Official Monthly Publication of the Society for Information Display

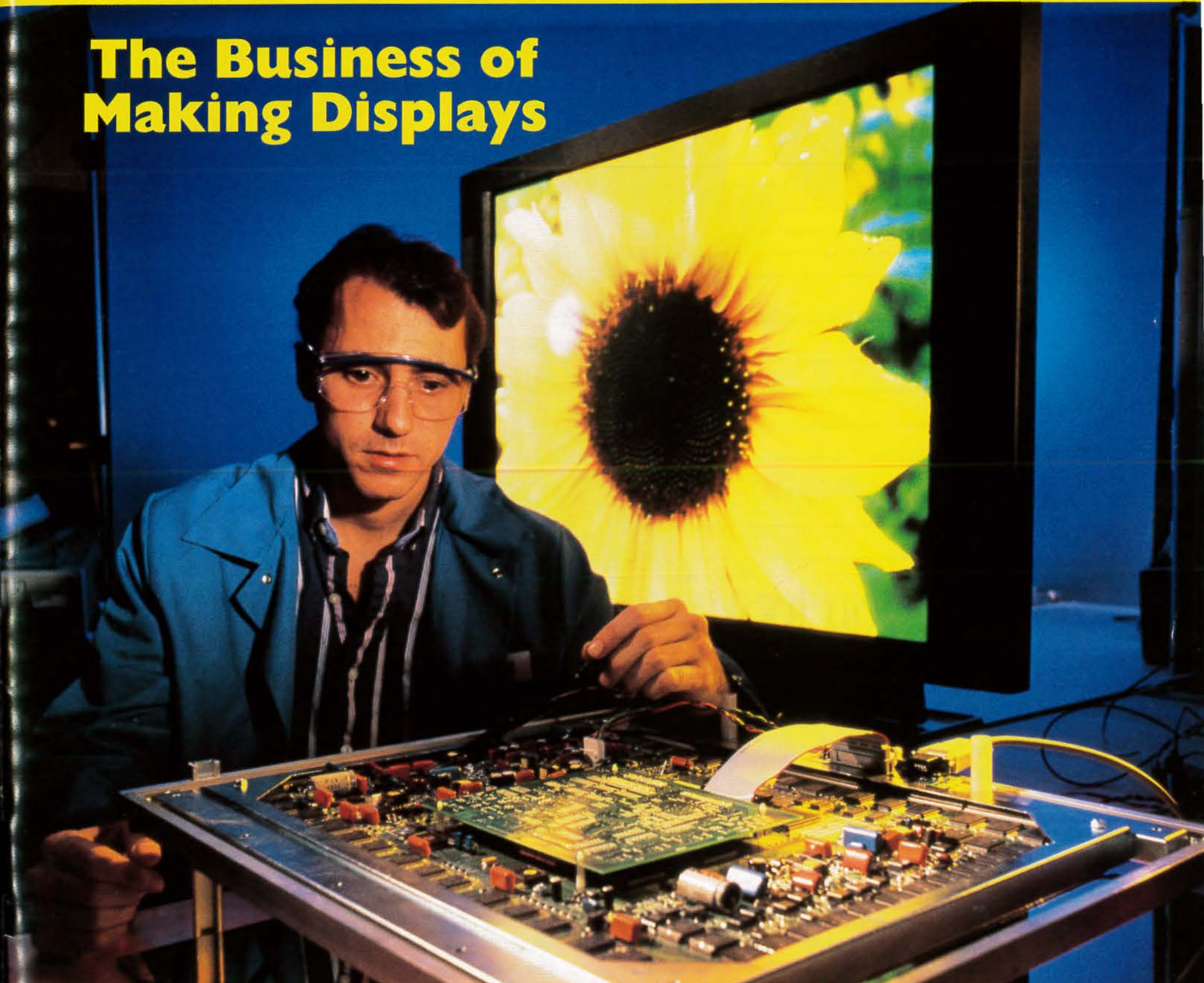
INFORMATION DISPLAY

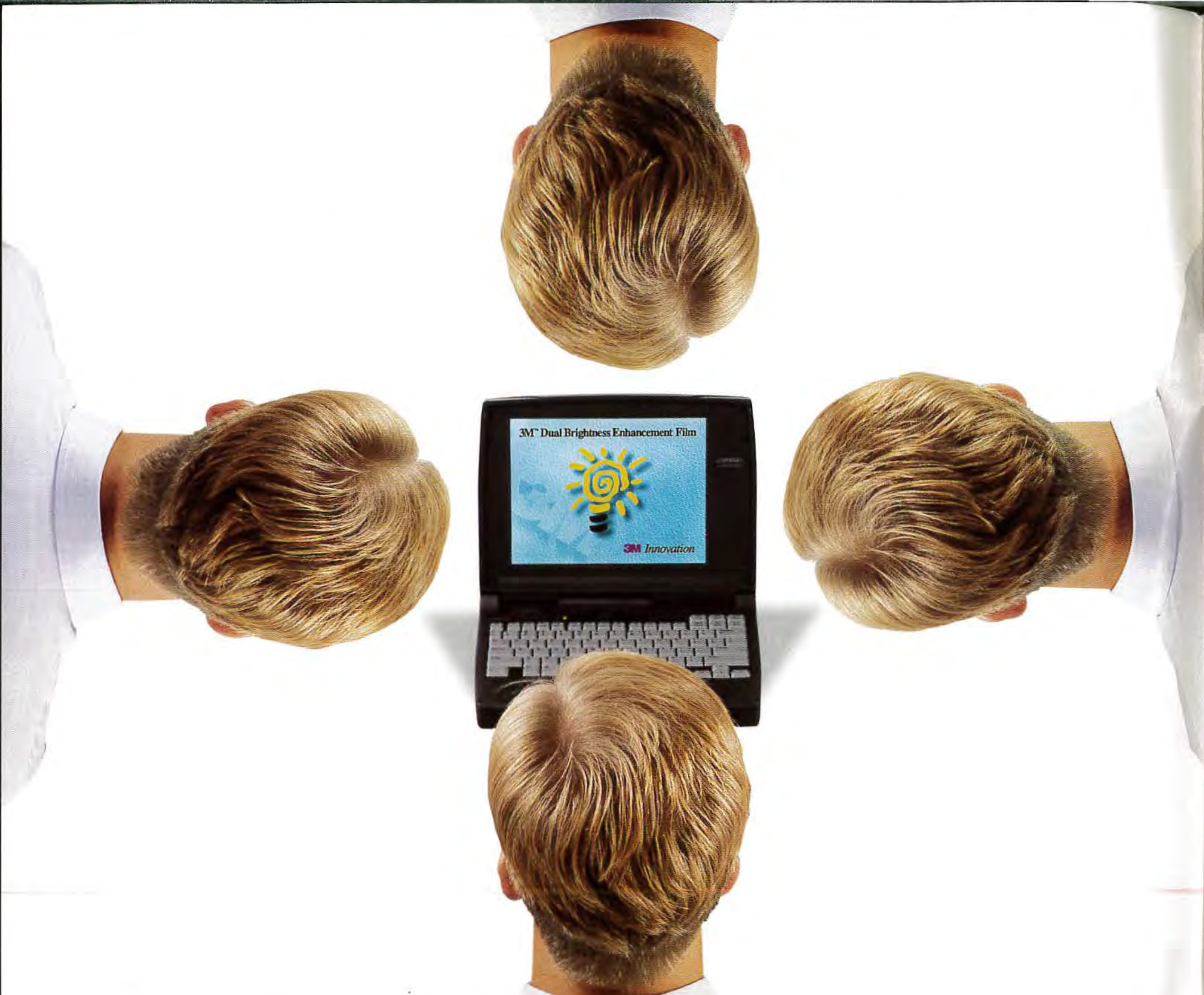
SID

July 1997 – Vol. 13, No. 7

DISPLAY-BUSINESS ISSUE

The Business of Making Displays





Any way you look at it, 3M™ DBEF improves display brightness.

The benefits of 3M Dual Brightness Enhancement Film (DBEF) are truly *dual*. It not only boosts display brightness up to 60%, but it does so over the entire LCD viewing range.

Enhanced screen brightness

With DBEF, you can increase your screen brightness OR translate the brightness into power savings. And by saving power you not only get more time between battery charges, but longer lamp life as well.

What is 3M DBEF? It's actually a thin film reflective polarizer that's placed right behind your LCD. It adds virtually no weight or thickness to the display, yet it's amazingly effective at recycling light otherwise lost to absorption. The wide angle brightness provided by DBEF is perfect for multi-viewer LCD applications such as monitors, TVs, instrumentation and multi-media notebook computers.

Increased power efficiency

Wide viewing angle

For more information on 3M Dual Brightness Enhancement Film — or any of our other 3M™ Optical Enhancement Films — call us at 1-800-328-7098, ext. 1. Any way you look at it, your displays will be better.

Circle no. 10

3M *Innovation*

≡ Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

JULY 1997
VOL. 13, NO. 7

COVER: Analog design engineer Robert Marcotte tests a 21-in. plasma panel at Plasmaco's facility in Highland, New York, while the new 42-in. panel glows cheerily in the background.

Credit: Matsushita Electric Corporation of America

For more on what's coming in *Information Display*, and for other news on information-display technology, check the SID site on the World Wide Web: http://www.sid.org.

Next Month in
Information Display

Industry Directory Issue
- Scanning laser projectors
- Photocathode displays
- MPEG standards
- CeBIT review
- Directory of display industry

INFORMATION DISPLAY (ISSN 0362-0972) is published eleven times a year for the Society for Information Display by Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014; David Slater, Chief Executive Officer; Leonard H. Klein, President; Laura Manganiello, Secretary/Treasurer. EDITORIAL AND BUSINESS OFFICES: Jay Morreale, Managing Editor, Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014; telephone 212/620-3371. Send manuscripts to the attention of the Editor, ID. Director of Sales: Erika Targum, Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014; 212/620-3375. SID HEADQUARTERS, for correspondence on subscriptions and membership: Society for Information Display, 1526 Brookhollow Drive, Suite 82, Santa Ana, CA 92705-5421; telephone 714/545-1526; fax 714/545-1547. SUBSCRIPTIONS: Information Display is distributed without charge to those qualified and to SID members as a benefit of membership (annual dues $55.00). Subscriptions to others: U.S. & Canada: $36.00 one year, $5.00 single copy; elsewhere: $72.00 one year, $6.50 single copy. PRINTED by Sheridan Printing Company, Alpha, NJ 08865. Third-class postage paid at Easton, PA.

The Future Is Now

A scattering of planners, analysts, consultants, and watchers of the display industry have been asking an unsettling question for some time now. As low-temperature polysilicon becomes common, and as more and more of the system electronics is put on the periphery of the display substrate when the display is made – virtually for free – what happens to the value added by the system maker who is integrating the display? It is just this issue that is explored in an excellent article by Robert Ristelhueber in the April issue of *Electronic Business Today.*

Interestingly, Ristelhueber is not writing about displays at all, but about ICs – and the recent trend toward putting more and more of the system on the chip. As Ristelhueber puts it, "The whole electronics industry is now grappling with the question: If the chip becomes the system, why do we need the systems company?" Or if the display becomes the system. A dramatic example: Intel "has grown wealthy selling the brains of the system, while Intel's OEM customers scramble for slim profit margins."

As more and more intellectual property becomes embedded in the silicon, OEMs are scrambling to readjust their strategies. According to Ristelhueber, forward-looking OEMs are

- Keeping internal R&D budgets low and leveraging the R&D of their semiconductor suppliers.
- Focusing most design effort on integrating components and/or differentiating the product with software.
- Outsourcing manufacturing, and sometimes – as with PCs – pushing system assembly into the distribution channel.
- Focusing marketing on branding the product and grabbing consumer mindshare.
- Emphasizing selling through distributors and resellers rather than through direct sales.

Recently, Sham Rayan of AST Computer commented to *Information Display* that 65% of the value of a CRT monitor is in the tube, but 95% of an FPD monitor's value is in the panel – and that's without on-panel integration of system electronics. Can it be that only companies such as Sharp, NEC, and Samsung will be able to sell FPD monitors profitably in the future? Will companies such as Sony have to develop in-house FPD capabilities in order to retain their monitor business? The rapidly changing relationship between chip makers and systems houses may give us some of the answers.

– Ken Werner

Official Monthly Publication of the Society for Information Display
INFORMATION DISPLAY

the display continuum

On the Backslopes of the Technology S-Curve ...

by Aris Silzars

Quite a long time ago, when I was about 11 years old, we lived in a small town in a late-nineteenth-century house with a one-story back addition. A few yards away from this back addition stood a large maple tree. The branches from the tree's canopy spread over the gently sloping roof. From up there, I was sure, one could see clear to the edge of town. I had often climbed part way up into this tree, but each time my parents caught me and told me never to do that again.

However, one day while they had gone on a quick trip to the grocery store, the tempting thrill of climbing up into that tree proved more than I could resist. The climb proved to be easier than I had expected. I made it to the roofline with no problem at all and, with a bit of a stretch, I was onto the roof. Wow, it was great up there! I could indeed see forever. I can still remember my feelings, even these many years later, as similar to the thrill one gets after a tough climb to the top of a mountain - that combination of living at the boundary where human beings are not supposed to be together with being in a beautiful spot.

However, with parents soon to return, all good things had to come to a premature end. So after a few minutes, it was time to face the challenge of getting back down. Unfortunately, through some strange law of perceptual physics, the gap between the house and the tree had suddenly become a chasm. My shaky third attempt to bridge said chasm failed, and I went tumbling down and landed with one arm straddling a flimsy enclosure that I had made for my two pet ducks.

