115,000), which provides 3500 lumens of light output and a 200:1 contrast ratio.

Information: Marc La Vecchia, Marketing Manager, Hughes-JVC Technology Corp., 2310 Camino Vida Roble, Carlsbad, CA 92009-1416. 619/929-5605, fax 619/929-5410.

Circle no. 10

Multicolor EL lamps

Nippon Graphite Industries (NGI), Ishiyama, Japan, has announced that their new FlexEL electroluminescent-lamp product line, restricted until now to a few major accounts, is now generally available. The FlexEL line offers advantages such as integrated anisotropic electroconductive adhesive for interconnects, thinner construction, and multicolor capability. When the lamp is activated, the user perceives a seamless transition from one color to another. With the ability to highlight different areas of the screen in contrasting colors and increase the information density of the display, the FlexEL line's seamless multicolor ability is renewing interest in electroluminescent lamps as backlights for LCD panels. The company is confident that their processing technology, combined with large-scale operations, will allow them to manufacture lamps comparable in price to LEDs for use in backlighting.

Information: Peter J. Opdahl, Managing Director, Pacifio Technologies, Inc., 123 N.W. 13th Street, Suite 304-2, Boca Raton, FL 33432. 407/392-2555, fax 407/392-0807.

Circle no. 11 ■

Please send new product releases or news items to Joan Gorman, Departments Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.

Compiled by Howard L. Funk
H. L. Funk Consulting

U.S. Patent No. 5,345,322; Issued 9/6/94

Complementary Color Liquid-Crystal Display

Inventors: Fergason, James L.
Assigned to: Manchester R&D Ltd. Partnership

A liquid-crystal color device includes at least one pel for affecting light incident thereon to produce output light, the pel includes three complementary color subsets each having controllable color-filtering capability in the respective complementary colors thereof. The color subsets are arranged in optical additive relation, and the color subsets include complementary color parts which are arranged, respectively, in optical using liquid-crystal materials with respective pleochroic dyes. A method of parametric color control of a liquid-crystal device, formed of plural picture elements, each picture element including plural pairs of complementary color filters, comprising directing light to or through an array of such electrically controllable pairs of complementary color filters, and controlling the filtering characteristics of at least one of such filters.

U.S. Patent No. 5,347,146; Issued 9/13/94

Polysilicon Thin-Film Transistor of a Liquid-Crystal Display

Inventors: Soh, Hoe S.
Assigned to: Gold Star Co. Ltd., Korea

A thin-film transistor (TFT) comprising a multilayer structure including an amorphous-silicon layer and a metal layer both forming source and drain regions. The source and drain regions have opposite exposed edges with a slant shape. An active semiconductor layer is disposed at a channel region defined between the source region and the drain region so that it is overlapped with the upper surface portions of the source and drain regions adjacent to their edges faced to each other. In a CMOS-type TFT, its n-type TFT has a gate overlapped with the source and drain regions and its p-type TFT has a gate offsetted from the source and drain region.

U.S. Patent No. 5,347,144; Issued 9/13/94

Thin-Layer Field-Effect Transistors with MIS Structure Whose Insulator and Semiconductor Are Made of Organic Materials

Inventors: Fichou, Denis; Garnier, Francis; Horowitz, Gilles
Assigned to: Centre National de la Recherche Scientifique CNRS, France

A thin-layer field-effect transistor (TFT) with an MIS structure includes a thin semiconductor layer between a source and a drain. The thin semiconductor layer is in contact with one surface of a thin layer made of insulating material, and in contact by its other surface with a conducting grid. The semiconductor is composed of at least one polyconjugated organic compound with a specific molecular weight. The polyconjugated organic compound or polyconjugated organic compounds contain at least eight conjugated bonds and have a molecular weight of no greater than approximately 2,000. The thin layer of insulating material is made of an insulating organic polymer having a dielectric constant of at least equal to 5. The transistor is useful as a switching or amplifying element.

U.S. Patent No. 5,334,859; Issued 8/2/94

Thin-Film Transistor Having Source and Drain Electrodes Insulated by an Anodically Oxidized Film

Inventors: Matsuda, Kunihiro
Assigned to: Casio Computer Co. Ltd., Japan

A thin-film transistor (TFT) panel comprises an insulative substrate, a plurality of TFT elements arranged at predetermined intervals on said substrate, and wirings electrically connecting the TFT elements characterized in that the TFT element comprises a gate electrode, a gate-insulating film, an i-type semiconductor layer to face the gate electrode through the gate insulating film therebetween, an n-type semiconductor layer, source and drain electrodes electrically connected the portions of the i-type semiconductor layer through the n-type semiconductor layer, and an anodically oxidized film located between the source and drain electrodes to electrically isolate, said source and drain electrodes.

U.S. Patent No 5,346,833; Issued 9/13/94

Simplified Method of Making Active-Matrix Liquid-Crystal Diplay

Inventors: Wu, Biing-Seng
Assigned to: Industrial Technology Research Institute, Taiwan

An inverted staggered (bottom gate) thin-film transistor (TFT for active-matrix LCDs is processed with three masks. The first mask is used to pattern a metal film on a glass substrate as the gate of the TFT, the scan line of the TFT array, and a portion of the data line of the TFT array. The second mask is used to form a TFT mesa with a gate dielectric layer, an a-Si layer as channel, and a heavily-doped n+s-Si layer for contacting the source and the drain of the TFT. A third mask is used to pattern the transparent conductive indium-tin-oxide film as the pixel electrode, the source/drain electrodes of the TFT, and the interconnections of the data line.

