

Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

SID

August 1997 – Vol. 13, No. 8

ANNUAL DIRECTORY OF THE DISPLAY INDUSTRY

**The Computer
of the Future?**



Industry Directory
Scanning Laser Projectors
Photocathode Displays
MPEG-2 vs. MPEG-1
Letters: Holzel Attacked!

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AUGUST 1997
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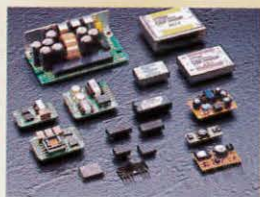
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INFORMATION DISPLAY

AUGUST 1997
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COVER: One of the main attractions at CeBIT '97 was Panasonic's Panel PC CF55, scheduled for a September '97 launch. The compact housing contains a 14.5-in. 1024 x 768 (XGA) LCD monitor and the necessary parts of a PC - notably a 150-MHz Pentium processor, a 1.2-GB hard drive, two PCMCIA card slots, a floppy disk drive, and a CD-ROM drive. For more on CeBIT, see Bryan Norris's article beginning on page 26.



Credit: Panasonic Deutschland GmbH

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

Next Month in *Information Display*

SID '97 Review Issue

- Overview
- CRTs/FEDs
- LCDs
- Emissive displays
- Flat-panel displays
- Manufacturing

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Shootout at the SID Corral

Tom Holzel's guest editorial in our March issue on alleged deficiencies in the ways PDPs and LCDs render video imagery has stimulated vigorous response. The responses have ranged from a casual verbal "Of course people prefer to watch video on CRTs" from several people in the CRT and TV businesses to a wide range of verbal, faxed, and e-mailed responses from people in various segments of the display industry.

For a sampling, see the "Letters to the Editor" column in this issue.

In the "Letters" column, Holzel responds by suggesting a side-by-side comparison of 40-in. displays showing entertainment programming in a controlled viewing environment. Consultant Fred Kahn goes further, and recommends a broadly based "shootout" of direct-view technologies with a variety of input material. Kahn's model is a smaller, direct-view version of the Video Projection Shootout that has become a popular feature of the annual InfoComm show.

Initial conversations at SID '97 in Boston indicated substantial interest in this kind of event, particularly if a wide range of imagery is used. Ray Soneira of Sonera Technologies, which supplied custom test patterns for this year's InfoComm shootout, has offered to develop appropriate custom patterns for a direct-view shootout. Phil Heyman, SID Convention Chairman, has authorized incorporating the event as part of SID '98 in Anaheim, California, if there is sufficient interest.

So, this is an RFP - request for participation - in the first SID direct-view display-technology shootout. Technical, ergonomic, and imagery details will be worked out with a committee of participating companies, but here are the initial ground rules:

- Participation is open to all exhibitors at SID '98 with products that fit into one of the shootout categories.
- There will not be any fee for participation, but participants will be expected to provide technical support for the event as a whole.
- All displays (or all displays within a particular category) will be provided with the same imagery. Care will be taken to use a distribution network that provides all displays with equivalent signals, and controller issues will be addressed fairly.
- Participants will be invited to join technical, ergonomic, and general advisory committees.

If you are interested in participating in the shootout or in obtaining more information, please contact: Shootout at the SID Corral, c/o Nutmeg Consultants, 2 Shady Brook Lane, Norwalk, CT 06854, e-mail: kwerner@netaxis.co, fax: 203/855-9769, phone: 203/853-7069.

We believe the shootout will be an exciting event that will draw even more people to the SID '98 show and symposium and increase SID's profile among OEMs and corporate users. Equally important, the show will provide designers and manufacturers of displays, monitors, and controllers with a valuable source of subjective performance information we do not now have.

Oil your six-shooters, pahdner, and sign up now for your place in *The Shootout at the SID Corral*.

- Ken Werner

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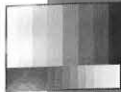
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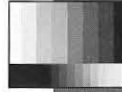
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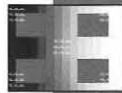


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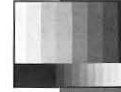
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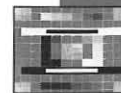
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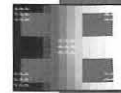
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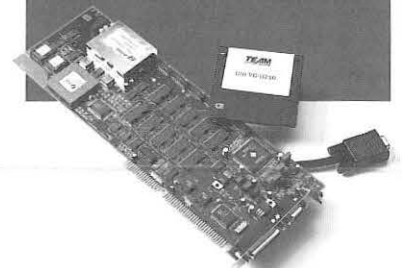


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Illusory 3-D Illusions ...

by Aris Silzars

A long, long time ago, in the October 1993 issue of *Information Display Magazine*, there appeared a column by this very author under the provocative title, "Is Virtual Reality About to Become Real Reality?" In this column, I suggested that by January 1997 there *could* be a consumer product called a Virtual

Reality Chair - a home-entertainment experience with 3-D computer graphics, surround sound, and interactivity. I asserted that all the necessary technological pieces were in place, and one would simply need to integrate them cleverly to create the product. Of course, the implicit assumption was that there would be a company or business entity that would find such an undertaking financially interesting.

Ah, but the world is not such a simple and predictable place. Just because a technology is available to create a certain product does not mean that the marketplace will respond. The progress of virtual reality for consumer applications hit a major snag when people and companies began to have concerns about display-induced motion sickness and even the possibility of long-term disorientation - like a lumpy airplane ride into eternity. And to complicate matters further, at about the same time, video games hit a temporary plateau in their popularity.

Nevertheless, the concept of an entertainment experience must have continued to bubble in at least a few creative technical and business minds. "If we can't get a product into a home and if we can't get quite everything that we want from the display technology, then what can we do?" must have gone the thinking. And with a bit of creativity and a slight modification of the Virtual Reality Chair concept, what recently burst onto the Seattle entertainment scene was ... **GameWorks**. This venture - bankrolled by DreamWorks SKG, Universal Studios, and Sega Enterprises - at the corner of Seventh and Pike, right next to Nike-town, has not just one Virtual Reality Chair, it has several hundred of them. Not only that, the price for a few minutes of fun is measured in dollars instead of quarters. Additional features are that some of the simulated auto and motorcycle races allow several players to simultaneously and interactively compete with each other.

Since GameWorks opened its doors within one month of when I had predicted we would have a Virtual Reality Chair product, it was no coincidence that I was one of the early visitors to search out what this purportedly new experience was all about. "Just how good is the display technology and what technologies are they using," I was anxious to know. The actuality turned out to be somewhat more mundane than the local newspaper articles had indicated. The game stations are all based around 50-in.-diagonal (approximately) projection displays, with each player sitting in a mock-up of a simulated car, motorcycle, or space vehicle that provides a modest amount of interactive mechanical motion. Sound is added with a rudimentary surround system. The display quality is similar to that of a good conventional projection television playing from a laser disk. The displays are bright and crisp-looking, with good off-axis brightness. Some of this is due to the dark walls and subdued lighting within the two-story open-ceiling building. At the simulated Indy 500 auto race game, which has eight side-

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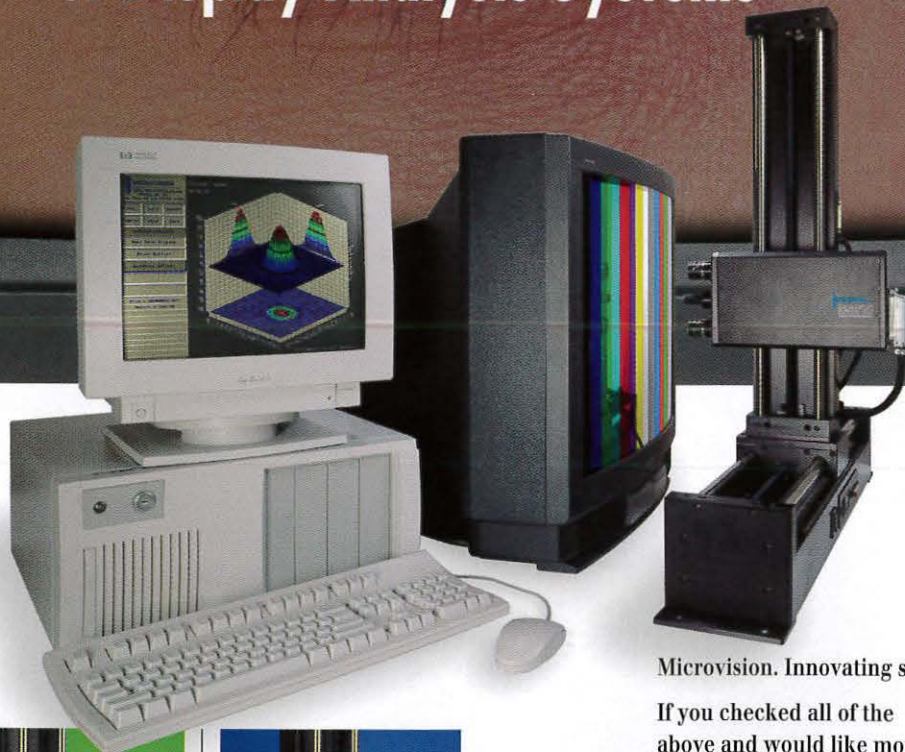
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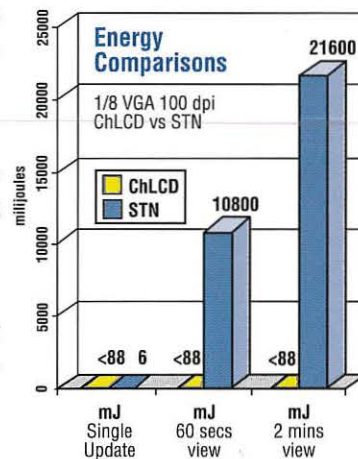
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Photocathode Displays

Marrying an inexpensive monochrome display to a photocathode image intensifier/color converter provides all the benefits of an FED without any of the problems.

by Brad Culkin

THE NEW TECHNOLOGY that currently seems most likely to provide some honest competition for plasma display panels (PDPs) and liquid-crystal displays (LCDs) is the field-emission display (FED). The FED combines a field-emitting cold cathode with light-emitting phosphors to produce a CRT-like image from a thin, flat package. At New Logic International, we are using another cold-cathode technology that, we believe, offers significant advantages over the FED approach. This new cold-cathode display uses a photocathode instead of field emitters to produce electrons. The resulting display is called a photocathode display (PCD) (Fig. 1).

How It Works

A PCD is a proximity-focused diode intensifier, the photocathode of which is closely coupled to a monochrome flat-panel display (FPD) (Fig. 2). The device can be modified to function as a color converter as well as an intensifier.

Conceived in 1930, and mass-produced beginning in the 1970s for military night-vision devices, the diode intensifier uses a semitransparent photocathode to produce an electron image through the photoelectric effect. The electron image emerging from the front of the photocathode is analogous to any photo image impinging upon the rear of the

photocathode. The high potential of the aluminized phosphor screen accelerates these photoelectrons directly across the high-vacuum gap, providing a luminance gain of about 100. (The screen is aluminized to prevent light from returning to the photocathode.)

PCD vs. FED

The limiting resolution of a proximity-focused diode intensifier is determined by the random energy of the photoelectrons as they leave the

photocathode. Fortunately, this random energy is only about 0.2 eV, which is much less than the random energy of field-emission electrons. The low photoemission energy sets the limiting resolution of a proximity-focused diode intensifier at about 70 line pairs/mm. This is the key reason why a photocathode is a better source of cold electrons than a field-emitter array (FEA).