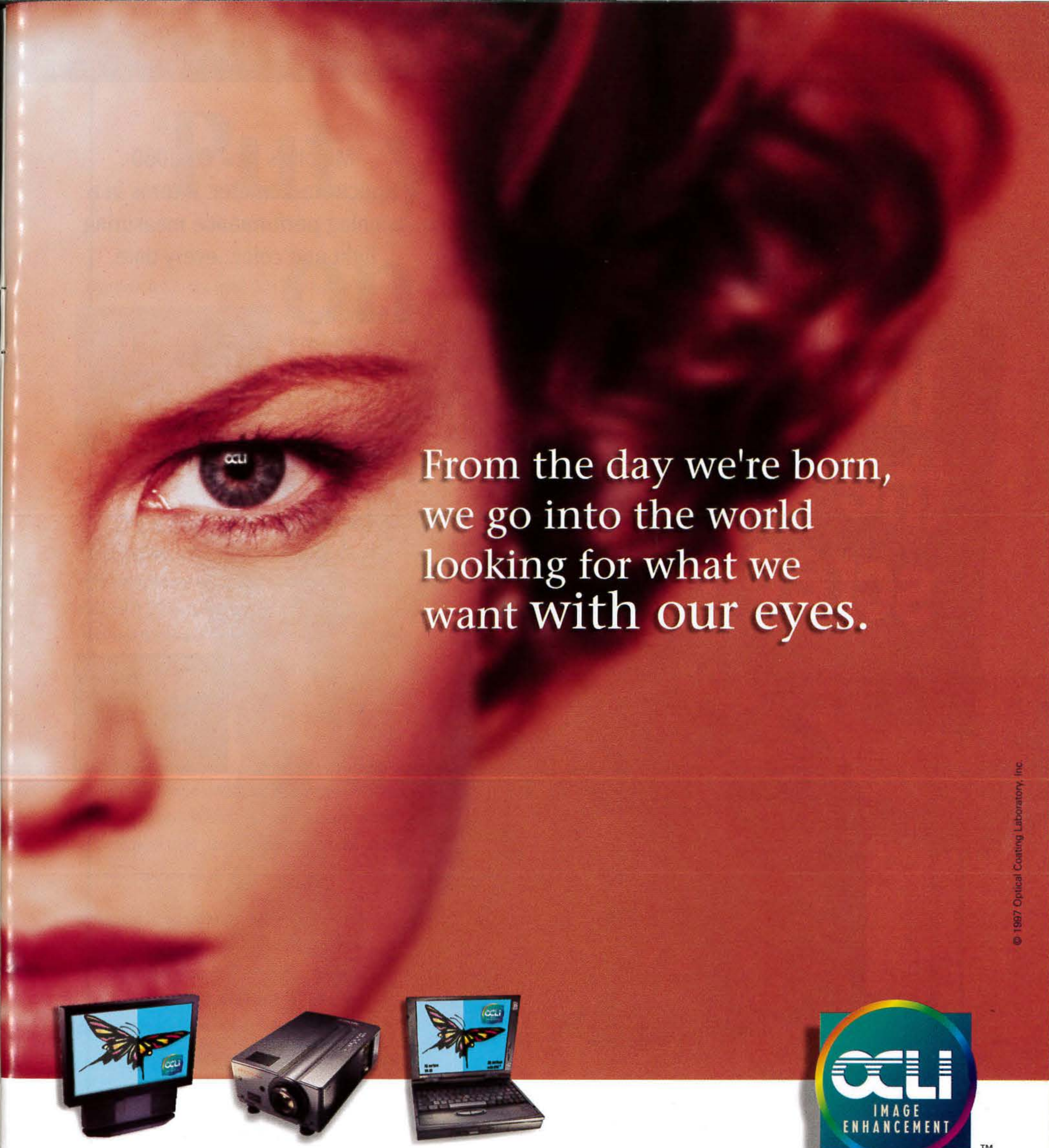
When my parents returned, they found me lying on the family-room sofa with an ugly blue lump under one side of my chin, one very bloody knee, the underside of my arm a nice bright red color, and my face a blanched white from the shock of my quick descent. The "official" story was that I fell off my bike near the front-porch stairs. It was some 25 years later before they heard the real version.

What often happens to new technologies, start-up companies, and even large mature businesses is not unlike my climb onto the rooftop, followed by my dramatic and unplanned descent. The development of a technology business is much like my climb to see the great view. There's that early period of anticipation, the period of rapid growth, followed by an all-too-brief time to enjoy the view. Then comes the uncomfortable period of ***now what?*** Most business texts, high-priced seminars, and MBA programs only deal with the growth and maturing period, typically called the "technology S-curve." What I haven't been able to find is much in the way of guidance regarding that scary phase of getting back down off the roof - managing that time of decline and obsolescence. It seems to me that most large, well-established companies today are challenged far more by this often urgent survival issue than by how to introduce something new. (The new stuff is easy - you don't even need to develop it yourself, you do an "acquisition.")

Before looking at some display-related examples and how they have gone up and down this technology S-curve, let's define the four distinct stages that constitute the process of technology birth, growth, maturity, and decline.

continued on page 30

Society for Information Display
1526 Brookhollow Drive, Suite 82
Santa Ana, CA 92705-5421
714/545-1526, fax -1547
e-mail: socforinfodisplay@mcimail.com


From the day we're born,
we go into the world
looking for what we
want with our eyes.
OCLI
IMAGE
ENHANCEMENT
TM
© 1997 Optical Coating Laboratory, Inc.

Minolta CS-1000 Spectroradiometer

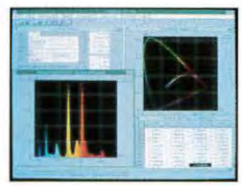
Minolta's new CS-1000 Spectroradiometer. It turns in a winning performance measuring light and color...every time.

Now you can get CRT, LCD, lamp and LED testing right on the first "take."

The CS-1000 offers the perfect combination of absolute accuracy, short-term repeatability and high speed for dozens of applications.

Performs solo or with a PC.

Lightweight and portable, the CS-1000 can measure luminance, color and relative color temperature either as a stand-alone unit or connected to a PC. It includes user-friendly, flexible Windows™-based software that lets you easily display, calculate, print and store measured results.



The CS-1000 utilizes autosynchronization for greater accuracy while sensor cooling improves the S/N ratio for precise low-luminance measurement. Plus, its minimal polarization error is ideal for measuring LCDs.

Minolta. The world leader in optical technology brings you another star performer: the CS-1000 Spectroradiometer. **For more information, call toll free 1-888-ISD-COLOR today, or check out our Website at www.minoltausa.com**

MINOLTA

INSTRUMENT SYSTEMS DIVISION

ISO 9001 CERTIFIED

Circle no. 13

Put your CRT on a Diet

Nutritional Facts

Serving size	14.5" Diagonal
Serving per container	1
CTX PanoView 745 TFT LCD Monitor	
Description	Desktop
Pixels	1024 x 768 XGA
Colors	16.7 Million
Brightness (typical)	200 nit
Power Consumption	30W
Multiscan	Yes
PC/Mac Compatible	Yes
Weight	12.1 lbs. (w/ stand)
Dimensions (WxHxD)	15.2"x15"x7.1" (w/ stand)

Watching what you put on your desktop? Choose the future in high performance LCD flat panel display monitors, the CTX PanoView 745. Featuring a 1 1/2" ultra thin space saving design, this compact high resolution active matrix monitor can fit anywhere. Direct analog RGB input makes set up to your PC or Mac easy.

CTX Opto is a world leader in LCD products with a complete line of TFT LCD color monitors.

Call us today toll free – **1-888-289-6786** or visit our website **www.ctxopto.com.**

PanoView 600MF, LCD monitor module ready to integrate into equipment design.

PanoView 745

CTX

CTX Opto, Inc.

1-888-289-6786

The Business Case for Motorola's Flat-Panel-Display Division

An optimistic Motorola takes a strategic look at the display universe and invests heavily in FED's promise.

by Thomas L. Credelle and Barry J. Moehring

WHILE THE FLAT-PANEL-DISPLAY (FPD) industry debates the potential of various new display technologies, Motorola has made a commitment to let the marketplace determine the future of field-emission displays (FEDs). In fact, the company is so confident about the future of FEDs, it has formed a new business division - the Flat Panel Display Division - built a new 275,000-ft.^{2} pilot production facility, and invested more than $100 million in this rapidly emerging commercial technology.

The catalyst for entering the FPD market was the basic vision of the corporation, and particularly that of Bob Galvin, who was the CEO of Motorola for nearly 40 years. (His father Paul founded the company; his son Chris is the current CEO.) Motorola has a long history of driving new markets with revolutionary innovations and gutsy investment decision-making. In the 1950s, the company established in Phoenix one of the largest integrated-circuit factories in the world, despite the newness and skepticism that surrounded the solid-state-electronics market.

***Thomas L. Credelle** is Director of Marketing for the Motorola Flat Panel Display Division, 7700 S. River Parkway, Tempe, AZ 85284; telephone 602/755-5511, fax 602/755-5502. He has more than 25 years' experience in FPD technology development and marketing, and is a Fellow of the Society for Information Display. **Barry J. Moehring** is the Manager of Marketing and Communications for the Flat Panel Display Division.*

In the 1970s, while the rest of the world was improving wired telephone communications, Motorola chose to develop wireless and cellular communications. In the 1980s, even while Motorola led the world in cellular technology, it led in the creation of Iridium™, a consortium that would take wireless to the next level: a constellation of dozens of satellites that could instantly send voice or data anywhere in the world on demand.

These were not intellectual laboratory exercises. Motorola developed these ideas - and invested significant amounts of capital - with the intention of bringing to market real products that would enable people to communicate in more ways, in more locations, and with more freedom than ever before. In all of these examples, there was speculation about the technology or about Motorola's ability to manufacture and bring these products to market.

It is in this same vein that Motorola has launched its entry into the FPD business by pursuing FED technology. Having established a leadership role in voice and data communications, Motorola envisioned developing another leadership position in the third leg of the electronic communications triad: the electronic visual display.

The display has become the platform upon which entire applications have been developed. Advances in LCD technology, for example, have been the driving force in the booming laptop market. As a result, many laptop manufacturers have become display manufacturers in order to leverage this market-driving technology into their products.

Just as LCDs drove laptop development, newer and better display technology will drive many more applications in the future. Such applications as advanced multimedia software, video teleconferencing, and the convergence of broadcast, Internet, and computing uses will require electronic displays that are thin, lightweight, portable, rugged, and low in power consumption. But these displays must also be video- and HDTV-capable, and must offer outstanding picture quality with bright, colorful images.

Motorola's vision is to be the market leader with a new color FPD based on field-emissive technology. This will be an FPD that can meet all current and future demands, and therefore play a vital role in the development of new applications - some of which will ultimately be developed as Motorola products (Fig. 1).

Vision is one thing; execution is something else entirely. To make its vision a reality, Motorola had to understand four primary factors before entering the FPD business:

- What are the real market opportunities for new display technologies in the future, and do these opportunities exist for future Motorola products, as well as other products?
- Are Motorola's built-in research, development, and manufacturing capabilities complementary to the capabilities required in the FPD business?

0362-0972/97/1307-010$1.00 + .00 © SID 1997

- What are the hard market realities of the display business, and is there a market for a new technology?
- Can FED technology be the next major innovation in displays, and can Motorola deliver on this potential?

FPD Opportunities

The new generation of display opportunities includes a rapidly growing demand for high-quality color displays of all types, but particularly FPDs; an expanding base of suitable applications for color flat panels; and a potentially large and diverse internal market among other Motorola businesses.

Projections for the future of FPDs vary. Generally, however, the growth is expected to carry FPDs from a market of roughly $12 billion today to more than $30 billion shortly after the turn of the century (Fig. 2). This growth will occur in existing and new applications, and will be driven both by current display technologies and by new technologies, such as FEDs, that have not yet been introduced to the market.

Potential applications for FED technology include desktop monitors, notebook computers, televisions, medical and test equipment, and a variety of displays for transportation devices such as seat-back entertainment, global positioning systems, and primary driver instruments. Ultimately, several of these applications may converge, creating demand for an "information appliance" that uses an electronic display as its primary human interface. Indeed, with the nearly insatiable demand for information in today's society, electronic displays of many kinds will become the primary vehicle for communications, information retrieval, and entertainment. This demand will not only occur at home but will be universal across a variety of modes and locations, further intensifying the need for thin, lightweight, and low-power displays.

Within Motorola itself, there are a number of products already in the computing and communications market that require a display for customer use, and future products will require even more advanced display technology.

***Fig. 1:** Motorola believes FED technology will enable or dramatically improve a wide variety of display-centric applications. Pictured here, from top to bottom: a wide-angle flat-panel travel entertainment center; a notebook PC that works in arctic temperatures without a heater; a document receiver/reader that works in tropical temperatures; and a portable medical terminal with high-quality display that permits group viewing and consultation.*

Motorola's Capabilities

Motorola's capabilities stem from its position as one of the top five semiconductor manufacturers in the world, which allows the company to exploit the similarities between the semiconductor and FPD industries. For example, both the semiconductor and FPD industries rely on photolithographic tooling and very similar deposition, patterning, and cleaning toolsets. This is particularly true for the manufacture of FEDs.

Motorola also has a long history of manufacturing capability for a wide variety of consumer products, from radios and televisions in previous decades to advanced telecommunications, satellite, and computer products today. In addition, Motorola has the capital resources to fund a new display start-up over the course of time needed to move from research and development to manufacturing and, ultimately, to market.

Market Realities

As in any risk analysis, Motorola had to weigh several key market realities against the opportunities presented by the FPD market and the company's inherent capabilities:

- LCD technology remains dominant for most flat-panel applications; displacing LCDs in some applications will prove to be very difficult.
- Other emerging technologies, such as plasma, are beginning to have significant impact on the market.
- LCDs are now a mature technology, with dozens of major and hundreds of minor suppliers worldwide.
- LCD technology has some limitations in the areas of brightness, operating temperatures, viewing angles, and power consumption.

Deciding to Move Forward

Technology Choices. After analyzing several potential businesses and carefully examining customer needs for FPDs, Motorola decided to develop a new type of display that could offer significant benefits over existing technologies. These existing technologies, most notably LCDs, have tremendous advantages in the current display market because of their technological maturity, widespread acceptance, and the economies of scale developed through extensive capital investment and R&D. Only a few technologies could contend with the formidable realities presented by LCDs. But one technology in particular, field emission, has by far the most potential not only to compete with LCDs but also to drive new applications for which LCDs are not particularly suited.

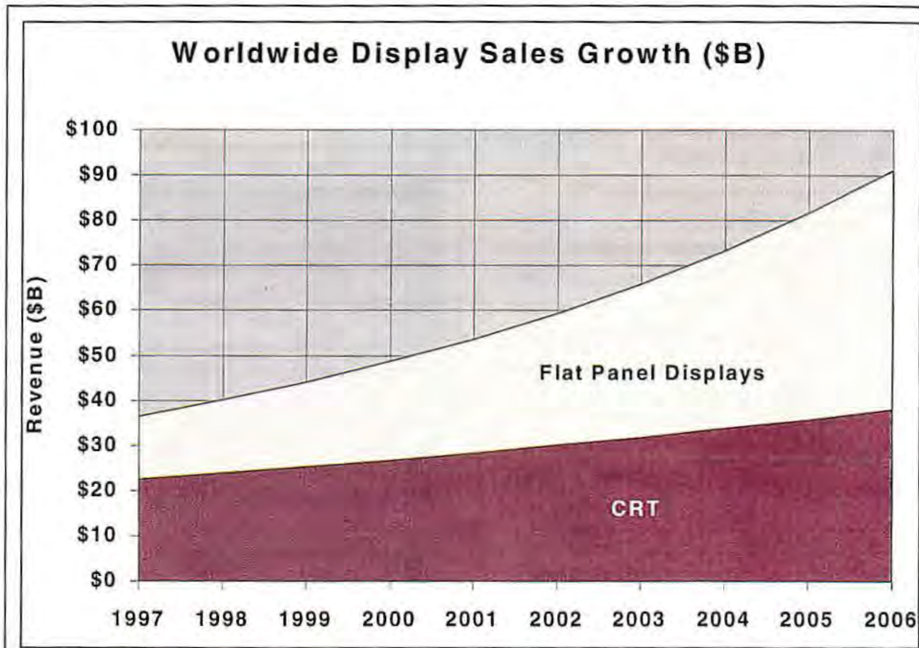


Fig. 2: The FPD market is expected to grow from roughly $12 billion today to more than $30 billion shortly after the turn of the century, and to surpass the market for CRTs by 2003. (Data from Stanford Resources, 1997; Motorola Flat Panel Display Marketing Dept.)