U.S. Patent No. 5,345,324; Issued 9/6/94

Active-Matrix Liquid-Crystal-Display Device Having Two Light-Shielding Layers

Inventors: Fukunaga, Tetsuya; Koseki, Toshihiko; Takano, Hideo; Yamanaka, Hidemine
Assigned to: IBM Corp., Japan

In a liquid-crystal-display (LCD) device including a first transparent insulating substrate having a common electode formed theron; a second transparent insulating substrate having gate lines formed in a first direction; data lines formed in a second direction so as to intersect said gate lines, LCD cells, each at a crosspoint of said gate and data lines; the cells having a thin-film transistor (TFT) and a display electrode; a light-shielding layer having an aperture for exposing a display area of each display electrode; a liquid-crystal material retained between said first and second substrates, and a liquid-crystal orientating layer on at least one of the substrates, the improvement comprising the light-shielding layer at an edge of said aperture being located in an up stream direction with respect to a rubbing direction of the orientating layer of the substrate, comprising a thin light-shielding layer formed at a periphery of the display electrode for defining an edge of the aperture, and a thick light-shielding layer having an edge positioned on the thin light-shielding layer.

U.S. Patent No. 5,343,066; Issued 8/30/94

Semiconductor Device and Method of Manufacturing

Inventors: Okamoto, Yutaka; Shinguu, Masataka; Yamada, Makoto
Assigned to: Sony Corp., Japan

In a semiconductor device having a thin-film transistor (TFT) in which a gate insulator film and a semiconductor layer are formed on a gate electrode layer, and a portion of the semiconductor layer is connected to a specific gate electrode layer through a contact hole formed in the gate insulator film, a static random access memory is constituted by memory cells in each of which a conductive layer stacked on the upper layer side of the semiconductor layer through an insulator layer is inserted in the contact hole formed in the gate insulator film. ■

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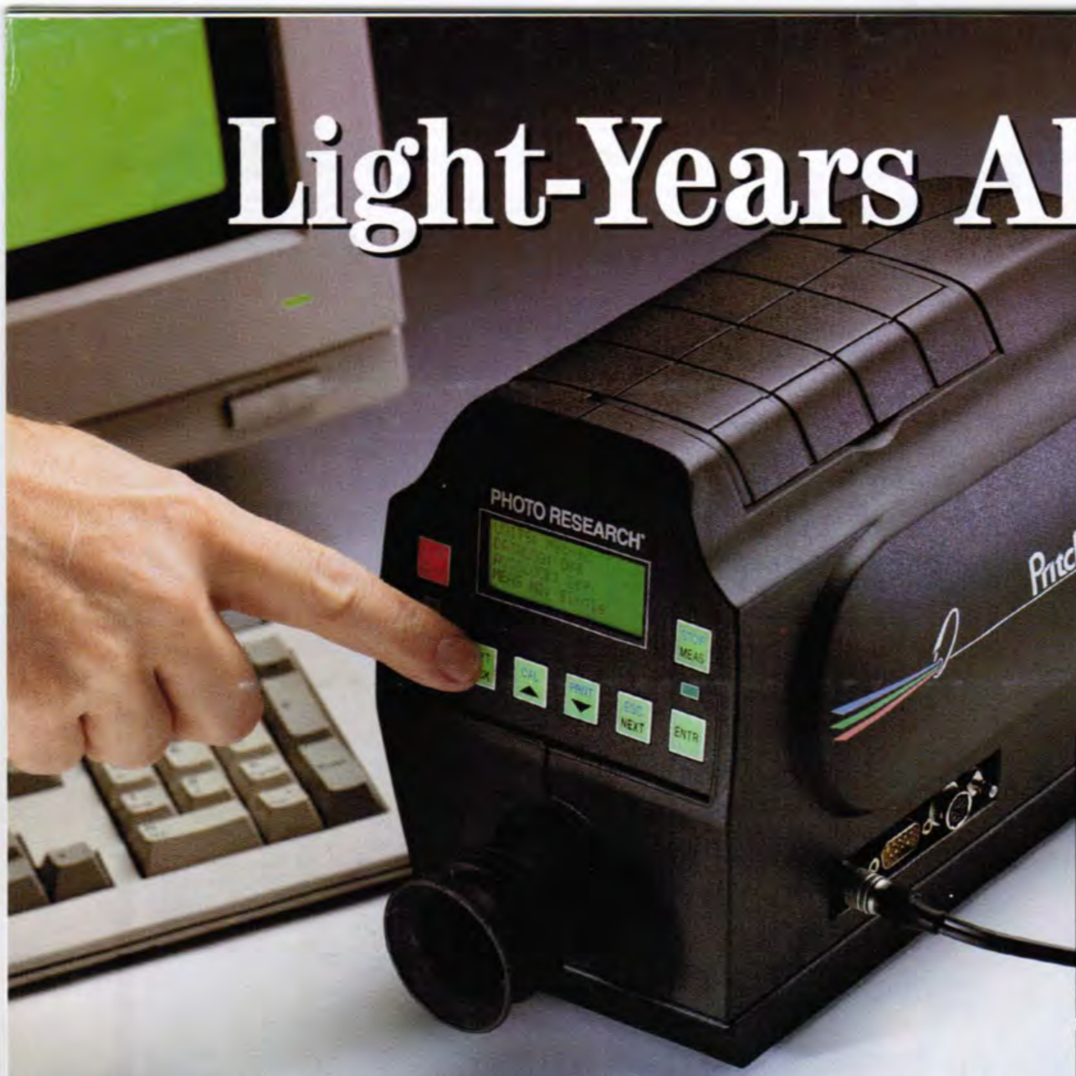

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