FEDs would be nearly as simple to build as the intensifier described here if only the field-

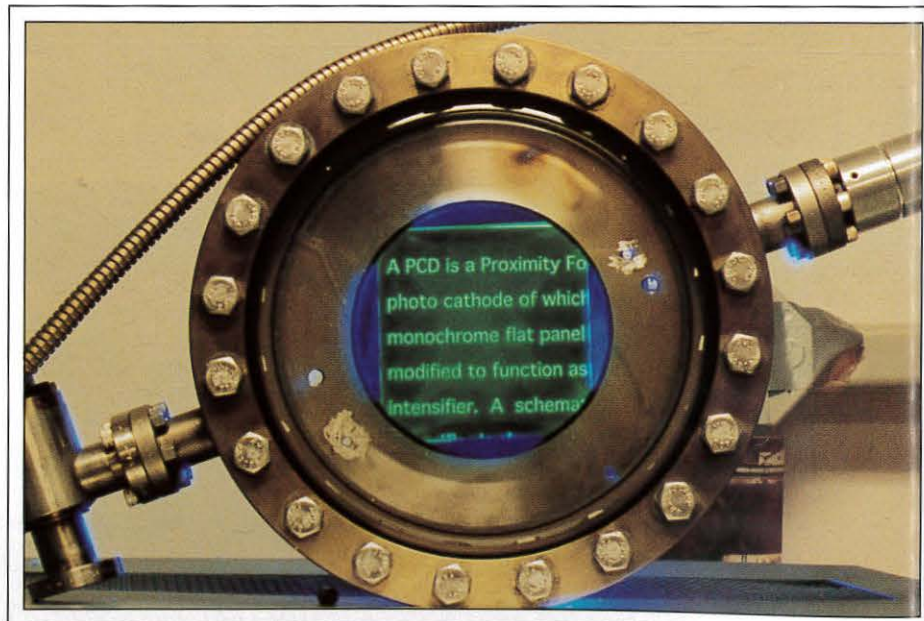


Fig. 1: Shown is a 3 × 3-in. photocathode display (PCD) prototype fabricated by New Logic International.

New Logic International

Brad Culkin is President of New Logic International, Inc., 1295 67th St., Emeryville, CA 94608-1120; telephone 510/655-7305 x230; fax 510/655-7307; e-mail: nli@vsep.com.

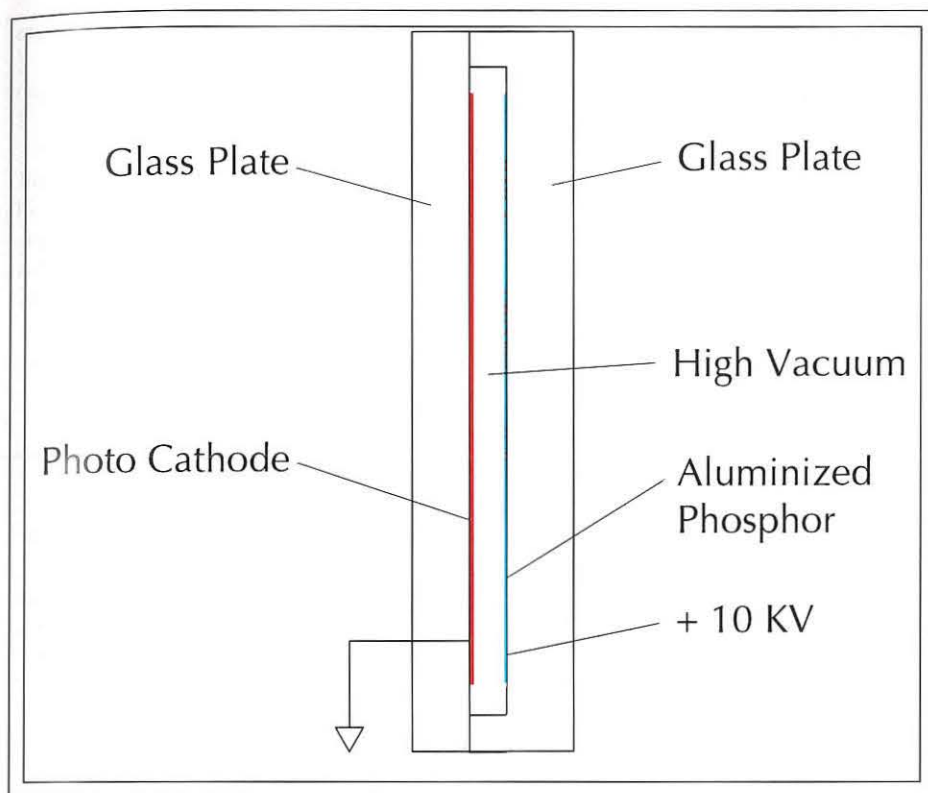


Fig. 2: A PCD is a proximity-focused diode intensifier, the photocathode of which is closely coupled to a monochrome flat-panel display.

emitted electrons were as low in energy as photoelectrons. Unfortunately, this is not the case.

The field-emission process uses high electric fields to extract electrons. The high field is produced by focusing an extraction potential of about 100 V at the tip of a micro-electrode. The tip of the electrode is roughly hemispherical, and the high-field region extends over this half sphere.

Electrons extracted by this field emerge at a velocity equivalent to about one-fourth the extraction potential, *i.e.*, at about 25 eV, in the direction of the extraction field. Since the electric-field lines near the tip are everywhere normal to the half sphere, the field-emitted electrons spray in all directions normal to the half sphere. They have parabolic trajectories instead of trajectories that are straight lines across the gap, as occurs in a photocathode image intensifier. More precisely, there is beam spreading in both PCDs and FEDs because of randomly directed electron emission, but the spreading in PCDs is only one-hundredth of that found in FEDs.

FED designers are currently attempting to overcome this field-emission problem with two competing FED designs. The low-voltage approach uses very-narrow-gap proximity focusing to prevent beam divergence from degrading the screen resolution. The second approach uses a focusing structure to control beam spreading and a high anode voltage with a wider anode-to-cathode gap. The low-voltage system is commercially available, but there are many questions concerning life and luminous efficiency, especially for color displays. The high-voltage systems - which require focusing electrodes to be supported above the emitters - are in development. Only time will tell how easy or difficult it will be to build these more complex displays.

Manufacturing a PCD

The input signal to an FED is electronic; the input signal to a PCD's image-intensifier section is necessarily optical. In fact, the input signal is provided by another display. The case for PCDs requires that they be less complex than FEDs, *i.e.*, the input display must

not add more complexity to the finished device than do the cathode and focusing structures of FEDs.

In a color PCD we have developed, the monochrome video image source that is close-coupled to the photocathode is an ac powder thick-film electroluminescent (TFEL) display (Fig. 3). This technology, which is used for LCD backlights, never achieved serious consideration for direct viewing because the contrast ratio (CR) of a Destriau-type powder EL display is very poor at a usable luminance of 200 cd/m². The poor CR is due to insufficient output nonlinearity (Fig. 4). Note the small luminance variation between 100 and 200 V. The technology also suffered from high emissivity, leading to poor CR in ambient lighting, and good color was never achieved.

In a photocathode display, these issues are of no concern. The video image source only needs to produce about 2 cd/m². Figure 3 shows that drive nonlinearity and CR are excellent at this low luminance. The image source's emissivity is irrelevant since it is close-coupled into the photocathode, and the blue-green output of common EL phosphors is perfect for producing efficient photoemission. Both the drive voltage and current are low, so STN drivers can be used. Most important, since the thick-film display is outside the high-vacuum envelope it can be prefabricated and tested at ambient pressure using standard thick-film methods.

The total cost to manufacture a PCD is therefore the combined cost of the STN drivers, a thick-film monochrome EL panel, and a diode intensifier/color converter. Because the design is modular, each subcomponent can be tested before proceeding to final integration of the image source and the intensifier. The same modularity allows many choices for the image source.

By registering the monochrome EL panel pixels to coincide one-to-one with corresponding red, blue, and green phosphor domains on the anode, this display can produce a full-color direct-view image. There is no need for registration between the photocathode and the phosphor screen or the image source, because the photocathode is a featureless metal film.

Electronically, the intensifier is a diode. Inside the high-vacuum envelope there are no focusing structures, current-limiting resistors, emitter arrays, matrix-addressing electrodes,

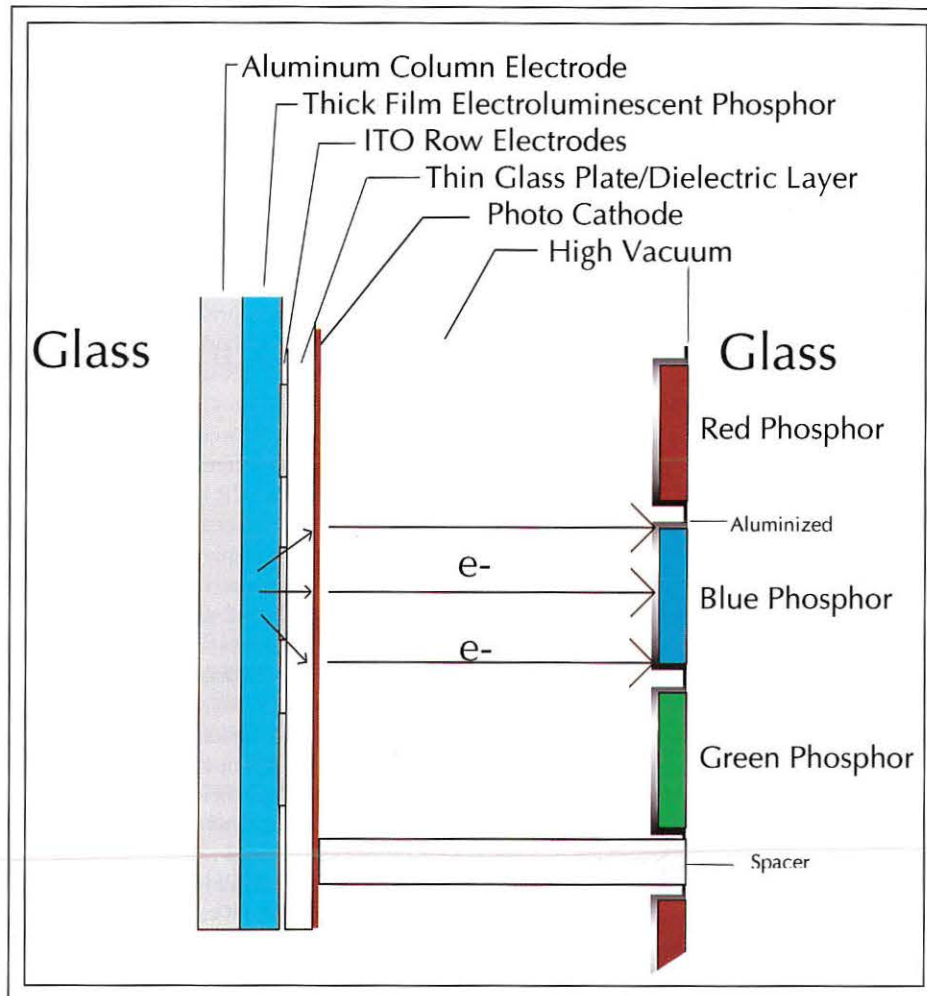


Fig. 3: One type of color PCD uses a monochrome ac powder EL image source that is closely coupled to the PCD's photocathode.

or extraction grids, as are found in FEDs. Only two electrodes pass through the high-vacuum seal.

Making the photocathodes used in the proximity-focused intensifier is well understood because of the decades of manufacturing experience in the night-vision industry. Photocathodes are also used in image orthicons, photomultipliers, x-ray intensifiers, and scintillation counters. Typically, a thin film of antimony is applied by sputtering. It is then reacted with an alkali metal by vapor infiltration after the device is assembled, and pumped down. Alternatively, in the "spray method," the antimony and alkali metal are co-deposited under high vacuum, and the device is then assembled using an indium press seal.

Photocathode performance requirements for a PCD are much less rigorous than those needed for night vision. Night-vision devices require sensitivity to red, so multi-alkali metal films are used.

These films require elaborate procedures to produce and they are limited to about 60°C operation and storage. Because their low-work-function surface layers are susceptible to chemical attack, very high vacuums are required, and gettering doesn't help because the photocathode itself is a getter.

But if we only require the photocathode to be sensitive to blue light, much simpler and more chemically robust films can be used. An easily made sodium-potassium-antimony film, for example, gives excellent quantum efficiency at 450 nm, and can operate at well over 150°C.