FEDs, sometimes referred to as flat or thin cathode-ray tubes (CRTs), are a new class of FPDs that combine the best performance features of CRTs with the thinness and low power of the best LCDs. While there is no standard form for FEDs, all include two sheets of glass, one with a uniformly distributed source of electrons which operates at room temperature and the other with a phosphor screen which emits light under electron bombardment. To achieve a thin package, the electron source and the phosphor screen are spaced closely together, typically less than 1 mm, and are sealed together in a vacuum tube. To achieve light weight, an integral spacer system is used to maintain the close spacing between the two glass plates. The spacers must be strong enough to support atmospheric pressure but small enough to be invisible.

In the Motorola version of the FED, the electron source comprises millions of tiny tips - over 50 million tips in a 5-in.-diagonal display - a simple triode addressing structure, and a patterned RGB color phosphor screen using standard CRT phosphors that operate at high efficiency and achieve excellent color rendition.

FED technology has the potential to drive new market opportunities with its mixture of high-quality viewing, brighter and crisper images, lower power requirements, ruggedness for outdoor use in various climates, and viewing angles as wide as those currently offered by CRTs. Essentially, FEDs offer the potential of having a picture quality equal or greater to that of the best CRTs currently available on the market, but in a form factor that is very similar to today's thinnest and lightest LCDs. Even while LCDs remain a dominant technology, FEDs will have the ability to be a key differentiator for many products because of the technology's inherent advantages over LCDs in several areas. Early adopters of this new technology will ultimately hold a key advantage in the struggle to gain share in their markets.

Besides offering performance advantages, FED technology may offer manufacturing advantages as well. When FEDs are manufactured in large volume, the conventional wisdom indicates they will be less expensive to manufacture than LCDs and other display technologies. This advantage is yet to be proved, as FEDs have not been manufactured in large numbers. Motorola hopes to be among the first companies to prove the manufacturing cost-advantage theorem.

Motorola is not alone in recognizing these advantages. More than a dozen other companies around the world are also pursuing some type of FED program, and the efforts are increasing each year.

Business Choices. Choosing a technology path is only part of the decision-making process; there are also many choices for business development. Although the approach entailed substantial financial risk, Motorola decided it was not going to just engage in FED-prototype development or small-scale specialty manufacturing. Motorola would bring these revolutionary displays to large-scale markets.

In 1995 Motorola committed the resources necessary to form a new stand-alone division, the Flat Panel Display Division, and to build a major research and development and pilot production facility in Tempe, Arizona. The 275,000-ft.^{2} facility represents an initial commitment of better than $100 million to bring FEDs to market (Fig. 3).

The pilot manufacturing facility, which can produce small to medium size displays, will generate initial revenues for Motorola's Flat Panel Display Division. Just as important, it will be the proving ground for the advanced manufacturing processes to be used in the first large-scale FED-manufacturing facility, which will produce larger displays and much higher volumes. Perhaps most importantly, Motorola's facility will provide enough capacity to make inroads in some major initial market segments among early adopters of new technology, providing credibility for this new display technology.

Business success - especially for new technology breakthroughs - must be established with broad market acceptance, typically through joint development with other major players in the display industry. Therefore, Motorola joined the FED Alliance with PixTech, Futaba, and Raytheon to speed the development of FED technology, as well as to gain valuable insight into manufacturing challenges. The alliance has benefited all participants by advancing the technology out of the lab and onto the factory floor.

Motorola Flat Panel Display Division

Fig. 3: The recently completed Motorola Flat Panel Display Division's new 275,000-ft.^{2} facility in Tempe, Arizona, contains more than 50,000 ft.^{2} of clean manufacturing space.

The FED Promise Fulfilled. FED technology holds the promise of equaling and perhaps surpassing today's best CRT picture quality, but in a form factor that may soon be thinner than today's LCDs. What does that mean for the millions of people who will look at FPDs in the future? Plenty. A wide variety of medical, test, and analytical instruments will be smaller, lighter, and easier to view, thus aiding health-care professionals, factory floor managers, and scientists.

FED technology's superior ability to display video, graphics, text, and multimedia applications will provide more entertainment and information choices for airline, rail, and auto passengers than are available today. Wide viewing angles will allow greater use of laptop and handheld computing devices, especially for collaborative computing and entertainment. No longer will display viewers have to look directly at their screen in order to use their electronic devices. Instead, FEDs will allow several people to look at an FPD simultaneously.

High brightness and rugged design will drive new scientific and medical applications. It will be possible to use systems for these applications outdoors in bright sunlight and in hot desert locations - and also at night in cold winter climates.

Ultimately, the high resolution, light weight, and outstanding brightness offered by FEDs will help drive the convergence of a variety of today's technologies. Computer monitors and televisions will unite in large-screen wall-hanging information appliances that will incorporate home security and control systems, teleconferencing, telecommuting, and a host of other uses.

Where Are We Now?

Motorola expects its decision to manufacture FEDs - like its gutsy decisions of the past - to delight its customers with ever better communications technology, this time with breakthrough displays. Motorola intends its FPDs to enable people to gain more information, have more fun, and be more productive in more places than ever before. But when? At about the time this article is published, Motorola will have demonstrated small color FED prototypes and will be supplying engineering samples from their new pilot production facility by the end of the year. ■

opinion

The Phony War

Some say the coming battle between FPDs and CRTs will be the display equivalent of World War III, but there are already signs of fraternization on the battlefield.

by Tei Iki

THE DISPLAY BUSINESS is a service industry that delivers information to the user through the best possible human/machine interface. The value of a display is therefore principally determined by a fundamental performance requirement, viewability, which consists of factors such as legibility, contrast, luminance, and color. These primary parameters affect the efficiency of the interface and enhance information transfer.

In addition to the primary performance parameters, there are secondary parameters, such as ease of use, size, bulk, and access, which add intrinsic value. Making a business of displays occurs only when our customer's perceived value exceeds our cost of providing the total value, *i.e.*, the value of the display's viewability plus the display's intrinsic value.

From this point of view, all displays are flat-panel displays (FPDs). The user is only interested in the image on the flat display screen. Everything else is just the nuts and bolts that put the image where the user can make use of it.

So, I think the fashionable view of seeing the evolution of electronic displays as a Herculean battle between the CRT and all other technologies is mistaken. There will be competition, of course, and a lot of continuing coexistence. But the most significant relationships are likely to be symbiosis and even cross-fertilization.

I would like to prove the truth of this outrageous statement by briefly reviewing the business status of CRT-based displays.

The CRT-based Display Business

On the strong foundation of picture-tube sales to the TV industry, CRT manufacturers have built a growing business in desktop PC monitors. Currently, the total worldwide CRT-display market is 220 million units, valued at almost $20 billion. This business is expected to see steady growth well past the year 2000 (Figs. 1 and 2). The predominant application of CRT displays will continue to be color TV, which will represent more than 60% of the market, according to a Stanford Resources market survey.

CRTs are currently used for both consumer and business/commercial applications, and are expected to show steady growth from 1996's 220 million units to 258 million units by the year 2000. In the U.S., the most popular items are the 25-in. color TV and the 15-in. color monitor for PCs, which can be purchased readily for between $250 and $500,

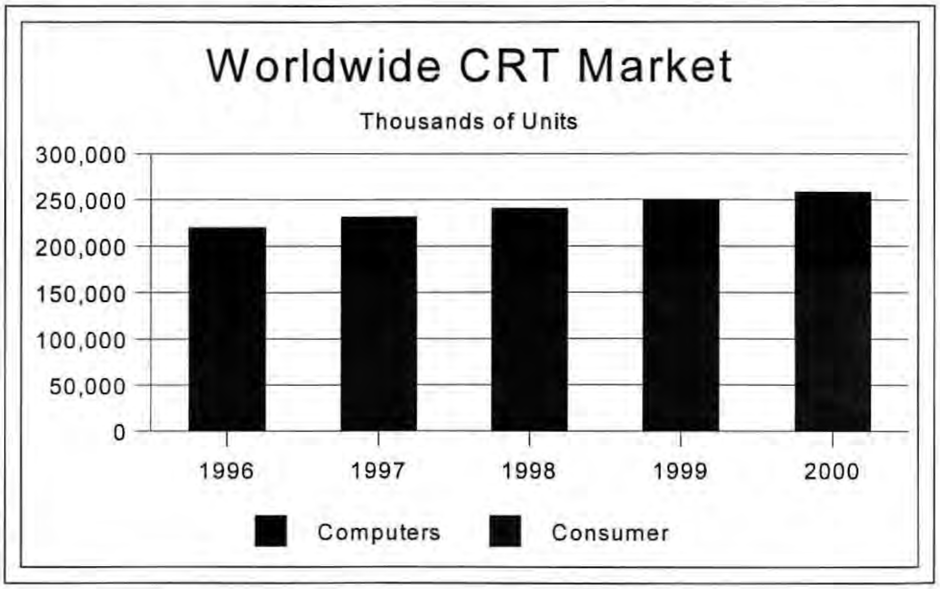


Fig. 1: The worldwide market for CRTs is expected to grow from 220 million units in 1996 to 258 million units in 2000. (Data courtesy of Stanford Resources)

***Tei Iki** is Senior Vice President of Sony Display Systems, Sony Electronics, Inc., Bldg. 5, 16450 W. Bernardo Dr., San Diego, CA 92127; telephone 619/673-2803, fax 619/451-8675. He is responsible for the company's display business and for supplying monitors to various computer manufacturers. This article was adapted from the author's address at the USDC Business Conference at Display Works 97 in January.*

0362-0972/97/1307-014$1.00 + .00 © SID 1997

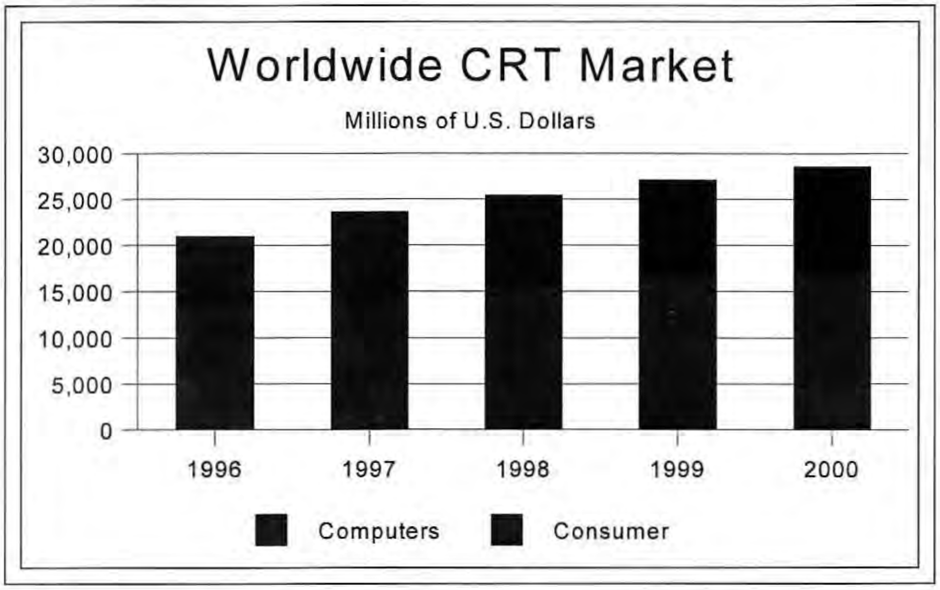


Fig. 2: The worldwide market for CRTs is expected to grow from 22 billion U.S. dollars in 1996 to 28.6 billion U.S. dollars in 2000. (Data courtesy of Stanford Resources)

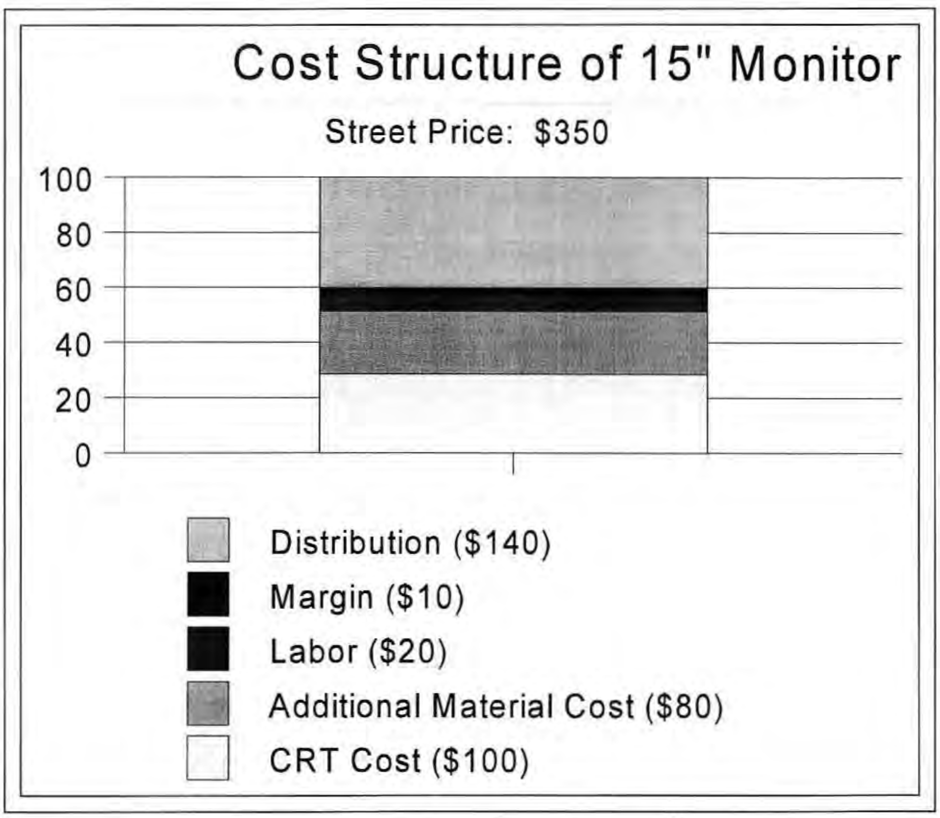


Fig. 3: In the cost structure of a 15-in. CRT monitor, over 85% of the manufacturing cost is in the materials cost. (Data: Sony Corp)

depending on the brand and features. As time goes on, we see constant incremental improvements in performance and technology to meet the ever-increasing expectation of users. Larger screen size, higher resolution for Windows™ applications, and higher luminance for video are some of the recent examples.

The increase in average unit price we are experiencing is a consequence of this growing screen size and the increasing ratio of PC monitors to TV receivers. For a particular product and screen size, prices are steadily decreasing. Even with generally decreasing prices, the $200 25-in. TV set is unique to the U.S. - the most competitive consumer-electronics market in the world. But value will continue to increase. The VGA monitor with 4:3 aspect ratio is already morphing into a 16:9 hi-res monitor of larger size at the same price.

Globally, the TV and computer businesses are strong. TV sales are growing in India, China, Russia, and Latin America. Computer sales are particularly strong in Latin America, Asia, the Pacific Rim, and Eastern Europe.

The annual U.S. market stands at about 22 million TV receivers and 25 million computer monitors. In the last couple of years, we have seen a major change in the market: for the first time, revenues from computer monitors exceeded that from TV receivers.

Synergy

Flat-panel displays have experienced their most remarkable success in the laptop-computer market. This is where I believe synergy can be achieved. In the U.S. in 1996, we are seeing sales of approximately 6 million FPDs for portable computers, in addition to the sales of those 21 million units of color-CRT monitors. My colleagues tell me that about 300,000 people bought CRT color monitors last year - many of them 17-in.-diagonal models - in conjunction with the purchase of laptop computers. (As a result, our monitor sales were higher than we had projected.)

The CRT color-monitor business benefits from being based on a mature but still-developing technology that offers constant cost/performance improvements and provides a moving standard for other display systems. The manufacturing efficiencies of CRT displays have grown to such an extent that, for most makers, the materials cost of the displays

opinion

takes up more than 80% of the total manufacturing cost.

The typical monitor has between 900 and 1200 electronic parts, 90% of them made in the Pacific Rim, and there are huge, very competitive supplier industries – such as electronic components, semiconductors, plastics, glass, and metals – vying for a share of this $20 billion business. The result is a very tight cost structure.

To see just how tight, let's look at the cost structure for a typical 15-in. CRT computer monitor in 1996 (Fig. 3). The typical 15-in. monitor currently has a retail price of $350–400. Since distribution costs normally represent 35–40% of the final price, a manufacturer needs to be able to cover all of its costs and profit at $210. That's a competitive market if ever there was one.

Although the materials cost shown in Fig. 3 is about 90% of the total manufacturing cost, it should normally be about 85%. With 85% of the manufacturing cost in materials, labor is not a major cost component. Clearly, materials cost is the key to success, and the well-developed infrastructure is what makes it possible to compete.

Creating a Universal Display

I don't think FPD makers want to compete with CRTs. Why would anybody in their right mind want to get into this kind of business? And up until now, FPD makers have maintained their sanity by sticking to applications where users are willing to pay a premium for special characteristics. That's a good way to create a business but, ultimately, that doesn't get you into the broadest applications.

What people want is a flat display that performs like a CRT for a CRT price, and we're a long way from that. According to Stanford Resources, the price ratio between an LCD monitor and an equivalent 15-in. CRT monitor is about 3:1. How do we get to the display that people want?

I think you have to make things to innovate. In the competitive monitor environment, true adaptation of the FPD will come not only through improved display quality – as we are seeing today – but also through achievement of a manufacturing synergy created by innovation or modification using the existing supplier infrastructure to offer better cost/performance for a broad-based display market.

Thus, over the next 5–10 years, the CRT is far from dead despite the enhanced competition. But the growth of flat-panel technology is so significant that investments in and understanding of both technologies is required to be a primary player in the display business.

With this understanding, we can offer a new generation of display products by

- Using the current infrastructure, including semiconductors.
- Focusing on manufacturing, cost, and design. (Although we are very good at preaching that gospel, we don't necessarily practice it.)
- Integrating CRT and FPD technologies to create the exciting new products our customers will want to buy.

So let us cease this talking of battles between FPDs and CRTs. If we are to prosper, we must focus our energies on synergy, not conquest. ■

Your image... it's everything

In today's world, selecting suppliers you can count on is a must. And when it comes to monochrome CRT's, high resolution displays, and contract assembly, only one company can provide the technology to meet your total requirements... Clinton Electronics.

There's much more to Clintons performance and total value than meets the eye.

With over a million possible ***CRT*** configurations ranging from 3" - 23", no one offers a more extensive selection of phosphors and mounting systems than Clinton. In addition to consistent quality, on-time delivery and technical support, we guarantee the quality of the final image.

Clinton also applies it's display technology to the design and manufacturing of ***high resolution monitors.*** These variable frequency, microprocessor controlled 19", 20" and 21" monitors are the most flexible monitors, continually setting industry standards for image, quality and readability.

We can support your company with ***contract assembly*** programs, using a flexible work cell technology center which can handle everything from component assembly to full turn key production. Tap into Clinton expertise in engineering, manufacturing, material sourcing, plus agency testing and approvals.

If you are planning a new product line, reengineering an existing system, or considering a make-vs-buy scenario, we can help you determine the best solution. Contact our specialists today for a review of your requirements.

CLINTON ELECTRONICS... THE COMPLETE PICTURE.

Clinton Electronics Corporation
6701 Clinton Road Rockford, Il 61111
815.633.1444 Fax: 815.633.8712
Website: http://www.cec-displays.com
E-Mail: 105503.2223

Circle no. 17

DTI: Lessons from a Successful Joint Venture

Many believed it couldn't be done, but hard work and a bold approach have made the IBM-Toshiba joint LCD venture a remarkable success.

by Jim McGroddy

A LITTLE OVER 10 YEARS AGO, on the strength of its extensive display R&D experience, executives at IBM foresaw the likely importance to the computer industry of large high-quality active-matrix liquid-crystal displays (AMLCDs). The company's desire to get into the AMLCD business was tempered by, among other things, its lack of high-volume LCD-manufacturing experience.

Executives at Toshiba had a similar vision. Toshiba was successfully mass-producing small LCDs, but the company's ambitions were tempered by its lack of large-screen experience. On the basis of their common goal and complementary strengths, the research units of the companies started doing joint R&D in 1986.

In 1989, IBM and Toshiba created Display Technology, Inc. (DTI), and began construction of a plant in Himeji, Japan. Three years later, DTI was the world's second-largest producer of AMLCDs. In 1996, DTI produced over 2 million panels.

Jim McGroddy *retired from IBM at the end of 1996 as Senior VP of Research and Special Advisor to the Chairman. He is currently an advisor to several government agencies and serves on a number of National Research Council panels. He is a member of the U.S. National Academy of Engineering and is Chairman of the Board of Integrated Surgical Systems, Sacramento, California. This article was developed from his keynote address at Display Works 97 in San Jose, California. He can be reached at 914/273-2499; fax 914/273-1809; e-mail: mcgroddy@advanced.org.*

National

Fig. 1: *DTI was founded with the belief that AMLCD technology would start with relatively small displays, such as this one for a c. 1986 3-in. TFT-LCD TV set, and "trickle up" to bigger and more expensive displays. [Photo from S. Tanaka* et al., National Technical Report *33/1, 64-75 (1987)]*

0362-0972/97/1307-018$1.00 + .00 © SID 1997

DTI's success is based, in part, on a disciplined view of what the enterprise should do. As a business strategy, the company's functions are strictly limited to late-stage display-process development and the design and manufacture of the active-matrix display cells themselves. DTI does not produce the finished display unit, and so, for example, it does not attach drivers or add backlights.

Good Fences Make Good Neighbors

A line from a poem by Robert Frost says, "Good fences make good neighbors." IBM's and Toshiba's effective relationship is based in part on the fact that the terms of that relationship are very clearly defined. Production output is divided equally between IBM and Toshiba. Both companies separately sell DTI-made displays into OEM markets, as well as using the displays in their own products. From IBM's perspective, selling to OEMs keeps the company in touch with market needs, as well as balancing demand/supply. The two companies cooperate fully in doing the research and development to support the joint venture, IBM in Yorktown Heights, New York, and in Japan, and Toshiba in Japan.

The Himeji plant, in western Japan near Kobe, was originally built with a Phase-1 production line; a Phase-2 line was added subsequently. A Phase-3 line and a color-filter manufacturing facility were later added at a converted IBM semiconductor plant in Yasu.

Trickling Up

Ten years ago, the common view was that most high-technology products start off in high-end applications and trickle down to less demanding ones, with prices decreasing and production volumes increasing as time goes on. At IBM 10 years ago, we believed that thin-film-transistor LCDs (TFT-LCDs) would be a "trickle-up" technology, with initial products being relatively small and inexpensive, such as pocket television sets (Fig. 1), and later ones being larger and more expensive as manufacturing expertise and substrate size increased.

That led us to Toshiba, with its small-display manufacturing expertise. Other aspects of a joint venture that were attractive to IBM at the time were an interest in seeing up close how a successful Japanese company introduced technology and a desire to take advantage of Japan's cost of capital, which was very low at the time.

These were IBM's initial motivations for wanting to do business with Toshiba, but joint ventures were not part of IBM's culture at the time. There were many skeptics, both internal and external.

Early Success, but Not Effortless

Despite the skepticism and the cultural leap, the joint venture with Toshiba was successful from the beginning. Early prototype units made on a cobbled-together pilot line at Toshiba's Shinsugita plant worked right off the bat. Then, a more refined pilot line at an IBM facility produced excellent large prototypes. It wasn't just that the prototype manufacturing processes were successful - more importantly, the interpersonal relationships worked very well at every level.

An essential element of DTI's success was that both Toshiba and IBM had an absolutely common goal: the manufacture of large high-quality AMLCDs. Commonality of goals is, in my experience, essential to the success of a joint enterprise. Many joint enterprises have been founded on the seemingly logical foundation of the partners having complementary goals - for example, one partner doing the software and the other doing the hardware, with the assumption that both will win. Such arrangements, however, often fail because the world evolves in a way that favors one partner while putting the other under tremendous pressure. The partners in DTI had a common goal, and they did the work that was needed to make their relationship work.

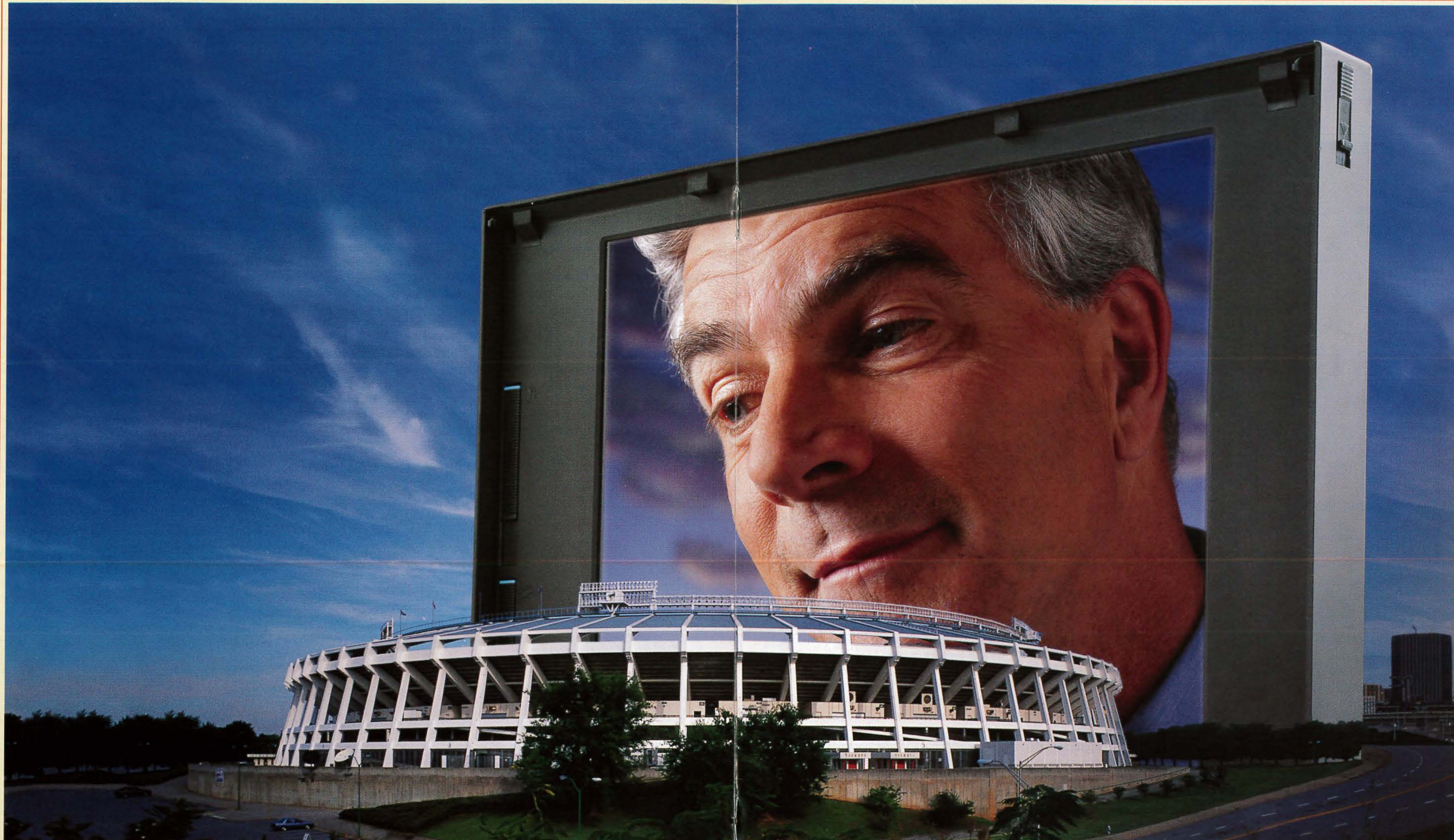
With technical feasibility demonstrated on the pilot line, the partners reached the point of building a $400 million plant. The low cost of capital in Japan at the time was an important motivation at this point, since it dramatically reduced the up-front investments required of the partners.

IBM

Fig. 2: IBM's strategy is that its top-of-the-line Thinkpad™ laptop computer always have a better display than its competitors. The current Thinkpad 560 family has a 12.1-in. 800 × 600 (SVGA) display.

IBM

Fig. 3: IBM's 16.1-in. 1280 × 1024 (SXGA) display is now used in a variety of monitor applications. This TFT display is becoming important in non-mobile monitors.



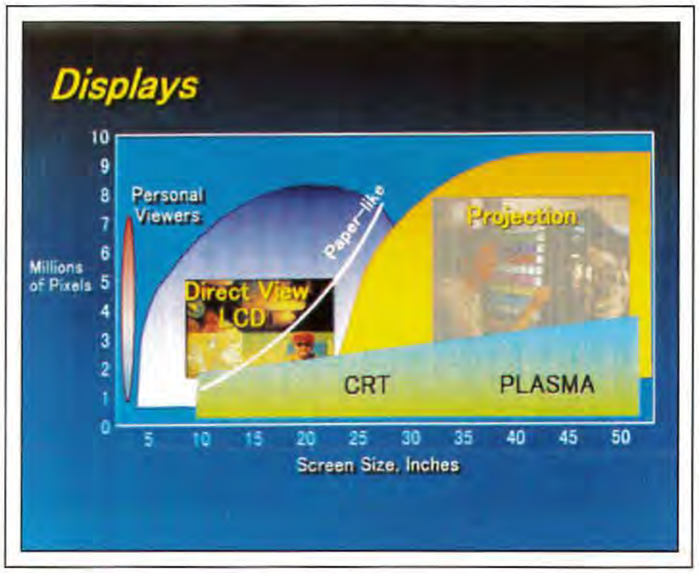


Fig. 4: AMLCDs will, over time, expand into a far greater portion of the display market.