This cathode is unaffected by small residual gas concentrations of oxygen, water, etc.

The only element of PCD design and manufacture that is not a *fait accompli* is spacers. Spacers are not used in night-vision systems because they can easily be eliminated in small intensifiers spanning less than 6 cm, and small PCDs can be manufactured using night-vision assembly methods without modification. This means that small PCDs for cellular-phone displays, automotive displays, toys, and ocular displays can be produced by known methods.

For laptop-computer displays spanning 20 cm or so, spacers must be used. Candescant Technologies claims to have successfully used 50 × 500-μm spacers of proprietary composition in a high-voltage FED. Our own work suggests that spacers with even higher aspect ratios can be made by using strips of mica. This material is ideal because it is ductile, like aluminum, and thus suitable for load sharing by adjacent beams. More-rigid materials - like glass or ceramic - are problematic because point loading at high spots results in fracture instead of yielding behavior.

Typical cathode-to-anode distances in PCDs are between 0.5 and 1 mm. A typical spacer is a strip of 50-μm-thick mica that is made slightly conductive by applying a conductive oxide film. The mica strips are then sheared or die cut to the desired width and placed periodically as simple beam supports between the cathode and anode. The conductive layer bleeds charge away from the spacer, preventing avalanche ionization and dielectric breakdown. The conductive layer also guarantees the electric field will be uniform, even near the spacers. Mica is strong, available in large sheets, and compatible with high-vacuum bake-out requirements.

All of the discrete PCD subsystems - the monochrome image source, the photocathode, and the aluminized P22 phosphor screen - are proven, readily manufactured components. In contrast, it remains to be seen whether FEDs can economically overcome the problems of lifetime, low-voltage color-phosphor development, electron focusing, micro-tip and micro-resistor array processing, and high-yield manufacturing.

Advantages of PCD Technology

High efficiency. PCDs are very efficient. Power consumed by the image source is negligible at 2 cd/m². By shifting the energy con-

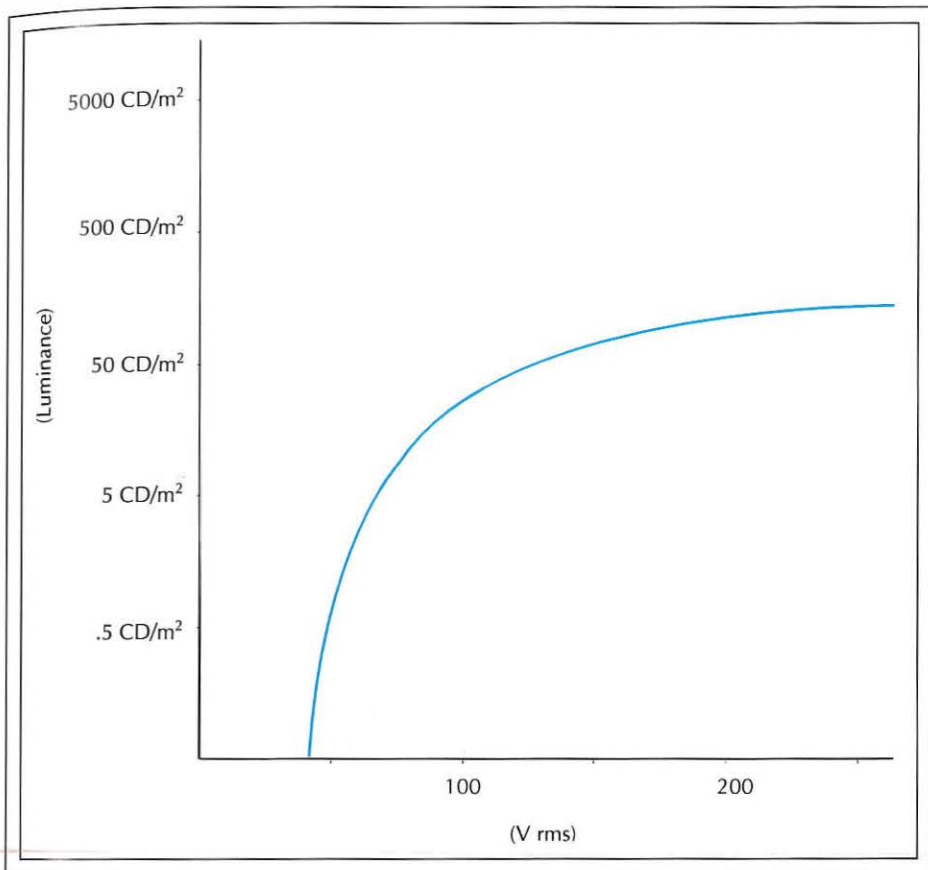


Fig. 4: Powder EL never achieved serious consideration for direct-view displays because the contrast ratio is very poor at high luminance due to insufficient output nonlinearity. This not a problem in PCDs because the powder EL display is operated in the low-luminance portion of its luminance-voltage curve.

sumption away from the image source and toward the intensifier, the overall efficiency is dominated by the intensifier efficiency, which for the aluminized P22 phosphor running at 10 kV is 40-50 lm/W.

Shifting energy use away from the image source and toward the intensifier has other advantages, too. Running the monochrome image source at 2 cd/m² means low drive voltage, low drive currents, and excellent life. These are important when producing very large displays, where line capacitance and ohm/square limits often define performance.

High luminance. PCDs can produce very high luminance. An intensifier gain of 100 combined with an image-source luminance of 50 cd/m² implies an output luminance of 5000 cd/m². Directly sunlit applications, such as avionics, automotive, and industrial process control, can exploit this capability using, for

example, a TFEL display or a backlit LCD as the image source.

Simplicity. The early promise of FEDs - which were remarkably similar to PCDs in their theoretical simplicity - has yielded to a more complex reality based on hard experience. In contrast, far from being a theoretical construct, the PCD is an integration of two mature technologies. We have extensive experience making the elements of PCDs, and we know that intensifiers and low-luminance monochrome displays can be built.

Where Do We Go from Here?

We believe PCDs can compete across the gamut of display applications. From miniatures through laptop computers to wall-sized displays, PCDs offer high luminance, high efficiency, and full color. They yield direct-view images of CRT quality at temperatures

to 150°C and above. Most technical hurdles to volume manufacturing have already been overcome through decades of experience in producing diode intensifiers and CRTs.

The low required luminance of the image source invites the use of remarkably simple, low-cost, and easy-to-build monochrome display technologies. This idea of using a display as part of a display may seem like unnecessary complexity at first, but it is really an elegant solution to a general and vexing problem. It is extremely hard to achieve high luminance and good color and high efficiency and good contrast and long life and direct view, all at the same time, from any fully integrated display technology, whether it be PDP, FED, TFEL, or LCD. It is much simpler to demand only good contrast and long life from a monochrome image source, and to demand only high luminance, good color, direct view, and long life from an image intensifier. The marriage of these is the PCD, a product much greater than the sum of its parts. ■

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Where Do the Different MPEG Standards Fit?

MPEG-2 provides bigger, higher-definition images than MPEG-1, so MPEG-1 is obsolete, right? Wrong.

by Pier L. Del Frate

FOR YEARS, the PC industry has looked for improved ways of delivering higher-quality video and audio content to the home. Transmitting video and audio in digital format is a major step toward achieving this goal, but it requires high-speed transmission and storage to succeed.

A single frame of uncompressed digital video displayed on a TV equates to roughly 1 Mbyte of data that must be transmitted. For 1 second of video - roughly 30 frames - 25 Mbytes must be transmitted. Saving a standard full-length feature film - 135 min - requires roughly 200 Gbits of storage space. Without some form of digital compression, cost-effective storage or transmission of such data isn't possible. Fortunately, a solution exists that delivers compression factors of up to 100:1.

MPEG Solves the Problem

MPEG refers to the Moving Pictures Expert Group - the industry group established to develop an algorithm for compressing and decompressing moving pictures - but perhaps a more deft interpretation of the acronym is Moving Pictures by Educated Guesswork! Guesswork is apt because the algorithm tries

Pier L. Del Frate is vice president of marketing at Mediamatics, a wholly owned subsidiary of National Semiconductor, located at 48430 Lakeview Blvd., Fremont, CA 94538; telephone 510/668-4850 x225; fax 510/668-4860; e-mail: pdelfrate@mediamatics.com. Mr. Del Frate has over 20 years' experience in graphics digital video and multimedia engineering and marketing.

to eliminate unnecessary replication of data by predicting future frames and eliminating areas that don't change from one frame to the next. By anticipating these "static" areas, MPEG stores the frames in a more efficient way.

The MPEG algorithm splits a picture frame into a grid of 16×16 macro blocks, and then determines the change between each macro block in succeeding frames. High-quality compression is achieved by the encoder's ability to look both forward and backward from a given frame to accurately compress the information. The decoding process works similarly: information on what has changed from frame to frame is used to efficiently play back the content.

With the emergence of the Digital Versatile Disc (DVD) and MPEG-2 technology, many are questioning the future of MPEG-1. Will the higher video quality of MPEG-2 eliminate MPEG-1 just as 16-bit audio quickly replaced lower-quality 8-bit audio? To set the record straight, MPEG-2 wasn't designed to replace MPEG-1. Rather, MPEG-2 supplies a different market that needs higher levels of video and audio quality. Because MPEG-1 and MPEG-2 serve different needs, they can co-exist without infringing on each other. To better understand this, let's look at the differences between these technologies and then examine where each fits in the PC market.

Technology: Separate but Not Equal

MPEG-1 produces video of a quality equivalent to that produced by most VCRs. It provides a picture that is 352×240 pixels in size - about one-quarter the size of an NTSC TV picture - and provides CD-quality audio. It

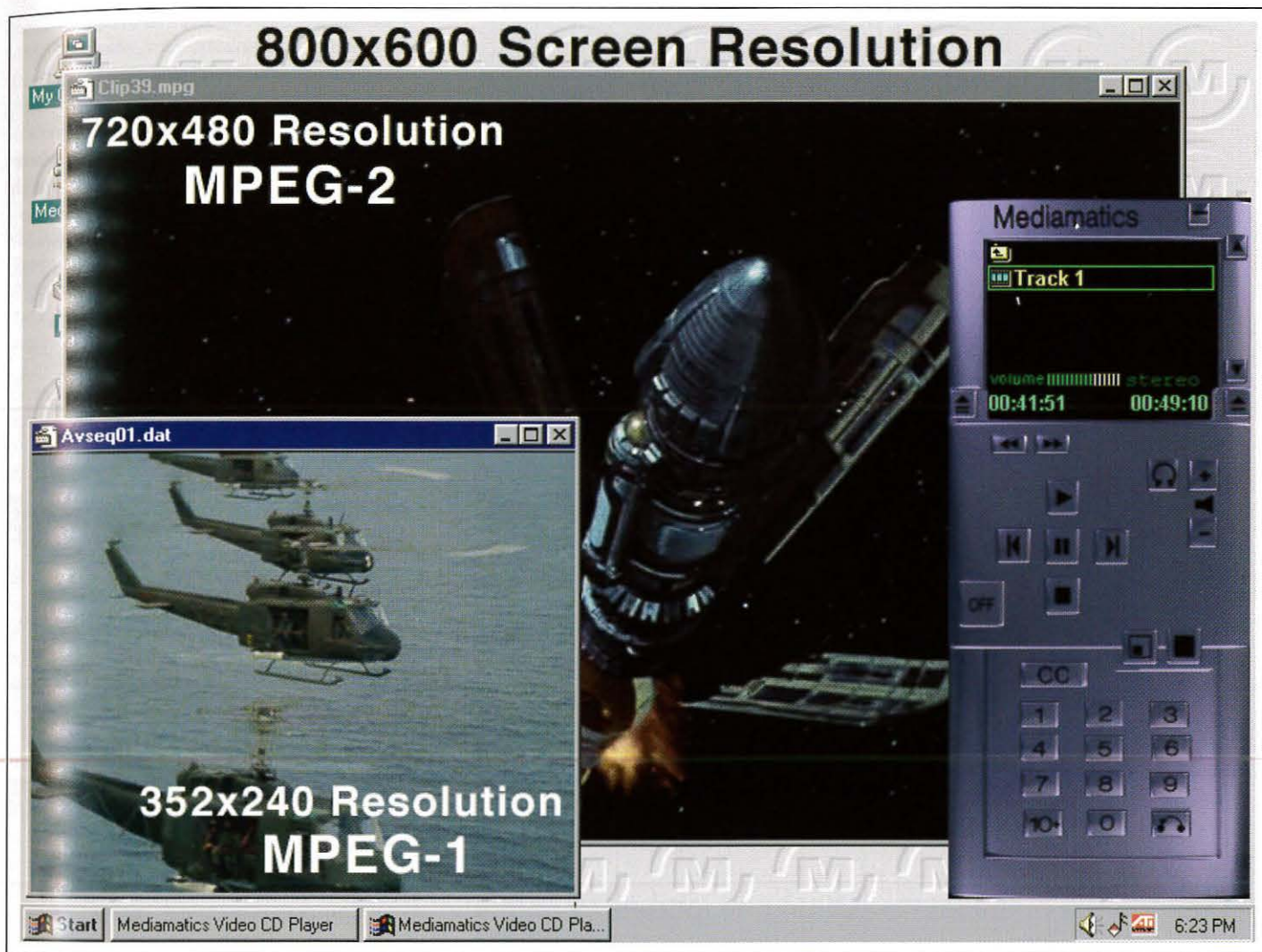
requires approximately 150 kbytes to store 1 second of MPEG-1 video and audio data.