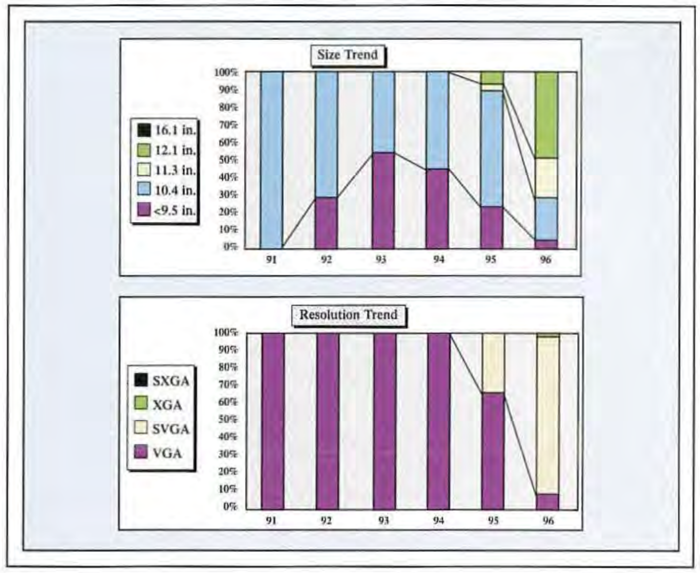


Fig. 5: The typical display produced by DTI for laptop use in 1996 was a 12.1-in. SVGA. The next wave is XGA, and then 16.1-in. SXGA.

The Payoff

In 1992, IBM introduced the Thinkpad™ notebook PC with a 10.4-in. DTI display instead of one of the 9.5-in. displays that were then common in competing PCs. Although the Thinkpad had other distinguishing characteristics, such as its innovative pointing stick, the large display made a critical contribution to the product's immediate success. Display availability for the Thinkpad was improved by what was effectively in-house production, and the display quality was excellent.

IBM's strategy was (and is) that the Thinkpad should always have the best available display, when compared to its competitors. The current Thinkpad 560 has a 12.1-in. 800 × 600 (SVGA) display (Fig. 2).

In addition to portables, these TFT displays are becoming important in non-mobile monitors. The current IBM 16.1-in. 1280 × 1024 (SXGA) monitor is another example of the fruits of this joint venture (Fig. 3).

The 10-Year Plan

In 1984, IBM's 10-year technology outlook predicted that AMLCDs would play a large role in our product line. The 1995 version of this technology outlook projects the introduction of paperlike displays based on AMLCD technology, as well as the use of AMLCDs as one of the technologies for large-scale projection displays.

It is one thing to project technological developments, quite another to act based on those projections. Although it is a great oversimplification, it is useful to think of two styles of corporate decision-making. The first is the "chess-playing style," which is well suited to periods in which technology and business practices are evolving predictably and continuously.

In the other style, the "poker style," major bets must be placed before technical or business certainty has become established. The poker style is the key to winning in an era when new elements are rapidly transforming an industry and time is the most relevant variable. And poker - well-researched and well-analyzed poker, but poker nonetheless - is what we were playing when we founded DTI. The uncertainties were huge. Remember, even 2 years ago some reasonable people believed that FEDs might displace AMLCDs and be the ultimate winner in laptop-display technology.

At this point, it is pretty clear that LCDs are, and will remain, *the* mainstream portable flat-panel-display technology because of the huge base of manufacturing experience and consequent rapid cost reduction (Fig. 4). Screen diagonals and pixel counts continue to grow, as confirmed by DTI's production experience (Fig. 5). From 1991 to 1994, virtually all of our output was in 9- and 10-in.-class VGA displays. In 1995, we produced a substantial percentage of SVGA product, some of it with 11.3- and 12.1-in. diagonals. In 1996, 90% of the output was in SVGA, and 70% was 11.3 in. or larger.

What We Learned

Speaking at Display Works 97 in San Jose in January, Hideki Wakabayashi, Senior Researcher for Nomura Research Institute, Tokyo, ranked DTI as the second-largest AMLCD supplier in terms of volume and the leading supplier in terms of technology. This success was hard won, and is based on a strategy of staying ahead of the competition. Implementing that strategy involved some things that were obvious, as well as some less obvious.

To further our commitment to clear and open communication between the partners, for instance, IBM hired a full-time Japanese teacher for its Yorktown Heights, New York, team.

IBM's motivation for participating in DTI has evolved with time and changing conditions. At first, we were moved by our "trickle-up" view of TFT technology and the desire to build on Toshiba's high-volume manufacturing experience, to learn the "Japanese Way," and to benefit from Japan's then low cost of capital. Later on, we were motivated by our own success, the rapid pace of progress, the effectiveness of the Toshiba-

IBM relationship, the commonality of our goals, and the still low cost of capital.

The risks and challenges have also evolved over time. Initially, we were concerned with technical uncertainty, cultural differences, and a large number of internal and external skeptics. It is a mark of the enterprise's success that later on the risks and challenges that most concerned us became those confronted in any business: schedules, costs, supply/demand issues, and business risk.

So what were the key lessons learned?

- Complementary partners and common goals are essential.
- Continuity is essential, as is commitment from the top. At DTI, and at both Toshiba and IBM, many of the key players have remained on the scene throughout the process.
- Teamwork at the working level is essential. Recruiting from both participating companies fosters the teamwork.
- Strong technical teams are key. In the case of DTI, both companies brought enormous technological strengths to the joint enterprise.
- Finally, it is necessary to apply highly focused management methodologies.

The lessons are clear, but that does not make them easy to implement. The implementation at DTI was highly successful, but it required a compelling view of the future, a commitment to making large investments and to bridging cultures - and a willingness to play high-stakes poker. ■

Circle no. 19

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.

Why Is Black-and-White So Important in Color?

The developers of NTSC television knew that in luminance-chrominance coding they had created something remarkable, but they didn't know why.

by Robert W. G. Hunt

IN THE VISUAL SYSTEM, the retina communicates with the brain by means of a black-white (achromatic) signal and two color-difference signals: a red-green and a yellow-blue. The existence of the black-white signal has important implications in imaging. First, if areas that are intended to be black, gray, or white are reproduced with even a slight tinge of hue, the defect is usually very noticeable because these achromatic perceptions correspond to the color-difference signals being balanced at their null levels. Second, the achromatic signal largely determines the apparent contrast of scenes, and their images look correct only if their gray scales are adjusted with due allowance for the effect of the surround on the black-white signal. Third, in luminance-chrominance television, important reductions in bandwidth are possible because of the lower sharpness required in the chrominance signals as a consequence of the greater number of cones necessary to generate the color-difference signals than to generate the black-white signal. The various forms of imaging take advantage of this situation to different extents, as we shall see.

***Robert W. G. Hunt** had a long career at Kodak, wrote the classic book* The Reproduction of Colour *(5th ed., Fountain Press, Kingston-upon-Thames, London, 1995), and is a legendary figure in the science and technology of color reproduction. Dr. Hunt currently teaches at City University, London, and maintains a consultancy located at 10 Kewferry Rd., Northwood, HA6 2NY, England; phone/fax +44-1923-827923. This article was adapted from the author's keynote address given at the Fourth Color Imaging Conference, Nov. 19–22, 1996, in Scottsdale, Arizona.*

A Short History of Vision Theory

In the first half of this century, color vision was most often thought to be fully explained in terms of the trichromacy provided by the three different types of cones. This way of thinking was promoted by the work of Thomas Young and Herman von Helmholtz in the 19th century, and is sometimes referred to as the Young-Helmholtz theory of color vision.

Towards the end of the 19th century, the German physiologist Ewald Hering advanced the view that, after the light had been absorbed by the cones, the responses were transformed into three opponent signals: a black-white (achromatic), a red-green, and a yellow-blue. This Hering theory of color vision remained overshadowed by the Young-Helmholtz theory for many years, although it found a place, in the first half of the 20th century, in various "zone theories" that combined both the tri-receptor and opponent processes in successive stages. But it was not until 1955, when Dorothea Jameson and Leo M. Hurvich published the first of a series of papers entitled *Some Quantitative Aspects of an Opponent-Colors Theory,* that Hering's ideas became prominent. This was followed by a series of papers from various authors in which black-white and color-difference signals were discovered in various species, particularly in fish and monkeys.

The Reproduction of Blacks, Grays, and Whites

Areas that are perceived to be black, gray, or white correspond to the color-difference signals being balanced at their null levels. Any deviation from these null levels is easily detected, so if blacks, grays, and whites are reproduced with even a slight tinge of hue, the defect is usually very noticeable. It is for this reason that overall color balance is so important in images. If an image has a color cast – a magenta cast, for instance – blacks, grays, and whites will be tinged with a very obvious magenta hue, and most pale colors will undergo noticeable changes in hue. It is interesting that in recently developed color-difference formulas the color spaces are more finely divided in areas near the gray scale than elsewhere. This is true of the CMC and CIE94 color-difference formulas and also of the OSA color space.

The Effects of Surrounds on Contrast

If the apparent contrast of an image is too low or too high, it has the appearance of being either misty or harsh, respectively. For good reproduction of images, it is essential to produce the right contrast. If this is not done, no amount of alteration of the color content will remedy the defect.

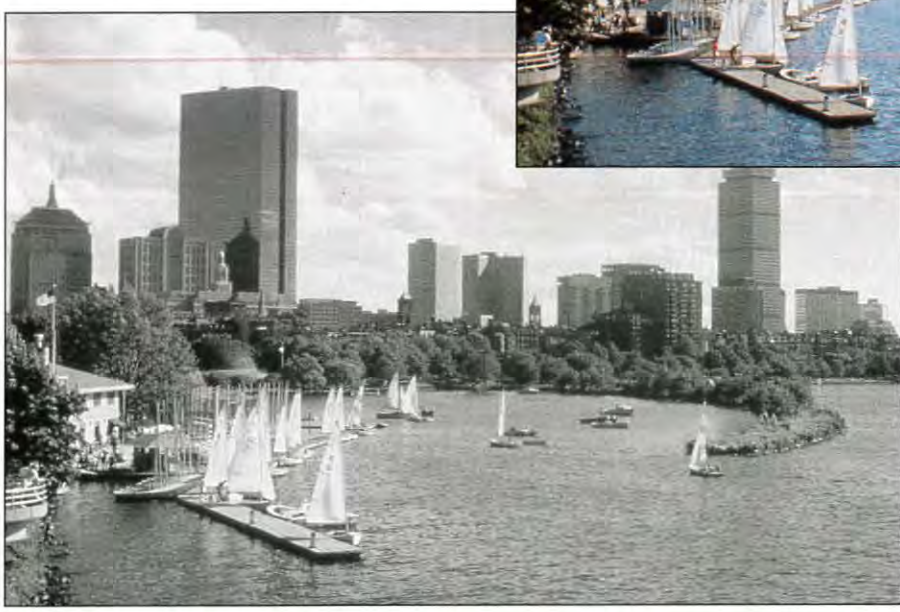
0362-0972/97/1307-024$1.00 + .00 © SID 1997

The contrast is determined mainly by the relation between the original and reproduced luminance, and these are mediated by the black-white visual signal. This signal is greatly affected by the nature of the surround. A dark surround, as occurs in projection, lowers the apparent contrast so much that an increase is necessary in the system gamma - the slope of the relationship between the log of the reproduced luminance and the log of the original luminance - from 1.0 to about 1.5. In the case of dim surrounds, as commonly occur in television viewing, the gamma has to be increased from 1.0 to about 1.25.

Color Reproduction Systems for TV

The vast majority of color reproductions do not attempt to reconstruct the spectral composition of the original colors, but only to elicit the same or similar responses in the three different types of cones of the retina. In television, these responses are produced by causing individually modulated sources of red, green, and blue light to excite the cones.

Various ways of combining the effects of the three sources have been used, including



- The projection of the three images in register on a screen.
- The superimposition of virtual images in the three colors.
- The presentation of red, green, and blue areas whose images on the retina are too small to be resolved - the mosaic method.
- The production of images in red, green, and blue light in rapid succession at a frequency high enough for the light to blend together to give mixture colors - the field-sequential system.

The first color-television images to be seen anywhere were demonstrated by John Logie Baird in London in 1928, using the field-sequential system. The first color-television broadcast service was introduced in the U.S. in 1950; it also used the field-sequential system, employing 144 colored fields per second. Currently, one form of Texas Instruments' Digital Micromirror Device™ display system uses field-sequential display at 150 or 180 fields per second.

The Luminance-Chrominance Concept

The conceptual simplicity of the field-sequential system has kept it alive, but in 1953 the National Television Systems Committee (NTSC) in the U.S. was instrumental in launching luminance-chrominance television for broadcasting, and this method is now used almost universally.

The seed thought for the luminance-chrominance method was sown in the mind of A. V. Loughren, a member of the NTSC, when he came to Plate VI, facing page 144, of the book *An Introduction to Color* by Ralph M. Evans (Wiley, 1948). This plate consisted of a full-color image, together with a black-and-white image of the same scene, and another image of the scene in which, as nearly as possible, all the luminance differences between different parts of the scene had been removed and only the chromaticity differences remained.

Evans produced this plate because, in the late 1940s, the projection of Kodachrome™ slides had become popular, and many who saw them commented that they perceived three-dimensional effects in the projected images, an effect that was often attributed to the color content of the pictures. Evans was not convinced that the color was responsible for the apparent depth and made this plate to investigate the situation.

On asking people how much apparent depth they saw in the images of this plate, the universal response was that the full-color image and the black-and-white image both exhibited considerable depth, but that the chromaticity-only image looked very flat. So Evans concluded that the apparent depth could not be attributed mainly to the color. The apparent depth and much greater realism of the projected pictures was caused by the isolation from their surroundings and their large size and color.

But Loughren's interest was not in apparent-depth issues. Because there were at that time some millions of black-and-white television receivers in use, it was important that the images produced by any new system incorporating color could be displayed on these monochrome receivers in black-and-white. With the field-sequential system this was impossible because the scanning speed had to be three times as fast as for black-and-white. What Evans's plate did was to suggest to Loughren that if color-television signals were broadcast, not as red, green, and blue signals but as a luminance signal and two other signals that carried only the additional color information, then it should be possible to arrange for the black-and-white receivers to respond to the luminance signal only, while the color receivers responded to all three signals. In this way, the color signals could be viewed in black-and-white on the existing monochrome receivers – a situation termed "compatibility." With today's almost universal use of color in television, this type of compatibility is no longer an important issue in broadcasting – but compatibility with high-definition television systems would be desirable if practicable.

Reduction of Chrominance Bandwidth

Although compatibility was the driving force behind luminance-chrominance television, the system provided another advantage of equal or even greater importance. It was found that the chrominance information can be much less spatially sharp than the luminance information without impairing the apparent sharpness of the composite picture. This discovery made it possible to reduce the bandwidth of the chrominance signals to one-quarter of that used for luminance. With this reduced bandwidth, it was then possible to interleave the chrominance information within the bandwidth used for the luminance information so that the total bandwidth for color transmission was no greater than that for monochrome.

Furthermore, because the eye is not corrected for chromatic aberration, blue light is not sharply focused on the retina, and it is therefore unnecessary for yellow-blue components of color differences to be displayed at a spatial resolution as high as that of red-green components. This effect is exploited in the NTSC system: one of the two chrominance signals has only one-tenth the bandwidth of the luminance signals.

The reduction in chrominance sharpness that could be incorporated in imaging systems without impairment to the sharpness of the final composite picture was a very striking and, at first sight, surprising phenomenon. The surprise arose because, in the 1950s, the visual system was generally thought of only in terms of its retinal trichromacy, and not additionally in terms of its black-white (achromatic) signal and its red-green and yellow-blue color-difference signals. Thus, although the luminance-chrominance television system was a *de novo* invention as far as the inventors were concerned, a very similar system was in fact fully operational inside their own heads, although they were quite unaware of it!