MPEG-2 produces images of 720×480 pixels - four times the size of MPEG-1 images - with higher resolution and Surround Sound (Fig. 1). The technology provides a "better-than-TV" display of laser-disc quality and requires a minimum of 600 kbytes to store 1 second of video and audio information. It would follow then that MPEG-2 is better than MPEG-1. But is it?

MPEG-2 does indeed provide better video and audio quality than MPEG-1, but it does so at notably higher cost. MPEG-2 requires more decoder memory, faster processors, higher-density storage devices (both players and CDs), added speakers, and expensive video and audio decoders. For best results, the technology also requires high-end display monitors and TVs. A 133-MHz Pentium[®] processor, for example, can decode and display an MPEG-1 video and audio stream in real time - 30 frames per second (fps) - all in software (Table 1). With MPEG-2, a P55C MMX-enhanced processor running at 266 MHz is required to achieve similar performance. Such processors are not expected until 1998. In addition, MPEG-2 encounters system bottlenecks that affect delivery of laser-disc-quality playback on PCs. (Fortunately, this issue is being addressed by a new breed of MPEG-2 accelerated graphics controllers.)

A Matter of Taste

MPEG-1 and MPEG-2 are designed for two very different market segments (Table 2). MPEG-1 is designed for a market where video



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Fig. 1: This screen shot from an SVGA display clearly indicates a major difference between the two versions of MPEG. MPEG-1 offers maximum logical image dimensions of 352×240 pixels; MPEG-2 offers a maximum of 720×480 pixels.

quality is not paramount, but where cost, file size, and data-transmission rate are the major concerns. In the consumer-electronics market, MPEG-1 proved ideal for VideoCD and Karaoke players, particularly in Asia, where content was readily available. But in the United States and Europe, where content was scarce, MPEG-1 achieved limited acceptance.

The market for MPEG-1 is in PCs, primarily on the desktop. With PCs, MPEG-1 became a standard feature, fueled by the availability of cost-effective software-based MPEG playback in Microsoft's Windows™ operating system. (The software was licensed from Mediamatics.) Currently, every Pentium PC

sold to the home market provides this functionality without additional cost.

Because of the technology's worldwide availability and its standard Windows interface, MPEG-1 clips are becoming widely used to demonstrate ideas and enhance learning. Uses range from electronic encyclopedias and games to educational applications and training programs. These applications do not require HDTV-level quality, but they do need better video quality than was previously provided by AVI technology. MPEG-1 fits the bill.

MPEG-1 is also seeing increased use over corporate intranets. While the Internet does not have the necessary bandwidth to transmit

video in real time, local-area networks (LANs) and intranets do. Companies can enhance corporate and training materials with streamed video and immediately distribute it via the intranet. Users can easily access this centralized information from their desktops at their convenience.

This functionality comes with little added cost, for most PCs today offer software MPEG-1 decoding as a standard feature. Since MPEG-2 requires four times the bandwidth of MPEG-1, this technology would bring even the most advanced intranet to its knees, particularly if several users were accessing content simultaneously. For this

video compression

Table 1: CPU Usage for MPEG-1 and MPEG-2

Function	MPEG-1 P5-133 (no MMX)	MPEG-1 P55C-200 (with MMX)	MPEG-2 P55C-200 (with MMX)	MPEG-2 P55C-233 (with MMX)
Basic graphics controller				
Frames per second (fps)	30	30	22	24
Audio quality	AM	CD	AC3	AC3
CPU utilization	80%	40%	100%	100%
MPEG-2 accelerated graphics controller				
Frames per second (fps)	30	30	30	30
Audio quality	AM	CD	AC3	AC3
CPU utilization	80%*	40%*	90%	80%

*Does not use acceleration logic for MPEG-1 decoding.

reason and others, MPEG-2 will achieve greater success in markets with different needs and demands.

Top-of-the-Line Entertainment

The main focus of MPEG-2 is home entertainment rather than the office. In this market, motion-picture-quality video and audio are most important. We are speaking here of users who will watch movies on 35-in. living-room displays using a PC rather than relying on the standard TV/VCR combination. Because MPEG-2 delivers theater-quality video and Surround Sound, ordinary PCs are transformed into full-featured entertainment systems.

MPEG-2/DVD formats promise to improve on VHS videotape in cost, durability, and content. The cost of manufacturing a VHS tape is around \$2.00, while the cost of pressing an MPEG-2/DVD disc is under \$1.00. While VCR tapes degrade with time and use, DVD discs retain their high-quality levels. DVD technology also gives content providers - primarily Hollywood movie makers - enhanced copyright protection that makes content piracy difficult. This should help promote the creation of DVD content, and should rapidly make available a wide variety of MPEG-2 titles. As these titles become available, the consumer-electronics industry will likely adopt this standard in lieu of MPEG-1.

MPEG-2 is also used in Digital Video Broadcast (DVB) technology, which provides HDTV to digitally savvy homes. As the

demand for higher-quality video increases, MPEG-2 should also penetrate digital TV cable systems.

Staking PC Ground

Since MPEG-2 provides better video and audio quality, why not use it for all applications, including the PC? The answer lies in cost and storage capacity.

Currently, MPEG-1 is free on the PC when done in software. Today's CPUs have enough processing power to perform video and audio decoding tasks with low-cost software. Standard CD-ROM drives, shipped with most PCs, provide MPEG-1 playback. MPEG-1 on the PC clearly demonstrated that to succeed a technology must be low in cost. More accurately, it must be free to the end user. Buyers will not tolerate additional cost for functions that are used sparingly.

So, will MPEG-2 make it to the PC? Yes, but only if the technology is free or if the PC moves into the living room and attaches to the TV as a "living-room PC." The "free technology" scenario is more likely.

To play MPEG-2 on PCs using software only, CPUs need to be faster, and system bot-

Table 2: Comparison between MPEG-1 and MPEG-2

Function	MPEG-1	MPEG-2
Design focus	PC, games, video, CD	Digital broadcast TV, DVD
Image quality	VCR	Laser disc
Image resolution	352 × 240 (NTSC) 353 × 288 (PAL)	720 × 480 (NTSC) 720 × 576 (PAL)
Audio quality	CD quality	Surround Sound
Speakers/channel supported	2 (stereo)	6 (5 plus a subwoofer)
Average bit rate (kbps)	150	600
Drive	Single-speed CD-ROM	6X CD-ROM or DVD
CD-ROM-drive price	~\$50	~\$75
CD-ROM storage (600 MB)	72 minutes	17 minutes
DVD-drive price	not required	>\$300
DVD storage (4.7 GB)	564 minutes	141 minutes
Decoder memory required	1/2 Mbyte (\$5)	2 Mbyte (\$20)
CPU requirement for full software playback	P5 133 MHz ^a	P55C 200 MHz ^b
Hardware video-decoder price ^c	~\$15 (includes audio)	~\$35
Hardware audio-decoder price ^c	\$0 (in video decoder)	~\$23

^aRequires video accelerated graphics controllers.

^bRequires MPEG-2 accelerated graphics controllers.

^cNot required on PCs using software decoders.

tlenecks need to be solved. Faster CPUs with MMX technology are starting to resolve the speed issues, while MPEG-2 accelerated graphics controllers are addressing system bottlenecks. Together, they will provide the processing horsepower needed for free MPEG-2 playback on the PC.

Matching the Product to the Consumer

The bottom line for the success of either MPEG standard is user experience. If users like it they'll buy it, regardless of how it's implemented. If it's free, even better!

On the consumer-electronics side, MPEG-2 has the advantage of providing improved video and audio quality. Unlike VHS tapes, DVDs won't degrade over time. DVD also offers interactive features and parental control. We believe users will want and enjoy these features.

To content providers, DVD provides inexpensive copyright protection. Also, the price point of DVD players will quickly decrease as production capacity increases and as more and more of the electronics is integrated on fewer and fewer chips. Users will like this even more.

On the PC side, MPEG-1 has the lead. It is shipped free with most home PCs today; Microsoft includes an MPEG-1 player with its Windows OS. Also, MPEG-1 is well suited for use in training applications and over the corporate intranet. But MPEG-2 is virtually certain to gain similar acceptance on PCs when, like MPEG-1, it is offered free to end users. This will occur as CPU manufacturers provide added horsepower and graphics-controller companies provide the necessary acceleration to allow software-only playback.

At Mediamatics, we have committed ourselves to helping bring cost-effective MPEG-2 to the PC, as we did with MPEG-1. It is software decoders such as those developed by Mediamatics that will enable DVD functionality in PCs at no additional cost to end users. A likely result is that users will continue to demand larger, higher-resolution displays when they buy their PCs, and that "living-room PCs" accompanied by very large, high-resolution displays will grow in popularity. ■

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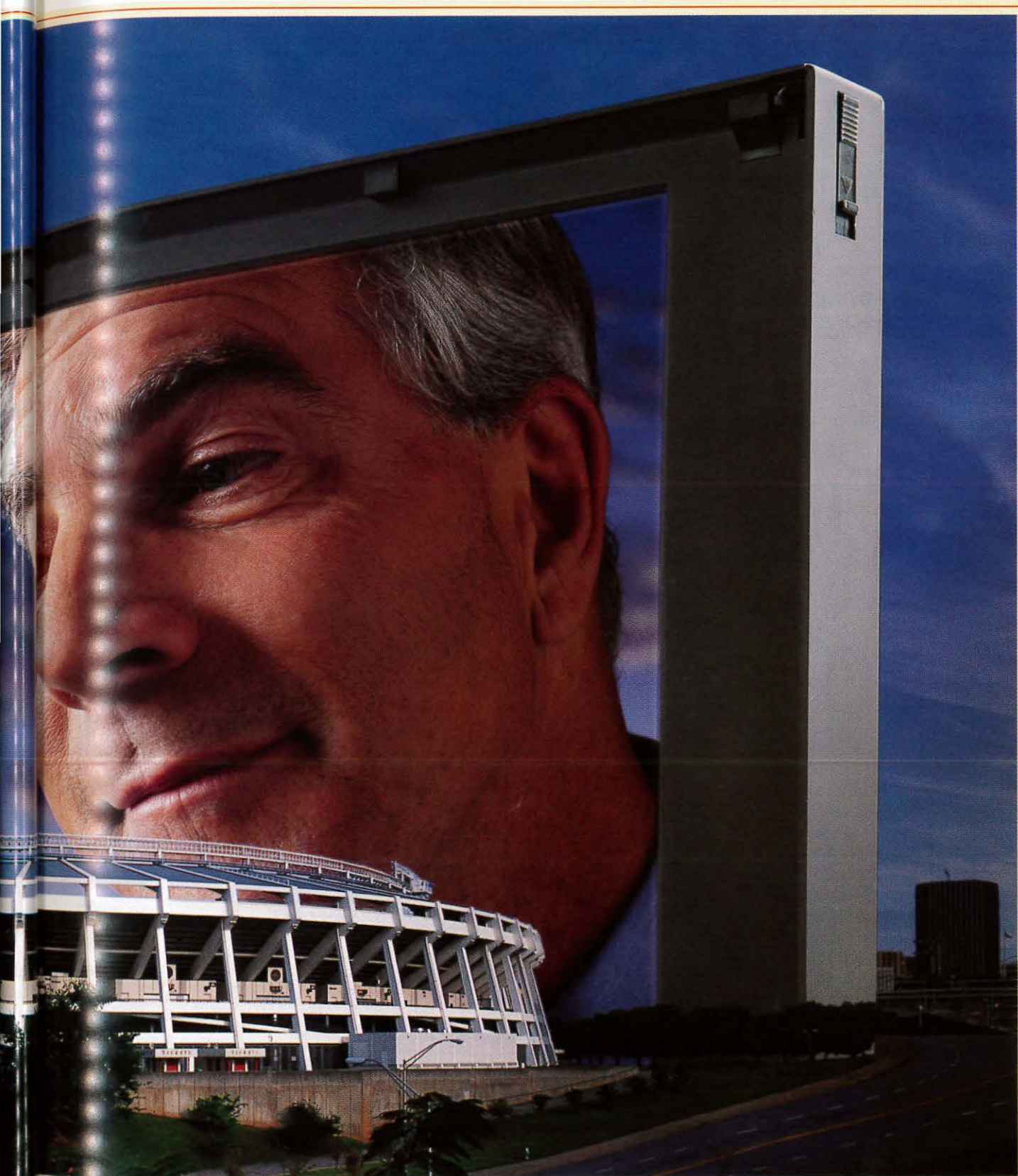
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Euro-Monitors Are Hot in Hannover

Europeans can't agree on a common currency, but they like to see "Made in Europe" on their monitors – and they are intrigued when those monitors are flat.

by Bryan Norris

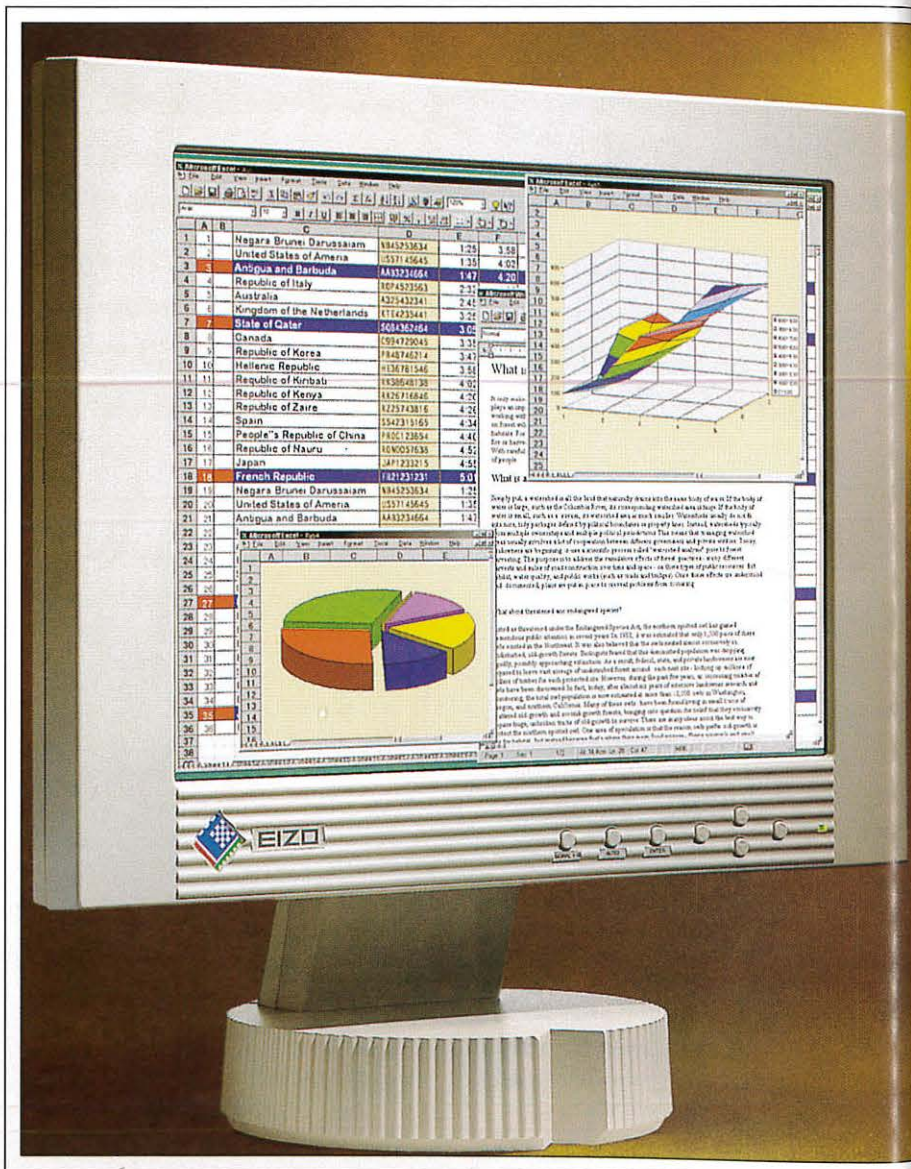
As the world's largest international IT trade fair, CeBIT is just too big to manage. How could it be otherwise? Nowhere else is so much information available in one week on one site.

During the 7 long days from the 13th to the 19th of March, the 11th CeBIT show, held as always in the enormous permanent fair site at Hannover, Germany, was the promotional ground of 6855 exhibiting IT companies – up 4.7% from 6549 in 1996. Their exhibition areas covered 352,623 m² of floor space in 23 of the 27 halls, compared with 339,108 m² in 1996! Forty-percent (2650) of the exhibitors came from outside Germany, with the largest "foreign" contingent of 445 from the U.S. and the next largest (401) from Taiwan.

Some 610,000 mostly professional visitors fought their way to and from the show site amid horrendous traffic congestion made

Fig. 1: Eizo's 13.8-in. L23 LCD monitor runs normally at 1024 × 768 (XGA). In VGA and SVGA modes, it uses an ASIC to interpolate and provide an image that almost fills the screen.

Bryan Norris is the Senior Partner and founder of Bryan Norris Associates, Consultants in Electronics, 7 Biddenham Turn, Biddenham, Bedford MK40 4AT, U.K.; telephone +44-(0)-1234-26-7988; fax: +44-(0)-1234-26-2345; e-mail: bnorris@kbnet.co.uk. Before establishing Bryan Norris Associates, he created and managed the Monitor Information Program at BIS Strategic Decisions. He is a contributing editor to Information Display Magazine.





Panasonic Deutschland GmbH

Fig. 2: Panasonic's Panel PC CF55 drew a lot of attention. The compact case houses a 14.5-in. 1024 × 768 (XGA) LCD monitor and the necessary parts of a PC, including a 150-MHz Pentium processor, two PCMCIA card slots, a floppy disk drive, and a CD-ROM drive.

worse by the construction work for Expo 2000. A significant proportion of the 100,000 attendees from outside Germany were from the Asia-Pacific region (16,400), Eastern Europe (14,000), or from America (5200). One-third of the visitors from these three regions were first-timers.

LCD Monitors Everywhere

This year, it was most noticeable that many of the stands showing displays had an *own-brand*, working stand-alone LCD monitor. Around 40 exhibitors took the opportunity to launch, or at least show, these new products. But it must be emphasized from the start that many of the models shown were just prototypes or pre-production units. Nevertheless, at least three exhibitors had 10-12-in. LCD monitors on their stands as demonstration units, notably *Fujitsu/ICL*, *Raab Karcher* for *Eizo*, and dis-

tributor/PC assembler *Wortmann Terra*. The screen sizes of the LCD monitors ranged from 10.4 in. through 11 larger sizes to the whopping 20.1 in. from *NEC*. (This *NEC* LCD2000 is scheduled for sale in the third quarter of 1997 at a price of around DM12,000/US\$7200.) Although quite a few of the LCDs at CeBIT employed D-STN panels, the dominant technology being used was AM-TFT.

It was interesting to see that, whereas the resolution of the LCD monitor had previously been fixed by the LCD-panel manufacturer, many of the monitors displayed now use special circuitry that allows resolutions lower than the maximum to fill the screen without the former reduced picture size and broad black border.

Eizo's 13.8-in. L23 LCD monitor runs normally at XGA (1024 × 768) but it uses digital technology with an application-specific inte-

grated circuit (ASIC) to interpolate in VGA or SVGA modes and to provide a display that almost fills the screen (Fig. 1). The photograph clearly indicates the major advantages of LCD monitors: considerably less bulk, depth, and weight when compared to conventional CRT-based models, features that provide opportunities for some innovative casing designs.

And capping it all was what must have been one of the stars of CeBIT '97: *Panasonic*'s Panel PC CF55 (Fig. 2). Scheduled for a September '97 launch and described as "an innovative concept for the desktop computer of the future," this unit's small housing contained both a 14.5-in. 1024 × 768 LCD monitor and the necessary parts of a PC - notably a 150-MHz Pentium processor, 1.2 Gbytes of hard disk, two PCMCIA card slots, and floppy disk and CD-ROM drives.

But the CDT Fights Back

It was also evident at CeBIT that the age of the CDT/CRT monitor is far from over. This year, Hannover witnessed the launching of monitors employing no less than four new CDT types: *Hitachi*'s 19 in., *Sony*'s 24 in., *Panasonic*'s PANA FLAT, and *Toshiba*'s Microfilter, as well as a large number of monitors using *Mitsubishi*'s and *Sony*'s aperture-grille CDTs.

Hitachi's brand-new 19-in. flat square black-matrix Invar shadow-mask CDT was presented in a surprisingly large number of prototype monitors. Along with *Hitachi*'s own model, 19-in. CDT monitors were displayed and promised from mid-1997 onwards by *ADI* (Fig. 3), *Bridge*, *Eizo*, *iiyama*, *Lite-On*, *MAG*, *Nokia*, *Princeton*, *Royal*, *Sampo*, and *Shamrock*. So it looks as if this new screen size will be popular. Its prime advantage is the fact that the 19-in. screen is the ideal size to run CAD-type applications at 1280 × 1024 (with high refresh rates) or at higher resolutions, where a monitor with a 17-in. tube is not really adequate. Furthermore, the 19-in. tube is less bulky and less expensive than the 21-in. tube.

The *Matsushita/Panasonic* PANA FLAT tube - with its plain screen that is flat both horizontally and vertically - was shown at Hannover in *Panasonic*'s new PF17 17-in. 30-86-kHz monitor that displays 1280 × 1024 pixels at 80 Hz. This tube, which is due for general release in Europe in mid-1997, pro-



Fig. 3: ADI showed one of a surprisingly large number of prototype 19-in. color monitors using Hitachi's brand-new 19-in. flat square black-matrix Invar shadow-mask CDT.

ADI

duces a clear and precise image, whatever the angle of vision. The flatness, assisted by the anti-reflection panel, results in considerably minimized reflections. The clarity of small characters is especially good because of the very fine 0.24-mm stripe pitch, and because this tube uses a stretch shadow mask there are no damper wires as in aperture grill tubes, and thus no lines across the screen.

Toshiba's new Microfilter 17-in. 0.24-dot-pitch (flatter-squarer) tube provides a 30-point improvement in luminance and contrast ratio, and was seen in use in *Microvitec's* advanced Pro 17 (95) SX monitor at Hannover. This 30-95-kHz monitor can operate at a resolution of 1280 × 1024 at 85 Hz or, if required for special applications, 1600 × 1200 at 76 Hz.