Explaining Chrominance Sharpness Reduction

The opponent nature of the color-difference signals of color vision provides an explanation of the sharpness reduction possible in chrominance signals. If we denote the strengths of the three cone outputs as r, g, b, we can represent the three signals as $2r + g + (1/20)b$ for black-white, $r - g$ for red-green, and $r + g - 2b$ for yellow-blue. The factors 1/20 and 2 in the black-white signal are included to allow for the fact that there are many fewer b cones in the retina, and perhaps rather more r cones than g cones. It is assumed that for achromatic colors (whites, grays, and blacks) the r, g, and b signals are equal; the two color opponent signals then become zero for these colors.

Consider now a horizontal gray line with a small gap in it of a lighter gray; the color-difference signals will be zero throughout, so, for the presence of this gap to be detected, there must be a change in the black-white signal. Because the black-white signal collects from all three types of cones, an adequate change will occur if the gap corresponds on the retina to a distance equal to at least one cone diameter. (If the cone happens to be a b type, the change in the signal will be rather small, but this will be a rare event because of the small number of b cones).

If we now consider a horizontal green line with a red gap in it of the same lightness, it will have to be detected by the red-green signal. It is thus necessary, in this case, to have at least two cones in the gap, an r and a g. This would lead to a requirement for chrominance signals to be half as sharp as luminance signals. But the different types of cones are distributed randomly in the retina and, when this is allowed for, it turns out that, on average, there must be at least four cones in the gap to detect a red-green change. We should therefore expect a four-to-one difference in the sharpness required for luminance and chrominance, and this is the ratio found to be acceptable in practice.

Considering now a horizontal blue line with a brown gap in it of the same luminance, this must be detected by the yellow-blue signal so that there must be at least one r, one g, and one b cone in the gap, and, because of the paucity of b cones, a much larger number of cones is now required in the gap. Hence, a yellow-blue chrominance signal can be reduced by a factor of about 10:1. The factor is not greater than this, such as 20:1, because the non-linearities introduced by gamma-correction (to be described in the next section) prevent changes in the strength of the yellow-blue chrominance signal from being equivalent to changes in the b-cone response only.

The Effects of Gamma Correction in Television

The luminance signal used in broadcast television is, in fact, not a true luminance signal. This is because the transfer characteristic of the display device most commonly used in 1953 was a power function with an exponent of about 2.2 – referred to as a gamma of 2.2. (The gamma in this case is the slope of the relationship between the input signal and the amount of light produced on a log–log plot.) The signals from the camera, E_R, E_G, E_B, were therefore gamma-corrected by being raised to the power of 1/2.2 (or 0.45). The luminance signal, E'_Y, then becomes

$$E'_Y = lE_R^{1/2.2} + mE_G^{1/2.2} + nE_B^{1/2.2}$$

with *l, m,* and *n* having values in the NTSC system of 0.299, 0.587, and 0.114. These factors are determined by the chromaticities of the display phosphors and by the reference white used in the system.

Because the chromaticities of modern phosphors are significantly different from those used in the original NTSC system, and because modern systems usually use Standard Illuminant D65 as reference white instead of Standard Illuminant C – as used in the NTSC system – there has been some discussion about changing the factors to correspond to current systems. However, so long as the signal is not a true luminance signal, there seems little justification for making changes. If, at some time, systems using true luminance signals are adopted, then adjustment of the factors would be desirable. A fact that should not be forgotten, however, is that real observers show a considerable spread of spectral luminous-efficiency curves, so that attaining true Standard Observer luminance will not achieve exact luminance for most real observers.

Because the E'_Y signal is not a true luminance signal, some of the luminance information is carried by the two chrominance signals

$$E_R^{1/2.2}\text{-}E'_Y \text{ and } E_B^{1/2.2}\text{-}E'_Y.$$

There is, consequently, some loss of definition in the final picture as a result of restricting the bandwidth of the chrominance signals. It is for this reason that in more recent systems – such as that used in PhotoCD and proposed for high-definition television – the chrominance signals are only restricted to half the bandwidth of the luminance signal. This restriction is, however, applied both horizontally and vertically, as in the PAL and SECAM systems, and not only horizontally, as in the NTSC system.

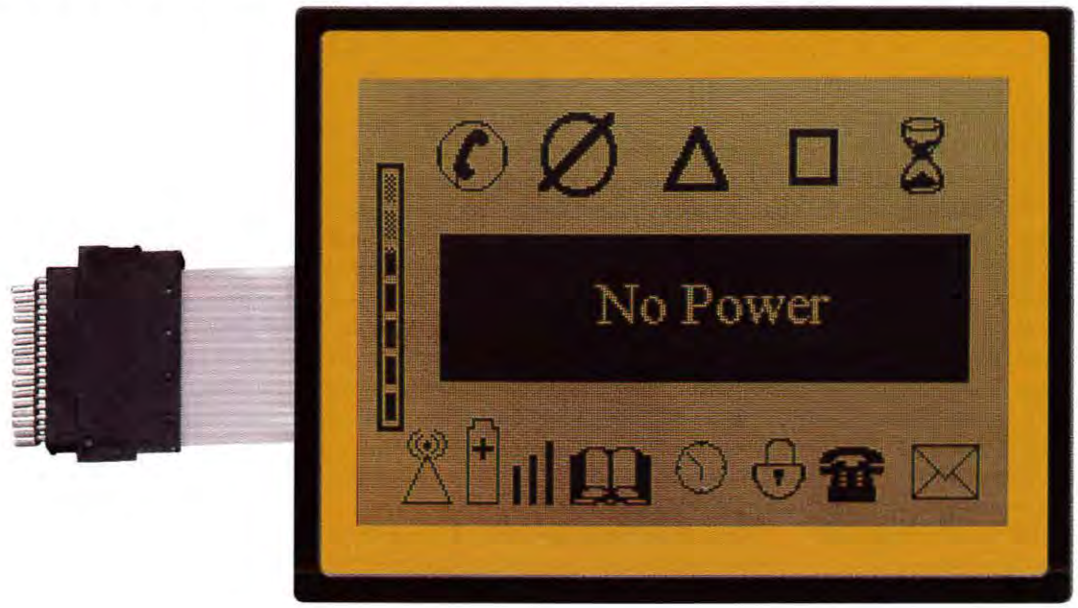
Conclusion

So why is black-and-white so important in color? First, because black, gray, and white colors correspond to the color-difference signals being at their null levels, any slight departure from the null condition is very noticeable. Second, images never look right unless their contrasts are correct and, because dark and dim surrounds affect the contrast of the black-white visual signal, images have to be adjusted to take these effects into account. Third, the sharpness of images depends much more on the luminance than on the chrominance content of the image, and if this is exploited it can lead to very useful economies in the information content necessary in transmitted and displayed signals. ■

Circle no. 22

Circle no. 23

Get Unplugged from Old Display Ideas



Kent ChLCD™ No Power Displays

Ready to get unplugged from the energy-robbing LCD displays you're now using? KENT Displays' ChLCD (Cholesteric Liquid Crystal Display) technology offers a solution for your electronic products.

Break the Battery-drain Barrier

Since ChLCD reflective and transparent textures are both stable states, an image can be displayed indefinitely without consuming battery energy – for seconds, hours, weeks, months or even years.

Easiest to Read Reflective Technology

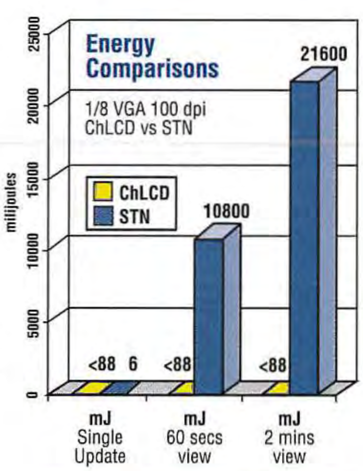
Compared to conventional LCD technologies, ChLCD displays offer better reflectiveness, 360 degree viewing cone and exceptional daylight contrast, even in direct sunlight, all without backlighting.

Standard or Custom Displays Available

Standard ChLCD displays and modules are available in 1/8 and 1/2 VGA sizes in colors to meet your needs. Have a special application? Kent Displays offers ChLCD displays and modules custom designed to your requirements.

Ask for the Facts

To learn more about this technology that enables you to do more, ask for this information package today. — — — — — — —



Unlike STN displays which use power to continuously refresh images, ChLCDs do not require refreshing to keep energy usage to a minimum.

KENT DISPLAYS INCORPORATED

A MANNING VENTURES BUSINESS UNIT

Kent Displays, Inc. • 343 Portage Boulevard • Kent, OH 44240 • Phone: 330.673.8784 • Fax: 330.673.4408 • E-mail: sales@kentdisplays.com

Products and technologies of Kent Displays, Inc. are protected by the following patents: Unites States; 5,463,863; 5,437,811; 5,384,067; 5,251,048. People's Republic of China; 92103952.2. Israel; 101,766. Taiwan; 801405631. PCT (EP, Canada, Korea, Japan and Norway); 92/03504; 9209367. Other Patents Pending.

Circle no. 24

continued from page 4

The initial phase consists of the discovery and introduction of a new technology, and the experimentation with this technology by "early adopters." Early adopters are people who will try anything new - at least once. Sometimes it is their assigned responsibility within a company to be aware of new products or new technology introductions, to evaluate them, and to provide a report to management. Similarly, there are consultants who have a need (or simply feel an urge) to try new stuff and then, perhaps, produce a magazine or newspaper article about it. These early-adopter activities produce a small market for almost anything that is developed, and allow a technology to receive written and word-of-mouth exposure. If a technology looks useful, it will receive favorable comments and can move to the next stage - the stage of rapid growth. On the other hand, if the early adopters don't like a technology, it will most likely go nowhere.

Sometimes the behavior of early adopters is misinterpreted to imply impending product success. That can be a big mistake. A new start-up company will get all excited because they are selling a small amount of their product. This leads them to make overly optimistic projections regarding future sales based on these evaluation quantities. However, early-adopter behavior is not a good indicator of future growth potential because they are not the *real* users. These are found in the second stage of the S-curve.

The second stage of the S-curve consists of the rapid growth and widespread acceptance of a new technology. Business texts claim that once a technology or a product is about 15% up the growth curve, reasonably accurate *quantitative* predictions of future success become possible. Although I have not had an opportunity to test this assertion, it seems reasonable. During this rapid growth period, "everyone" wants the new technology. The "everyone" typically means those who are likely customers. For example, in medical imaging they might be hospitals or radiologists, while for home computers they might be, well, people who live in homes. Home computers or, more broadly, desktop computers, are today approaching the third stage of the growth S-curve: maturity.

This third stage, often the final one to be mentioned in business texts, is the stage in which the technology has saturated the user base and new improvements mostly serve a replacement market. We can safely put products such as refrigerators, washing machines, 25-in. television sets, and 35mm cameras in this category - at least in the more developed parts of the world.

This brings us to the fourth, the most interesting, and the most often neglected part of the technology S-curve: the ***then what?*** stage, or the backslope of the S-curve. What happens when a company's investors expect continued growth even though the core products have matured? What happens when a new technology comes along, and the existing supplier can't implement it?

When we as consumers decide to accept a new technology into our lives, what do we stop doing that we did before? Whatever it is that we stop doing will most likely negatively impact one or more business entities. Wouldn't it be important for them to know that this is about to happen?

What I'm finding is that there is a wide range of backslopes to the technology S-curve. There are so many interesting ways to fall off the roof and out of the tree. Some products mature and then hang around for many years: the gentle and controlled descent approach. Others mature quickly and get replaced just as quickly: the rapid descent with minor broken bones approach. And yet others are around for many years and then crash precipitously: hanging on till the tree rots away and then incurring 911-level injuries.

It seems to me that for mature companies like IBM, DuPont, Kodak, H-P, Tektronix, and many others, the ability to understand where some of their technologies are on the ***backslopes*** of the S-curve is at least as important as understanding how a new technology will grow.

Let's consider two contrasting examples that are pertinent to us in the display business: the venerable CRT and electronic imaging/photography.

Why won't the CRT die? In its 100th year, it has certainly had a full and productive life. But it just keeps on going and going - like that bunny in the CRT-displayed television commercials. I believe the CRT survives because it provides the best combination of technology and financial value. It may not be fashionable to say this, but new display technologies do not offer a compelling advantage in the core applications of 15-27-in. consumer televisions and desktop computers. Flat is good, but not important enough to justify more money. Plasma is good, but it looks just like a CRT except maybe not quite as bright. FEDs? As with LC and plasma technology, they will take another 10 years before *real* displays are available. Thus, CRT production will continue its steady growth for at least the next 10 years, and CRTs will still be around for at least the next 20 years. When it does occur, the CRT's end-of-life will be graceful: a predictably slow tapering off of use.

Now that I have nearly lulled you into complacency with this idyllic scenario, let's shift our gaze to a technology horizon where an interesting and dramatic storm is brewing. Let's look at the thunderstorm that technology is about to unleash on the conventional photography business. Electronics and chemicals are about to have a major clash, and this clash will benefit us in the display community. For Kodak, Fuji, and Polaroid there is, I'm afraid, no place to run and hide.

This technology storm has been brewing for at least 5 years now. It started with rudimentary color ink-jet, thermal-transfer, and sublimation color printers. Then along came the first digital cameras. Prior to that, 8mm home movies had already disappeared with the advent of video camcorders. And at about the same time, Polaroid lost most of its consumer instant-photography business to the 1-hour minilabs.

Filmless digital cameras by themselves could not create the coming electronic storm. But in combination with photographic-quality printers there is enough energy to make for a spectacular show. If one can have a camera that stores 50 or more high-quality images, allows one to quickly view and sort them, then transfer them to a computer or other storage medium for viewing, transmission, or manipulation, and if this is combined with a high-quality printer to instantly convert these images into quality photographs, why would anyone wish to continue to use conventional film?

The only possible reasons would be the acquisition cost of the equipment or that the technology is difficult to use. And until recently, electronic color printers were indeed expensive and still did not have full photographic quality. But soon we will see quality color printers in the $500–1,000 range. Cameras of 1280 × 1000-pixel resolution – comparable to 35mm film in actual use – are already on the market and proliferating like the proverbial rabbits. Performance is going up and costs – already below those of top-end 35mm cameras – are coming down rapidly. Ease of use was definitely a problem when all we had were slow scanners and Adobe Photoshop. But new, simpler, and much cheaper software programs are making it possible for casual users to learn to do the basic stuff like selectively modifying colors or fixing blemishes – capabilities previously unavailable even to skilled chemical-photography hobbyists.

I have been a semi-serious photographer for many years. I have a darkroom and several larger-format as well as 35mm cameras. I have always felt that 35mm film did not provide acceptable quality for the 16 × 20 and larger prints that I like to make. Thus, you might expect that I would want to hang on to conventional photography longer than most. But my estimate is that within 5 years I, too, will have converted even my high-resolution 6 × 7-cm equipment to electronic capture and printing.

Can you imagine what it must feel like to be a chemist at Polaroid, Fuji, or Kodak, to realize that not only are you stuck up on the roof with the tree limbs too far away but that the BIG STORM is going to hit very soon?