Sony's 24-in. aperture-grill Trinitron tube has a 16:10 format, can run 1920 × 1200 pixels at 75 Hz, and was seen in monitors from

Sony itself, *Elsa, miro*, and *Step Electronics*. Sony's example, the Multiscan GDM-W900, was promised for April '97 delivery at a price of DM6500/US\$3900 (Fig. 4). Any monitor using this sharp, high-contrast tube has the advantage of being able to display two full A4-sized pages, and is thus ideal for CAD, graphics, layout, and document-imaging applications.

Aperture-grill tubes in general - both the Trinitron from *Sony* and the Diamondtron from *Mitsubishi* - are increasingly employed by monitor suppliers. At CeBIT, European brands with these tubes included models from *Peacock, miro Displays, Step Electronics, Vobis*, and *Yakumo*. Even *NEC* showed a new Diamondtron-tubed 21-in. model, the MultiSync P1150.

On the other hand, *NEC's* CromaClear™ tubes, seen, of course, in both existing and

new *NEC* 15- and 17-in. models, were also found in new 15- and 17-in. models from Taiwanese *Smile*, on whose stand parent company *KFC*-branded product was also displayed.

Environmental Issues Are Still Important

Germany and Sweden have the most active bodies in Europe concerned with promoting environmental issues. Therefore, it was not surprising to find that again a great deal of emphasis was placed on environmental aspects at the Hannover fair, and that both the important *TÜV Rheinland* test house (which awards the definitive Eco-Kreis certificate) and the Swedish *Confederation of Professional Employees Development Unit (TCO)* (which awards the TCO '92 and TCO '95 accreditation certificates) had booths at CeBIT. In addition, a considerable amount of effort was spent by the display suppliers in promoting environmental features, notably TCO '92 and '95, and higher refresh-rate capabilities. The forthcoming 19-in. monitor from *Nokia*, for example, exploits its new tube fully, producing a specification of 30-107 kHz to allow flicker-free resolutions of 1280 × 1024 at 100 Hz and 1600 × 1200 at 85 Hz, and it will comply with TCO '95.

Present at CeBIT were most of the 63 companies that have among them about 600 monitor models meeting the stringent TCO '92 requirements. (These companies are currently listed in the February 1997 issue of the "Environmentally-labelled Computer Displays" pamphlet.) TCO '95, with its extra environmental conditions, was accredited in February '97 to 133 CRT monitors from 26 suppliers and to two PC monitors from *Tandberg Data*.

At the Hannover show, *NEC* announced that from April 1, 1997, it would have a new recycling partner in Germany, *RPG*, a Pan-German cooperative of socially engaged, flexible, and highly specialized recycling companies. Together, *NEC* and *RPG* undertake to handle any kind of electronic waste made by any manufacturer and to recycle this material safely to existing ISO standards.

What's New, Doable, and Sellable?

Along with the environmental factors, new features are being sought by all monitor suppliers to give them an edge over the competition and to help sell their brands. Once-novel

features such as Plug & Play and assorted on-screen-display (OSD) systems are now seen to be commonplace. Three-year warranties are becoming the norm.

One of the most interesting – although yet unproved – new features is the Universal Serial Bus. USB was being offered with a number of the monitors on display, indicating that many suppliers consider this to be a thing of the future. Prominent suppliers committed to having USB models included **ADI, CTX, GVC, Hyundai, Nokia, Philips, Sampo, Samsung,** and **Shamrock.**

German distributors and PC assemblers are nowadays well aware that selling monitors is often more profitable than selling PCs or other computer peripherals. Many have added their own-brand “label” monitors to their catalogues, as well as promoting a range of other well-known branded monitors. Typical examples of “me-too” own brands being promoted included M-Brand from **Actebis** (in addition to its ‘Targa’ range), PC2000 from **C2000,**

Diamond from **J & W,** **Macom** from **Macrotron,** **Magic** from **Wortmann Terra,** **Highscreen** from **Vobis,** and **Yakumo** from **Frank & Walter Computer** (now part of the CIS Group), plus the outstandingly successful **Belinea** from **Maxdata.** Belinea was the best-selling monitor brand in Germany during 1996, with sales of over 400,000, and was also sold in Austria, France, and Switzerland. With the **Maxdata** U.K. office beginning operations in April 1997, another step was taken by **Maxdata** to fulfill its plans of selling 700,000 monitors in Europe during 1997 and becoming Europe’s No. 1 brand by the end of 1997.

The move towards monitors with larger screen sizes continues throughout Europe, especially in Germany. But, judging from products still on offer from some suppliers, there is still an entry-level market for low-end 14-, 15-, and 17-in. monitors. (In Germany in 1996, the market-volume share for 14-in. branded monitors went down to 17.4%, com-

pared with 32.7% in 1995!) SVGA-only 14-in. models could still be seen in the catalogues of **Cotton, Daewoo, Philips,** and **Samsung** (but since 1996 **Samsung** has not sold 14-in. models in Germany). Models with 15-in. screens and horizontal scan frequencies up to just 50–57 kHz were offered by **Cotton, Funai, GVC, Hyundai, Lite-On, Peacock, Philips, Sampo, Samsung, Shamrock, Tatung,** and **Yakumo.** Models with 17-in. screens, scan frequencies up to 50–57 kHz, and 0.39-mm tubes were not as numerous as expected, although companies which had such models in their range included **Bridge, Chun Yun, Hyundai, LG, Lite-On, Peacock,** and **Yakumo.**

Manufacturing monitors in Europe is now perceived to be a positive selling feature. New data sheets from **Hitachi** have a special EU symbol to indicate which of its monitors are made in Wales. At the **Korea Data Systems/Aquarius Robotron Systems** (now **Fujitsu/ICL**) plant in Sömmerda, Germany, 200,000 15- and 17-in. monitors were produced in 1996. Overall, the 20 companies producing in Europe made over 4.6 million monitors in 1996. During 1997, in the U.K. alone, **Hitachi, iiyama, Microvitec, Samsung, Sony,** and **Tatung** all plan to increase their monitor production, and **Lite-On** and **LG** will come on-stream. Expect around six million monitors to be produced in Europe during 1997!

Next year’s CeBIT will be from 19th to 25th March, and, according to the organizers, 90% of 1997’s exhibitors have committed to attending CeBIT ’98. In the meantime, why not take a business-funded holiday to Italy at the beginning of October and, while you are there, attend Europe’s other important IT Fair? SMAU, a friendly show that is well worth visiting, will be held in Milan from 2–6 October. For further details about SMAU, call +34-2-760-6757 or fax +39-2-760-7300. ■

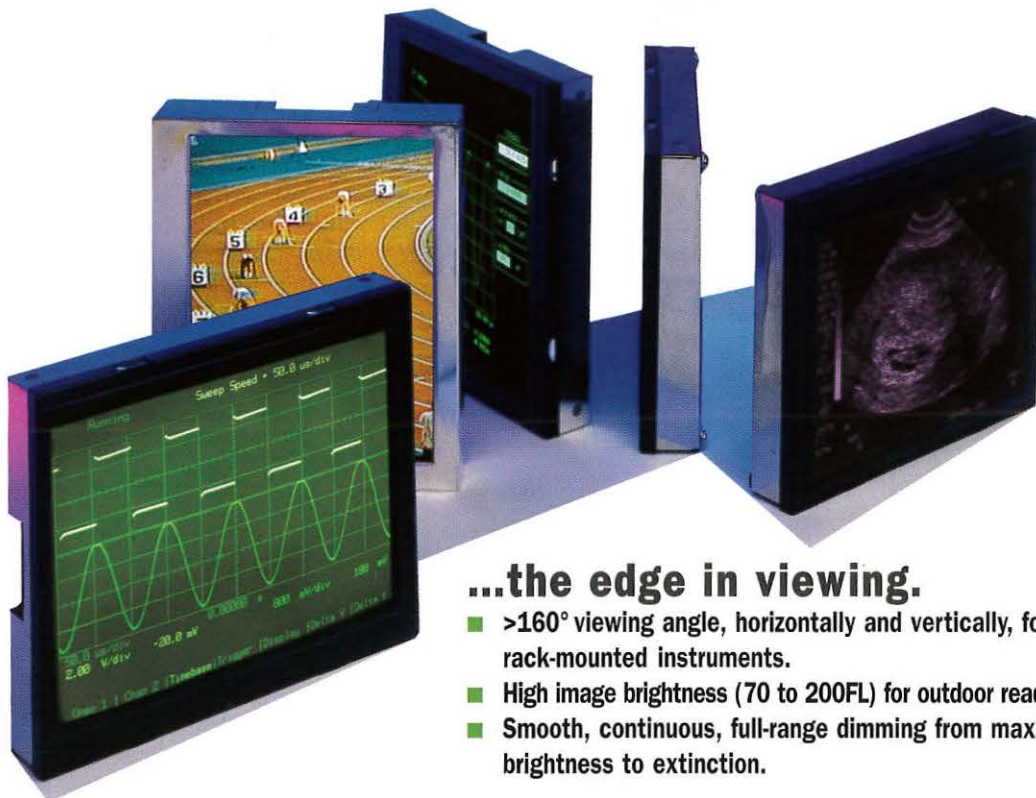


Sony

Fig. 4: Sony’s Multiscan GDM-W900 monitor is built around Sony’s 24-in. Trinitron tube, which has a 16:10 aspect ratio and can display up to 1920 × 1200 pixels at a 75-Hz refresh.

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Scanning Laser Projectors

Why do scanning laser projectors look better than the measurements say they should?

by William K. Bohannon

SCANNING a modulated high-intensity light beam across a screen would seem to be an obvious approach to making a projection display. Obvious, but not easy to implement. And once implemented, not easy to measure or compare to conventional projectors.

First, although experiments with scanned-light-beam projectors were conducted before World War II – decades before the laser was invented – lasers make it much easier to construct a projector that produces an image that is bright and has high resolution, both at the same time. Second, the well-developed techniques for making routine illumination measurements of conventional projection displays break down with video-rate scanned-line displays. And third, now that credible measurement techniques have been developed for laser projectors, we find that the subjective responses to the measured values are not what we would expect from conventional projection displays.

This is not to say that scanning laser projectors are not being built (Fig. 1). In fact, many methods have been proposed to construct them. One method is to scan a laser beam across the screen in two dimensions, much as an electron beam is scanned inside a CRT. The scanned spot is modulated at every pixel

point to create an image that the eye can retain without flicker – if the scanning is done quickly enough, at 60 Hz or better.

If a very fast freeze-frame image were taken of the pixel-scanned laser-projector screen just described, only a single point of



Fig. 1: A laser projector displays colors that are more saturated and subjectively brighter than conventional measurements would lead us to predict. This projector from the Corporation for Laser Optics Research (COLOR) is in the baggage area at the Manchester, New Hampshire, airport.

COLOR

William K. Bohannon is Chief Scientist at Manx Research, a display technology and marketing consultancy, located at 2060 Ridgecrest Place, Escondido, CA 92025; telephone 619/735-9678, fax 619/735-8987. He is the author of a series of reports on LC projection systems and the Japanese display industry.

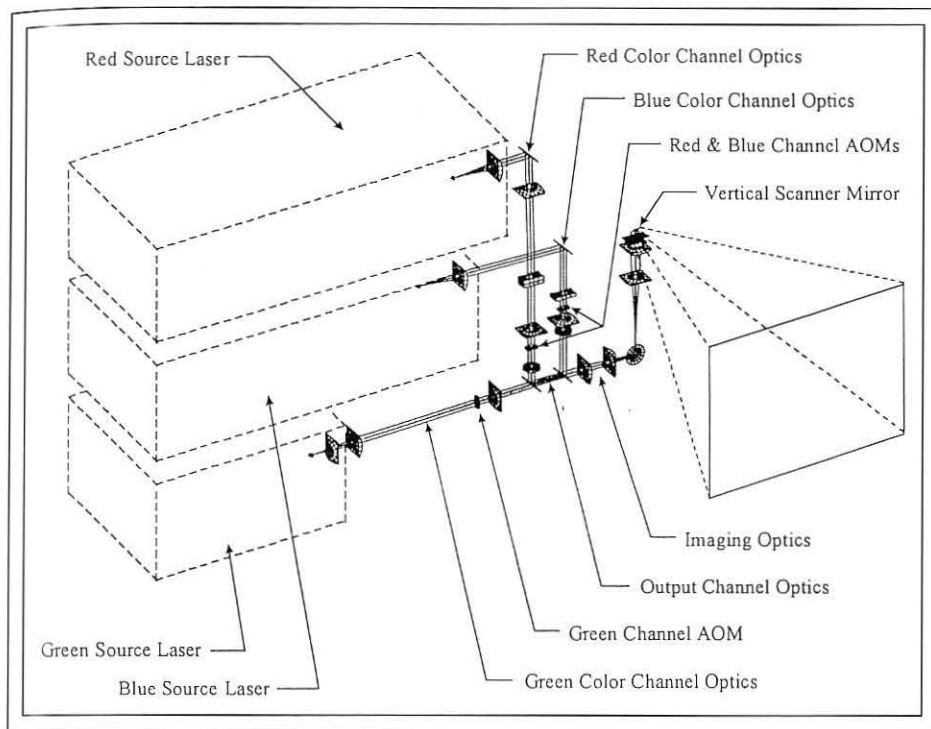


Fig. 2: In the laser projector developed by the Corporation for Laser Optics Research (COLOR) of Portsmouth, New Hampshire, a laser beam is formed into a thin, line-shaped beam that is modulated by a high-resolution AOM to contain one entire line of video information.

light would be seen, not the full image seen with an LCD or CRT projection system, and not the bright image that persists on the screen of a CRT because of the phosphor's persistence.

To lessen the modulation speed and signal bandwidth required of the scanning laser system, several laser-projector development groups have proposed using multiple lasers operating in parallel – an idea that has been used by designers of high-performance CRTs many times over the years. These individually modulated parallel laser beams could be of lower power than the beam in a one-beam laser system and could be scanned together at a lower speed using a rotating polygon or some other kind of movable mirror. The resulting image would be produced by several scanning spots instead of one. However, several problems need to be solved to make the individually addressable lasers compact enough, to allow the beams to be sufficiently close together to produce an image with adequate screen resolution, and to ensure there are no artifacts due to the fact that the various beams are not precisely equivalent.

Two of the groups working on scanning multiple beams – Advanced Laser Technologies (ALT) of Moorpark, California, and Laser Power Optics (LPO) of San Diego, California – have solutions for these problems. ALT has constructed a dual x and y plane acoustical-optical modulator (AOM) system that spreads one beam of laser light into 28 individually modulated laser spots which are then scanned onto the screen in parallel with a rotating polygon. In an alternative approach, LPO creates “hundreds” of spots from one beam with a special diffractive optical element. Each spot is then individually modulated by a proprietary electro-optical element before being scanned onto the screen, as is done in ALT's system.

Another method – one that takes advantage of coherent laser light without forcing designers to worry about developing compact laser sources or tiny diffractive optical elements – also involves combining an AOM with a scanning laser beam. In the laser projector developed by the Corporation for Laser Optics Research (COLOR) of Portsmouth, New Hampshire, a laser beam is formed into a thin

line-shaped beam that is modulated by a high-resolution AOM to contain one entire line of video information (Fig. 2). With the COLOR method, the resulting laser line only needs to be scanned in one direction, vertically, instead of two. By vertical stepwise scanning of the laser line with a movable mirror, the image is built up on the screen without additional optical elements.

The COLOR method requires that the AOM be loaded with an entire line of video data within about one pixel period. Otherwise, noise with duration greater than one pixel period would degrade the image. The AOM's data is “read out” with a similarly short burst of laser light and then projected onto the screen. Since the pixel period in an NTSC video signal of maximum resolution – 440×525 interlaced – is about 80 ns, a burst of light shorter than 80 ns is necessary to avoid smearing. The laser must also be ready to pulse again within the line period (about 60 μ s) necessary for running two interlaced 30-Hz video fields at 60 Hz.

According to COLOR, the individual red, green, and blue lasers used in their test system pulse at approximately the rate just described. However, because of timing issues, most of the light from the combined red, green, and blue pulses (necessary to form “white”) occupies a window about 180 ns wide. This limits the test system's screen resolution to that of a normal NTSC VCR.

Determining the Brightness of Scanned Systems

How bright are the images resulting from scanning laser projectors? How can their luminance be measured? How powerful would the laser have to be to make a person see a reasonably bright image – and how would one compare the luminance to that of an ordinary projection system?

If a light meter, such as a simple Minolta meter with a 1-in.-diameter sensor area, were placed on a screen scanned by a laser projector to measure footcandles, it would only see the rapidly moving spot (or spots or line) for the short time that the spot was actually on the sensor head. The Minolta meter doesn't read out quickly enough – it has a response time of 1 ms – to even record the data of one “flying” laser spot. If the meter could record and then display that data on an oscilloscope, one would see a peak-shaped waveform about one

display measurements

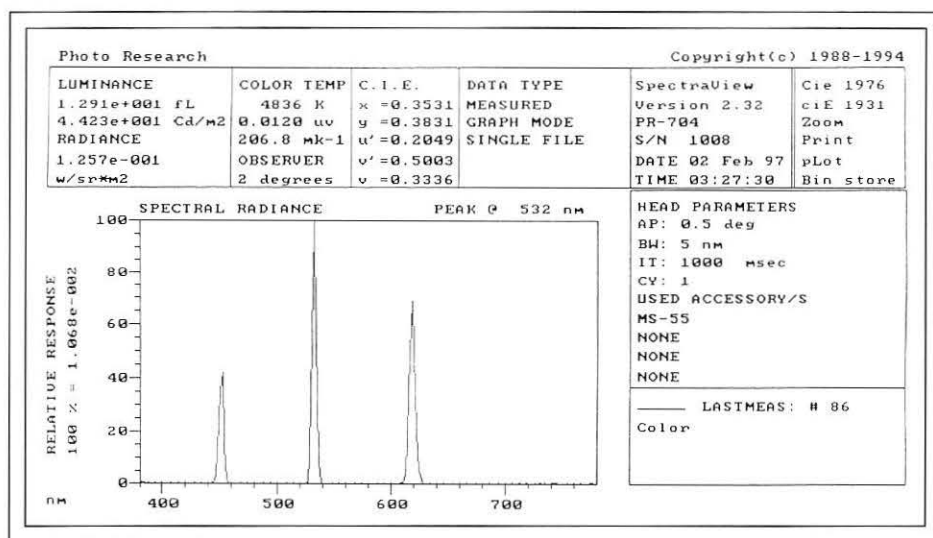


Fig. 3: "White" light from a laser projector is actually narrow-band red, green, and blue light that is mixed in the right proportions to be perceived as "white."

pixel (180 ns) wide once every 16.7 ms for an image with a 60-Hz refresh. As a result, when the trusty Minolta T1 Illumination Meter was held up to a scanning laser projector's screen, it could not record the expected illumination value in footcandles (based upon input power). The value we obtained was far lower.

If we could use a screen-sized meter - something like a giant solar cell that could capture and integrate the entire image - then we might be able to record the expected value. Unfortunately, such a meter is not available, and users of laser projectors need some other method to validate their systems. Even though we can't possibly see the flying spot or moving line in a scanned laser projection system that completely lacks optical persistence, we perceive an image that looks brighter than conventional instruments predict.

Laser Power and Pulse Timing

Experts in human perception have long held that time-varying light sources are as luminous as the time-average of their luminance. For example, if a 10-fc spot is repeatedly turned on for 10 ms and off for 10 ms, the spot's illumination is the average of 10 and 0, or 5 fc. For a single-spot laser-beam projection system, the illumination of any measurement might be taken as the average resulting from being on for 180 ns once per 16.67-ms frame and off the rest of the time. Even if an "all white" frame were projected, the laser

would only visit any one spot once per frame time - 1/60 of a second for most data signals, or 1/30 of a second for interlaced video.

When the spot is on for 180 ns and off for 16.67 ms, the time-averaged illumination is 0.00018/16.67, or about 0.0000107 times the spot's peak amplitude in footcandles. A 10⁶-fc spot would therefore be required to make a 10-fc time-averaged image across the whole screen. We can calculate how many footcandles or lumens a laser makes from the CIE photopic efficiency function.

For example, if 1 W of green laser light, centered at 555 nm, equals 683 lm, then that 1-W laser could create a 683-lm image on-screen. Additional 1-W (or so) lasers operating in appropriate red and blue wavelengths would also have to be used to achieve proper color balance. But would a 3-W total RGB laser system really provide about 1000 lm of color-balanced light when all of the power is dumped into one or more tiny spots that whiz past the eyes?

Single-Line Measurements

One of the COLOR laser systems was used as a measurement testbed to see if the calculated results could be verified. This laser can put an over-sampled NTSC video image on a 7 x 10-ft. screen. The green laser alone put about 10.6 W of 532-nm green on the screen - appropriately balanced with several watts of red and blue. At 532 nm, 10.6 W should equal 6360 lm, taking CIE efficiencies into account. Since the COLOR system scans a single line vertically on the screen, we began our calculations with line widths.

A one-pixel-tall line on a 7 x 10-ft. screen should contain less than 0.03 m². We stopped the line-scanning function and measured the line at 0.78 x 113.75 in. (0.057 m²). There was some broadening of the line, perhaps resulting from its extreme intensity (the line had to be viewed through safety goggles). With 6360 lm in 0.057 m², the illumination, if constant, would have been 10,365 fc!

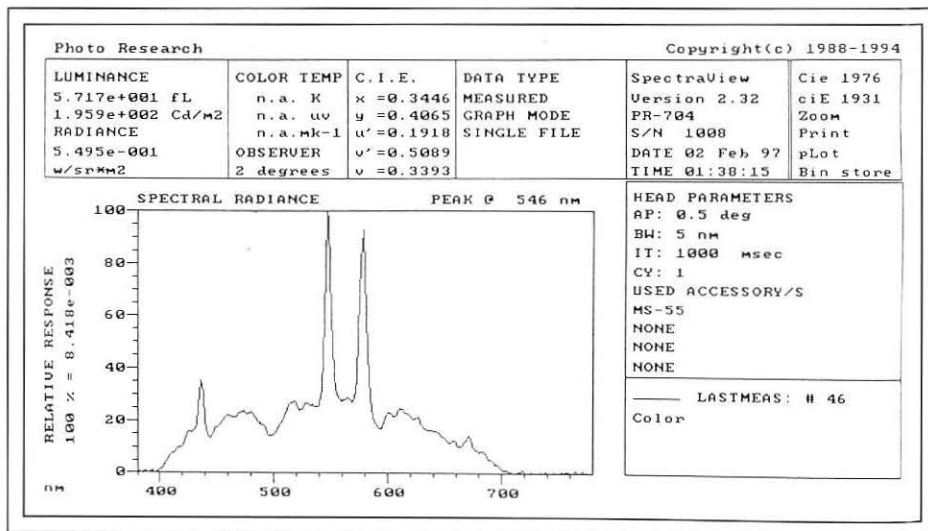


Fig. 4: The "white" light of an LCD projector has a complex spectrum that inherently limits the range (gamut) of colors that can be displayed and, in some cases, the purity of those colors.

But the luminous power described above must be time-averaged because the system writes the 180-ns-wide line over and over every 60 μ s. So, $0.18/60 \times 10,365$ fC gives an average of about 31.09 fC. If this illumination could be averaged over the entire screen – and this should be possible since the line-to-line timing doesn't change – then $31.09 \times 10.76 \times 6.75$ (the entire screen area) gives 2258 lm.

Our measurements of the illumination of a single line with the Minolta meter were almost 800 fC on average. But measurements taken of the system scanning normally across the entire screen were less than 6 fC on average, which indicates the light output from the projector to be about 430 lm. Obviously, the Minolta meter couldn't keep up with either the intensity of a single line or the sparse activity of a fully scanned image. This isn't surprising, and Alan Sobel, editor of the *Journal of the SID*, observes that it's a problem that is continually being forgotten and rediscovered. (See The Meter, the Eye, and Scanned Displays.)