From what I can tell, Polaroid only recently discovered that as they reached for the tree the limbs were further away than they thought. For the last several years, Polaroid's annual reports have been saying that the tree limb of medical imaging, as well as smaller branches in their more familiar instant-photography businesses, would keep them from falling. But darn if they didn't get caught by that same perceptual physics problem that stymied me on that rooftop many years ago. That tree limb of medical imaging was not big enough or sturdy enough to keep them from losing their balance.

Fuji seems to have decided *not* to wait for the storm to hit. This company appears to be reaching for the electronic tree and the opportunity to make a graceful transition to filmless photography with a range of new products, from simple, moderate-resolution consumer cameras to full professional-quality digital-image-acquisition photography.

Kodak, on the other hand, seems to be developing a split personality. While the Digital Sciences group is searching for ways to get down off the roof, the traditional part of the company is still entranced by the view of acres of photographic film and paper, stretching as far as the eye can see. In this profit-making part of Kodak, there seems to be only a small nagging worry that their Mom and Dad will soon come home and that they too better hurry and get down off the roof. And darn if that technology wind isn't starting to blow, moving those branches ever farther away. What do you do with a company full of chemists when the future belongs to electronics? Can they all find happiness in the color-printer business? Or do they still believe that APS is the wave of the future?

Finally, consider these varied outcomes, which ambushed others on the backslopes of the S-curve. The slide-rule took a quick and fatal fall when the hand-held calculator came along. LEDs died as a technology for wrist-watches but were reborn for many other interesting applications. The direct-view storage CRT created the workstation business but then was pushed off the roof by cheap solid-state memory and high-resolution color CRTs. LCDs allowed the laptop-computer business to develop but didn't threaten or replace much of anything CRT-related. Electronic projectors haven't done much to hurt the conventional overhead-projector business. The CD replaced 33- and 45-rpm records. Broadcast TV and cable TV learned to live happily together. Movies lived on and prospered even after television came along. Live theater, concerts, and sports events have continued to enjoy great views from their respective rooftops. The electronic storm didn't bother them much at all. Newspapers, magazines, and bookstores seem to be thriving and show no signs of being blown away by TV or the Internet. (Magazines and books even seem to be benefiting from electronic technology.) But when is the last time that you sent someone a handwritten first-class letter? And when do you think you will send someone your last chemically produced photograph?

That back-side of the technology S-curve really is a fascinating place isn't it?

Since I have by now fully recovered from my encounter with that tree many years ago, you may wish to reach me by e-mail at silzars@ibm.net, by phone at 206/557-8850, or by fax at 206/557-8983. And if you would still like to practice the disappearing art of letter writing, you may reach me at 22513 S.E. 47th Place, Issaquah, WA 98029. ■

Edited by JOAN GORMAN

Ultra-miniature LEDs

AZ Displays, Inc., Aliso Viejo, California, has expanded its line of LEDs with the addition of miniature Axial LEDs, measuring 2.5 × 2.0 mm at the base and only 2.45 mm high. Designated as the L-170 series, these LEDs are available in five colors: red, hi-efficiency red, green, yellow, and ultra-red. All colors are available in water clear, tinted clear, and color-diffused epoxies. The Axial LEDs feature a typical drive current of only 20 mA for normal operation and a viewing angle of 100° for the diffused types. Typical brightness values for clear types are 3.5 mcd for standard red and 7.0 mcd for hi-efficiency red. The ultra-red is rated at 40.0 mcd, and the green and yellow are rated at 6 mcd. These ultra-miniature LEDs are ideal for telecommunications equipment such as cellular phones, pagers, modems, computers, telephones, and PBX. In addition to bulk packaging, all colors are available on tape and reel. Special lead forms and bends are also available upon request.

Information: Rick Babur, AZ Displays, Inc., 75 Columbia, Aliso Viejo, CA 92656. 714/360-5830.

Circle no. 1

Full-VGA 4.7-in. baby module

Shoreline Electronics, Inc., Santa Clara, California, has introduced the BabyVGA™ HS47VGA, a 4.7-in. high-contrast (30:1) full-VGA color module ideally suitable for portable instrumentation and industrial control applications. Using a standard color STN transmissive-type negative display, the HS47VGA was designed to interface with industry-standard flat-panel drivers for PCs. Extremely light (116 g) and thin (7.0 mm), it is an ideal choice in applications where size and viewability are paramount. The unit is backlit by a cold-cathode fluorescent tube and operates at 0–45°C. It features a 1/240 duty multiplex driver and a non-glare surface texture for all of its 640 × 480 × 3(RGB) pixels. Module dimensions are 140 (L) × 98 (H) × 7 (W) mm, while the viewing area is 98 (W) × 74 (H) mm. A minimum 15-V power supply is required to drive the LCD and a 5-V power supply for the logic circuits, with a typical current consumption of 67.4 mA. Pricing starts at $325.

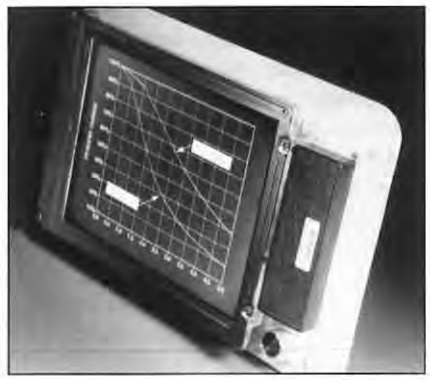
Information: Shoreline Electronics, Inc., 2098 B Walsh Ave., Santa Clara, CA 95050. 408/987-7733, fax 408/987-7735.

Circle no. 2

Inverters for backlit FPDs

Endicott Research Group, Inc. (ERG), Endicott, New York, is offering a range of inverters and converters that supply power to backlit flat-panel displays (FPDs). The MT Series of dc-ac inverters provide power to high-brightness transflective or transmissive flat-panel LCDs. A single MT inverter can be used to power an FPD that is currently backlit by 10 cold-cathode fluorescent tubes. MT Series inverters are encapsulated for ruggedness and feature compact size, a very low profile, and low cost. For electroluminescent (EL) backlit FPDs, ERG offers the LP Series of Smart Force™ dc-ac inverters. These compact inverters (less than 9 mm in height) form a resonating oscillator with the capacitance of the EL lamp, allowing the voltage and frequency applied to the lamp to change as the overall impedance of the EL lamp changes. The inverters can be connected in parallel to power larger total EL lamp areas. Pricing is under $5.00 each in OEM quantities.

Information: Endicott Research Group, Inc., 2601 Wayne St., Endicott, NY 13760. 607/754-9187 x3048; fax 607/754-9255.



Circle no. 3

CRT focus meter

Minolta Corp., Ramsey, New Jersey, has introduced the CB-150 CRT focus meter, a compact, lightweight instrument that replaces the subjectivity of visually assessing CRTs with a more accurate quantitative evaluation method. The CB-150 allows quality-control and R&D personnel to quickly and easily perform on-site quantitative evaluations of CRT focus performance. The focus meter consists of a processing unit with a built-in video generator that supplies the necessary test pattern, measuring head, and Windows®-based software. The software and processor command the measuring head and video generator to measure CRT focus performance and luminance using electron-beam profiles of CRT phosphors. Beam-size calibration is completed in 23 s, luminance calibration in 1 s, beam-size measurement in 5 s, and luminance measurement in 2 s. The CB-150 can produce three-dimensional graphs, contour-line diagrams, vertical/horizontal cross-sectional diagrams, and beam-diameter values. Additional features include auto focus, auto head positioning, jitter-control mode, auto iris, and quick, normal, and high-accuracy measuring modes.

Information: Minolta Corp., Instrument Systems Div., 101 Williams Dr., Ramsey, NJ 07446. 1-888-ISD-COLOR.

Circle no. 4

or below a tabletop, and a rack mounting kit which allows the unit to be installed in a standard 19-in. instrument rack. The 801SL is the lowest priced stand-alone generator in the Quantum Data product line and sells for $2995.

Information: Robert S. Rhine, Quantum Data, Inc., 2111 Big Timber Rd., Elgin, IL 60123. 847/888-0450; fax 847/888-2802; e-mail: sales@quantumdata.com.

Circle no. 5

tight areas in control panels, cabinets, or machinery. Alternate use as a stand-alone workstation or networked computer is also supported.

Information: Hai Nguyen, National Display Systems, 761-A University Ave., Los Gatos, CA 95030. 408/395-8688 x18; fax 408/395-5288

Circle no. 6

Low-cost portable video generator

Quantum Data, Inc., Elgin, Illinois, has introduced the model 801SL, a low-cost portable video test generator designed for use in production plants and service and repair centers. The generator features a programmable video clock rate up to 160 MHz, allowing the latest 1600 × 1280 display monitors to be tested, and produces output to measure linearity, convergence, and brightness, as well as other monitor and video-display features. The 801SL is lightweight and user friendly, can generate up to 256 colors from a palette of 16.7 million colors, and easily fits into a briefcase alongside tools and other monitor-repair supplies. Over 150 standard images and over 100 formats come pre-programmed into the unit. Custom sequences, formats, and images can be created and stored using the built-in user interface, or by using a PC and a Windows®-based software program that comes with the generator. Images, formats, and sequences created using the 801SL can be stored and transferred between the 801SL and other Quantum Data test generators. Options include a carrying handle which can also be used as a support stand, a case mount which allows the generator to be mounted on top of

FP monitor with embedded PC

National Display Systems, Los Gatos, California, has announced the TouchStation™ Pro, a 12.1-in. active-matrix flat-panel monitor with a touch screen and an embedded PC enclosed in a slim, lightweight aluminum-alloy frame measuring less than 2.25-in. deep. Designed for harsh industrial environments and areas where space is at a premium, TouchStation Pro offers Integrated PC Display (IPCD™) technology for use as both a personal computer and monitor. Standard models include a 12.1-in. SVGA (800 × 600) color TFT display, high-resolution resistive touch screen, 100-MHz Intel Pentium™ processor, 8-MB DRAM, 256k cache, choice of 540- or 810-MB hard drive, two type-II or one type-III PCMCIA slot(s), and serial, parallel, and keyboard ports. The TouchStation Pro is compatible with a wide range of standard software applications within a number of operating systems, including Windows 95™, Windows NT™, OS/2™, and MS-DOS™. It is an ideal man/machine interface for harsh industrial environments, withstanding wide temperatures ranges (0–45°C), constant vibration and shock, and airborne contaminants such as oil, water, and dust. The unit is designed with front or rear mounts for easy integration into

First 17.7-in. color STN-LCD

Computer Dynamics, Greenville, South Carolina, has introduced the VAMP-Pan Vista, the first 17.7-in. color STN-LCD on the market. The panel features a resolution of 1024 × 768, ideal for high-information-content screens, in a display that rivals color TFTs in viewing quality at a lower cost than a 12.1-in. color TFT. Display sizes of 15.1 and 13.8 in. are also available, as are optional guided acoustic wave or resistive touch screens. The 17.7-in. VAMP-Pan Vista's screen offers the same viewing area as a 21-in. CRT at a fraction of the CRT's weight, volume, and power consumption. The display offers 512 colors, a brightness of 150 nits, and a 25:1 contrast ratio. In addition to standard VGA signals, the VAMP-Pan Vista also accepts synch-on-green, composite, and other custom analog signals. Overall system dimensions for the open-frame VAMP-Pan Vista are 18.7 × 14.3 × 3.5 in. It consumes 30 W and is rated for 0–40°C. Enclosures and swing-arm mounts for wall, ceiling, or machine mounting are available. The cost of the 17.7-in. VAMP-Pan Vista, including guided-wave touch screen and all interface electronics, mounted in a rugged metal OEM frame, is $4490 and $3990 for the 13.8-in. display.

Information: Sales Department, Computer Dynamics, 7640 Pelham Rd., Greenville, SC 29615. 864/627-8800, fax 864/675-0106.

Circle no. 7

Ruggedized 13.8-in. AMLCD

Interstate Electronics Corp., Anaheim, California, has added a new 13.8-in. color AMLCD to their WarriorVision™ line of LCDs. Designed for operation in harsh environments, the display is being offered as a low-cost solution for a variety of airborne, shipboard, and ground-mobile applications. Available as a commercial off-the-shelf unit, the display features a resolution of 1024 × 768, a palette of 262,144 colors, and analog VGA or XGA video input. The ruggedized package features reduced size, weight, and power; infrared touch panels and sunlight-readability are among the options.

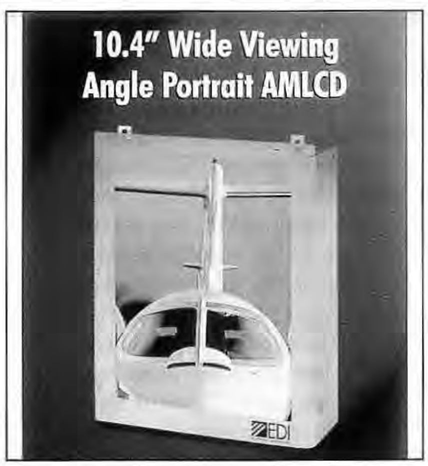
Information: Zeev Kalansky, Interstate Electronics Corp., 1001 E. Ball Road, P.O. Box 3117, Anaheim, CA 92803-3117. 714/758-0500; 1-800-854-6979; fax 714/758-4148.

Circle no. 8

Portrait TFT-AMLCD

Electronic Designs, Inc., Westborough, Massachusetts, has developed the EDI1D5, a 10.4-in. portrait low-profile color TFT-AMLCD module designed for tough applications in high ambient sunlight and harsh environments. The EDI1D5 offers 640 × 480 VGA resolution and an RGB digital interface, with ± 60° horizontal portrait viewing. Glass filters are optically bonded to the AMLCD and polarizer, creating a seal that provides protection against humidity and mechanical damage. The reinforced glass sandwich also protects the display against shock and vibration. Modules are ready for mounting into customized enclosures or bezels. Anti-reflective coatings, filters, and the high-brightness low-profile 200-fL backlight assist in making the displays sunlight readable. The operating-temperature range is from -20° to +70°C, with LCD and backlight heaters available to extend the low-temperature range. The EDI1D5 is priced at $4500 in quantities of 200.

Information: Electronic Designs, Inc., One Research Drive, Westborough, MA 01581. 508/366-5151, fax 508/836-4850.



Circle no. 9 ■

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.

calendar

Display Technology

The 17th International Display Research Conference and Workshops (IDRC '97). Co-sponsored by SID and the Advisory Group on Electron Devices (AGED) in co-operation with the IEEE Electron Devices Society. Contact: Ralph Nadell, Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014; 212/620-3341, fax -3379, e-mail: rnadell@newyork.palisades.org.
Sept. 15-19, 1997 Toronto, Canada

1997 Flat-Panel Display Strategic Forum and Technical Symposium. Co-sponsored by the University of Michigan, Center for Display Technology and Manufacturing. Contact: R. Donofrio, Display Device Consultants, 6170 Plymouth Rd., Ann Arbor, MI 48105; 313/665-4266, fax -4211.
Sept. 22-23, 1997 Ypsilanti, MI

The Third International Conference on the Science and Technology of Display Phosphors. Co-sponsored by the Phosphor Technology Center of Excellence, Defense Research Projects Agency, and Society for Information Display. Contact: Bill Klein, Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014; 212/620-3377, fax -3379, e-mail: bklein@newyork.palisades.org.
Nov. 3-5, 1997 Huntington Beach, CA

Fifth Color Imaging Conference: Color Science, Systems & Applications. Co-sponsored by IS&T and SID. Contact: IS&T, 7003 Kilworth Lane, Springfield, VA 22151; 703/642-9090, fax -9094.
Nov. 17-20, 1997 Scottsdale, AZ

Electronic Information Displays (EID '97). In association with the Society for Information Display. Contact: Association Exhibitors; +44-1822-614671, fax -614818.
Nov. 18-20, 1997 Surrey, U.K.

The Fourth International Displays Workshop (IDW '97). Co-sponsored by the Institute of Television Engineers of Japan and the Japan Chapter of SID. Contact: IDW '97 Secretariat, c/o The Convention; +81-3-3423-4180, fax +81-3-3423-4108.
Nov. 19-21, 1997 Nagoya, Japan ■

SID Conference Calendar

Next Show!

The 1997 International Display Research Conference

The 17th edition of the International Display Research Conference will be held at the Sheraton Centre Toronto Hotel in Toronto, Canada on September 15–19, 1997. The conference will emphasize research and fundamental development activities in display technology and related human interfaces. Full-day workshops on September 15 and 19 will focus on passive LCDs and materials; AMLCDs; and light-emitting materials and devices. Invited talks for these workshops will be presented in a format designed to stimulate discussion on recent advances and future directions of display research. Papers relevant to the advancement of the state of the art of electronic displays will be presented September 16–18, 1997.

15 SEPTEMBER 97

17th International Display Research Conference

TORONTO, CANADA
SEPTEMBER 15 – 19, 1997

- An international conference on display research and development aspects of:
  - Display Fundamentals, Display Devices
  - Hard Copy & Storage, Input Systems
  - Integrated Devices and Applications
  - Image and Signal Processing
  - Color Perception, Human Factors

3 NOVEMBER 97

Third International Conference on the Science and Technology of Display Phosphors

HUNTINGTON BEACH, CALIFORNIA
NOVEMBER 3 – 5, 1997

- An international conference on the future prospects of phosphors for:
  - ELDs – FEDs
  - CRTs – Plasma Displays
  - PL Devices – LC Backlights

16 NOVEMBER 97

Fifth Color Imaging Conference: Color Science, Systems & Applications

SCOTTSDALE, ARIZONA
NOVEMBER 17 – 20, 1997

- An international multidisciplinary forum for dialogue on:
  - Creation and capture of Color Images
  - Color Image reproduction and interchange
  - Co-sponsored with IS&T.

20 JANUARY 98

Display Works 98:

SAN JOSE, CALIFORNIA
JANUARY 20–22, 1998

- An international conference addressing all aspects of Display Manufacturing including:
- Flat Panel and CRT Manufacturing
- Display Materials
- Manufacturing Equipment
- Cost Reduction and Yield Improvement
- Industry Forecasts
- Investor Presentations
- International Standards

For additional information:
Lauren Kinsey
Society for Information Display
1526 Brookhollow Drive
Santa Ana, CA 92705-5421
714/545-1526, fax - 1547
socforinfodisplay@mcimail.com

SID

Since 1962, a professional worldwide interdisciplinary society committed to the advancement of information display.

FPD MANUFACTURING PROGRAM STATUS (Spring 1996)

To date, USDC's Technical Council has selected 36 priority programs covering various areas of process technology used in manufacturing FPDs. These include programs for establishing a U.S.-based supply of equipment, materials, or process technology, using existing technical know-how, as well as both evolutionary and revolutionary technology advancements. Twenty-four of these programs have been brought under contract and development has begun. The others are in various stages as summarized below.

Topic/Contractor	Program Cost ($M)	USDC ß-site	Status	Current Milestone
Color filters *Rohm & Haas, Shipley Co., Clarkson University*	1.8	Several	Contract completed; 12/96	Final report 3/97
Color filter fabrication			Canceled	
Pre-assembly test & inspection *Photon Dynamics*	2.4	dpiX	Development under way; 3/23/94 start	ß-site testing report 7/97
Treated substrates *Applied Films Corp.*	2.5	Several	Contract completed 7/96	Commercial supply in place
Polymer coating *Candescent, FAS Technologies*	2.7	FAS	Development under way; 7/12/94 start	β-site testing modifications implemented 5/97
Dry etching *Lam Research, Lawrence Livermore National Labs, University of Wisconsin*	15.1	dpiX	Development under way; 6/20/94 start	Contract completion 5/97
Glass supply *TBA*			On hold	
Glass inspection *Display Inspection Systems*	1.4	OIS	Development under way; 6/11/94 start	β-site testing in progress 4/97
Automated interconnect *Anorad*	4.4	Planar	Development under way; 10/28/95 start	Bond module operational 4/97
Spacer application & cleaning *Accudyne*	1.7	Accudyne, Photonics, Candescent	Development under way; 6/13/94 start	β-site testing at PDP facility in progress; spacer tool testing at Accudyne
Handling (benchmarking) *Competitive Strategies*	0.2	N/A	Study completed 10/1/94	Final report issued 3/95
Handling (cassette design) *Progressive System Technologies, H-Square*	0.7	Several	Development under way; 7/10/95 start	Modified Gen. 2&3 cassettes completed 3/97
Handling (tracking) *PRI Automation*	2.5	Candescent	Development under way; 7/7/95 start	Acquire and integrate new laser source 4/97
Factory modeling *IDC*	1.1	Several	Development under way; 2/9/96 start	Complete β-site evaluation enhancements (LCD & FED) 5/97
Handling (storage & retrieval) *PRI Automation*	1.6	Candescent	Development under way; 5/13/96 start	Multi-carrier compatibility demonstrated 5/97
Handling (manually guided transporer/loader) *PST*	0.35	Candescent	Development under way; 6/1/96 start	Fabricate β-site tool MTL 5/97
Large-area lithography *Tamarack Scientific*	2.1	Photonics Imaging	Development under way; 3/1/95 start	Installation at β-site 5/97
Large-area mask fabrication and blanks	3.8	Several	Development under way; 12/7/96 start	Install plate cleaning system 7/97
Direct laser imaging			Contract negotiation	Contract signing
Wet processing (etching) *CFM Technologies*	4.1	dpiX	Development under way; 2/12/96 start	β-site delivery 5/97
Polarizers, UV & retardation films *Polaroid*	10.9	Several	Development under way; 3/1/95 start	Clean room operational 4/97
Literature translation & database management *InterLingua*	0.4	N/A	Development under way; 2/15/96	Publish Nikkei 1997 FPD Yearbook 3/97

Topic/Contractor	Program Cost ($M)	USDC ß-site	Status	Current Milestone
Backlighting				
SAIT/BHK	4.5	Several	Development under way; 10/25/95 start	Report test results 4/97
Flat Candle	0.2	Several	Development under way; 12/15/95 start	Delivery of prototype lamps 5/97
Hughes Power Products	1.8	Several	Development under way; 4/1/96 start	Demonstration of first operational backlight 5/97
Glass cutting			RFP re-issued 2/10/97	Proposals due 4/18/97
Driver infrastructure				
Driver chips *Supertex*	1.1	Several	Development under way; 9/5/96 start	Low-voltage design completed 7/97
High-voltage TAB *Supertex*	0.4	Several	Development under way; 9/5/96 start	Develop test capabilities 6/97
Dielectric isolation wafers *Supertex, Bondtronix*	0.9	Planar	Development under way; 9/5/96 start	Produce 50 prototype wafers 6/97
ac/dc converters/inverters			Project canceled	
Plastic substrates *Dow Chemical*	3.5	Several	Developed under way	Identify desired co-polymer for sheet fabrication evaluation 4/97
Reactive ion etching *Plasma-Therm*	4.8	FED	Development under way; 7/3/95 start	Project completion and final report 4/97
High-resolution pattern lithography			RFP reissued 2/10/97	Proposals due 4/18/97
LC materials, processing, and alignment			Contract negotiation	Contract signing 4/97
Large-area vacuum sealing			Contract negotiation	Contract signing 4/97
Inorganic planarization layers			On hold	No proposals received
Patterned glass plate inspection & repair			Contract negotiation	Contract signing 5/97
Thin-film vacuum coating			RFP under review	RFP scheduled for issue 5/97
Cleaning technology			RFP issued 2/10/97	Proposals due 4/18/97
Glass sealing materials			RFP development	
FED getters and activation			RFP development	

Source: USDC News, Vol. IV, No. 5, Spring 1997

sustaining members

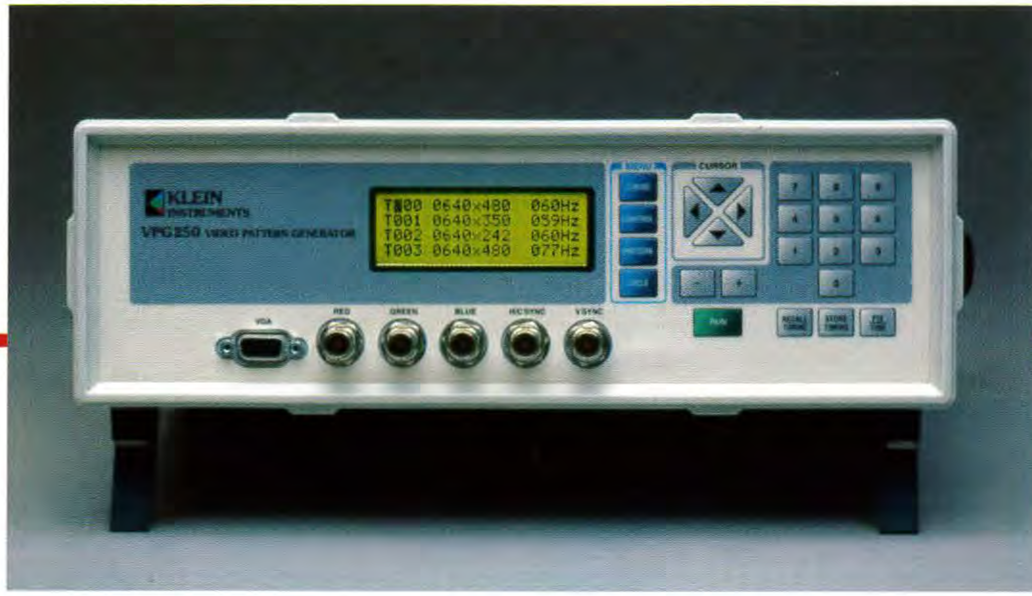
Acer Peripherals
Ad-Vance Magnetics, Inc.
Advance Reproductions Corp.
AlliedSignal, Inc./ MicroOptic Devices
Arconium
Brewer Science, Inc.
Brimar Ltd.
Canon, Inc.
Capetronic Computer USA (HK), Inc.
Celco
Cherry Electrical Products
Chunghwa Picture Tubes, Ltd.
Clinton Electronics Corp.
Corning Inc.
Corning Japan K.K.
Crystaloid LCDs
Dale Electronics, Inc.
David Sarnoff Research Center
Diagnostic/Retrieval Systems, Inc.
Display Inspection Systems
Display Laboratories
DNP Denmark
dpiX, A Xerox Company
Electronic Designs, Inc.
Electro-Plasma, Inc.
Endicott Research Group, Inc.
Epson America
FED Corp.
F-P Electronics
Flat Panel Display Co. (FPD) B.V.
Futaba Corp.
General Vacuum
Gerome Manufacturing
GE Plastics Japan Ltd.
Graseby Optronics
Grimes Aerospace Co.
Hewlett-Packard Co.
Hitachi, Ltd.
F. Hoffmann-La Roche
Honeywell, Inc.
Hoya Corporation USA
Hughes Lexington
Hyundai Electronics America
IBM Corp.
Imaging & Sensing Technology
Incom, Inc.
Industrial Electronic Engineers, Inc.
Industrial Technology Research Institute
In Focus Systems, Inc.
Infodex, Inc.
Innotec Group, Inc.
Interface Products, Inc.
Interserv Corp.
Interstate Electronics Corp.
ISE Electronics Corp.
Kent Display Systems
Libbey-Owens-Ford Co.
Linfinity Microelectronics
Litton Systems Canada Ltd. (2)
Loral Librascope
Man & Machine, Inc.
Micron Display Technology, Inc.
Micronic Laser Systems AB
Microvision Corp.
Minolta Corp.
Minolta Hong Kong Ltd.
Mitsubishi Electronics America
Motif, Inc.
Motorola FPD Division
MRS Technology, Inc.
NEC Corp., Japan
Nippon Seiki Co., Ltd.
Norden Systems Westinghouse
OIS Optical Imaging Systems, Inc.
OKI Electric Industry Co., Ltd.
Optical Coating Lab., Inc.
Photonics Systems, Inc.
Photo Research
Photronics, Inc.
Pilkington Micronics Ltd.
Planar Systems, Inc.
Plasmaco, Inc.
Polytronix, Inc.
Progressive Systems Technology, Inc.
Q.C. Optics, Inc.
Quantum Data Inc.
Raytheon Company
Regisbrook Group, Ltd.
Rockwell International
ROLIC Liquid Crystals R&D Co.
Schott Corp.
Semiconductor Systems, Inc.
Sharp Corp. - Japan
SI Diamond Technology
Sony Corp. of America
Sony Corp./Corporate Research Labs
Standish Industries, Inc.
Stanford Resources, Inc.
Steag MicroTech, Inc.
Supertex, Inc.
Syntronic Instruments, Inc.
Tamarack Scientific Co., Inc.
TEAM Systems
Techneglas, Inc.
Teledyne Electronic Technologies
Terapixel, Inc.
Thomas Electronics, Inc.
Thomson Components and Tubes Corp.
Toshiba America
ULVAC Technologies, Inc.
Viratec Thin Films Inc.
Wande, Inc.
The Westaim Corp.
WinTron
XMR Inc.

index to advertisers

Business and Editorial Offices
Palisades Institute for Research Services, Inc.
201 Varick Street, Suite 1006
New York, NY 10014
Jay Morreale, Managing Editor
212/620-3371 Fax: 212/620-3379

Sales Office
Palisades Institute for Research Services, Inc.
201 Varick Street, Suite 1006
New York, NY 10014
Erika Targum, Director of Sales
212/620-3375 Fax: 212/620-3379

A New Generation Of Video Pattern Generators



Based on a new generation of video chip sets...

Higher Performance Lower price
...and no cut corners.

That's as clean as it gets. That's Klein.

- **Field Programmable**
- **170-210-250 MHz Video**
- **2K X 2K Video Memory**
- **V Freq. 999.9 Hz max**
- **H Freq. 999.99 KHz max**
- **PC Interface: Store timings on PC**
- **Fully Remote Controllable**
- **More than 100 Standard Timings**
- **500 Programmable Timings**
- **32 Familiar Patterns Stored**
- **Timing Grouping Feature**
- **Universal 90-250vAC Power Input**
- **2 Unique Timing Entry Modes**
- **Auto Calibrated Video Outputs**
- **Easy To Read 4 Line LCD Display**
- **Portable 9 lb. Unit**

KLEIN INSTRUMENTS CORPORATION
8948 SW Barbur Blvd. Dept. 100
Portland Oregon 97219
Ph: (503) 245-1012 Fax: (503) 245-8166
Email: sales@KleinInc.com
web site at www.KleinInc.com

Circle no. 31