Narrow-Strip Measurements

Since we couldn't construct a screen-sized integrating light meter, the vertical scan on the laser projector was adjusted to move over a wider range but at the standard line timing and laser power levels. If we can assume that the eye-brain system has a minimum detection time of 1 ms, then the pixel- or line-scanner will have moved down about 8 lines at a 30-Hz rate. At the throw distance and screen size used for the measurements to be taken, these eight lines equal a height of about 3–4 in. on the screen – a fraction of an arc degree at a reasonable viewing distance.

The resulting bright band was measured and found to be about 5.25 in. high by 114 in. long, giving an area of 0.39 m². This band had several times the area of the Minolta's sensor head. Measurements taken at a well-positioned series of points gave a value of more than 135 fC on average. If it is assumed that the meter was reading an accurate value for that limited area, the illumination for a single line can be calculated by taking the ratio of the heights. So, 135 fC times 5.25/0.78 gives 908 fC. Taking the time average of this value at 30 Hz (for the average vertical scan rate) gives 30.2 fC. With the assumption that this should approximate the average illumination for a single line anywhere across the

entire 6.75-m² screen, we can calculate a total illumination of 2200 lm. This value is very close to that predicted from the lasers' output power levels.

Color, Saturation, and Brightness

In addition to brightness, laser projection systems offer a unique color gamut because of the intense saturation simultaneously available for all three primaries with single-line light. This allows the display to show a greater range of saturated colors. This is beneficial for a variety of reasons, including the fact that highly saturated colors appear brighter than less-saturated colors with the same luminance, an observation first made by Chapanis and Halsey in 1955 (see note).

The narrow-band color produced by laser projectors comes very close to the peak absorption point of human light-sensing cones – at least for blue and green. Many systems use a narrow-band 532-nm green and a narrow-band 450-nm blue light along with a red near 624 nm. Some developers of laser projection systems think that the human eye's response to single-line color produces a “reso-

nance” effect when the laser line coincides with the sensitivity peak of the eye's cones, and this heightens color perception. But the increase in perceived brightness may just be a consequence of increased saturation, as Chapanis and Halsey first reported years ago.

When a typical high-powered LCD projector – a BARCO 9100 that produced 2720 measured ANSI lumens – was set up to project side by side with a laser projector, the difference was dramatic. The laser projector produced colors that appeared far more saturated, and it seemed to match or exceed the BARCO's overall brightness. A comparison of measured CIE red, green, and blue endpoints for these projectors does not fully explain the large perceived color difference between the laser- and lamp-based systems, although the measured endpoints are very different.

One explanation might involve the different white points of the two systems. *Journal of the SID* editor Alan Sobel observes, “The higher the color temperature (the ‘bluer’ the white), the brighter the display appears to be.” An additional phenomenon might have con-

The Meter, the Eye, and Scanned Displays

The measurement problem with scanned optical displays involves tremendous overloading of the meter. Let's assume that the TV picture has $480 \times 640 = 307,200$ elements. The laser light has no persistence, so if a pixel is to produce an average luminance of 100 fL over a frame, then all of that light must be delivered in one pixel-time, and the instantaneous luminance of the pixel is approximately $100 \times 307,200 \approx 30 \times 10^6$ fL (ignoring things like flyback times).

There is no meter available with this kind of range: 100,000:1. If the meter is set to read 100-fL full scale, that instantaneous blast of light just overpowers it.

Quite a bit has been published about the eye's response to short pulses, and it turns out that the eye is considerably more flexible than an illumination meter. The research – including some done with very-short-persistence CRTs years ago at Zenith – indicates that a short pulse does not affect the perceived brightness.

The fundamental issue is reciprocity: If a stimulus is Bt , where B is the luminance and t is the time, is the response just proportional to Bt or does it depend on the values of B and t ? The Zenith experiments showed that it's just a matter of Bt within the range that is most interesting to display makers, although at very low intensities there is a failure of reciprocity, and there is surely a failure at very high intensities.

Incidentally, reciprocity works for photographic film as well as for the eye, and photographic reciprocity has been studied extensively. The standard photographic tactic of maintaining an exposure by halving the lens area (increasing f /stop by one) and simultaneously doubling the exposure time depends on the reciprocity of photographic film. Few people other than astronomical photographers – who sometimes expose film for hours using motor-driven camera mounts that can track a constellation across the sky – run into reciprocity breakdown in the photographic domain.

– Alan Sobel and Ken Werner

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display measurements

tributed to the overall effect. The coherent laser light can interfere with itself inside the eye, producing tiny beat patterns that are seen as points of flashing light. These patterns, called "speckle," can even be perceived by people with terrible vision, because they occur within the eye itself.

It would be very interesting to try an experiment with human observers to determine how bright laser colors appear, with and without speckle, in comparison to broader-band filtered light. Light from a laser projector that is perceived as "white" (Fig. 3) is very different from an LCD-projector "white" (Fig. 4), and it is possible that these different types of waveforms, which have their counterparts in many of the colors actually shown on displays, can stimulate the eye differently. It is interesting to ask whether the subjectively greater color saturation of laser projectors is primarily the result of narrow-band excitation itself or is speckle involved?

Conclusion

Manufacturers of projection systems have long traded off color saturation, contrast, and other image-quality parameters for illumination. Laser projectors seem to verify the predictions of Chapanis and Halsey that deep color saturation can be worth a substantial tradeoff in illumination.

Note

Alphonse Chapanis and Rita Halsey, "Luminance of Equally Bright Colors," *J. Opt. Soc. Am.* **45**, No. 1, 1 (January, 1955). The paper describes an experiment in which a group of subjects reported that highly saturated colors look as bright as less-saturated colors with almost twice the luminance. ■

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.

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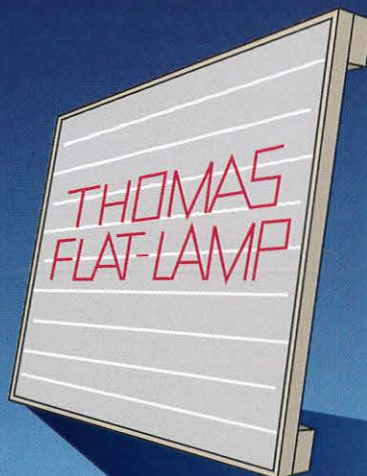
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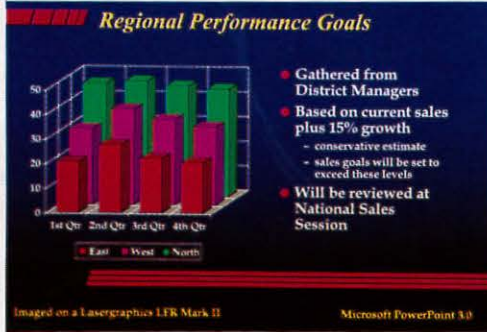
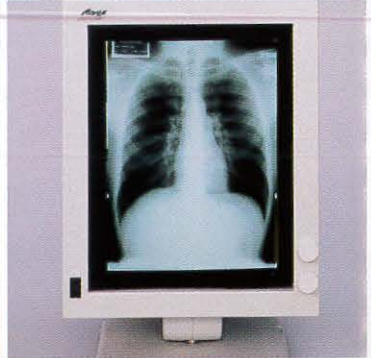
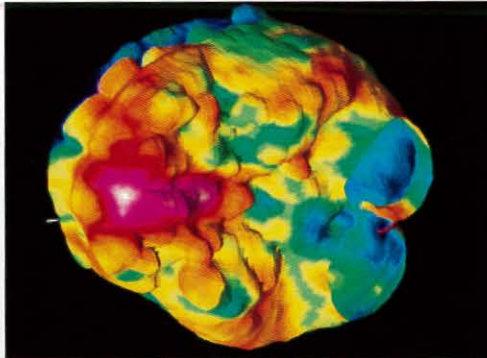
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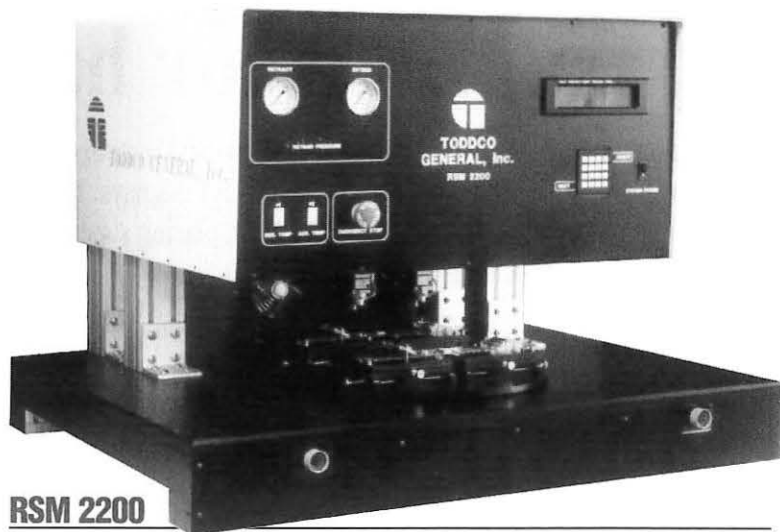
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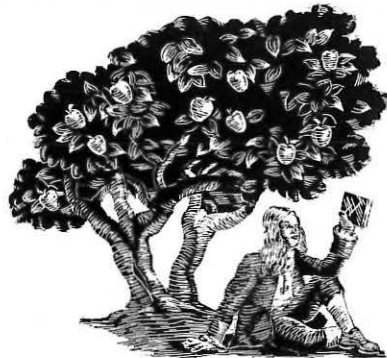
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Industry Directory

ID's eleventh annual directory of the display industry.

COMPILED AND EDITED BY THE EDITORIAL STAFF

Part I, beginning on this page, is a listing of products and services relevant to the display industry. Part II, the company directory, begins on page 50.

Part I: Products and Services

ANTIREFLECTION COATINGS

See optical coatings

ANTIREFLECTION SCREENS

See filters

ANTISTATIC CHEMICALS AND DEVICES

□ ACL/Staticide □ Exxene □ Homalite
□ Ion Systems □ Lamination Technology
□ Screen Shield □ Tech Spray
□ Teknek Electronics □ **3M Electronic Products** □ **3M Product Information**
□ UNIA □ Viratec

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□ Dolch Computer □ Dynamic Displays
□ CRL □ **CTX Opto** □ Diamond Tech One □ Dimension Technologies
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□ Imaging & Sensing □ IST □ **Jaco Electronics** □ JKL Components □ Korry Electronics □ Lamination Technology
□ Lamplighter Industries □ Landmark Technology □ **LCD Lighting** □ Linfinity
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□ Lumitex □ Milgray Electronics
□ Modutec □ National Research Resources □ National Semiconductor
□ Pacific Technologies □ Performance Display Systems □ Precision Lamp

□ Racal Acoustics □ Racal-Mesl
□ Raytheon □ Regisbrook □ Reynolds Industries □ Rikei Corp. □ SAIC □ SAI Technology □ Seiko Instruments □ SI Diamond □ I. I. Stanley □ Stanley Electric □ Swiss Controls □ **Thomas Electronics** □ Three-Five Systems □ **3M Optical Systems** □ **3M Product Information** □ Transicoil □ Ushio America □ Visus □ VL Electronics
□ Voltarc Technologies □ Wedglight
□ Winsor □ World Products □ Wyle Electronics □ XTEK

BALLASTS

□ WPI Electronics

BARCODE READERS

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□ Pentax Technologies □ Percon
□ Spectra-Physics

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□ Intevac □ Kurt J. Lesker Co.
□ Mushroom □ Philips Display Components □ SI Diamond □ UTI Corp.
□ VDC (Apex) □ VDC (Southwest Vacuum)

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□ Burle Industries □ CID Technologies
□ Circon ACMI □ Coreco □ Data Plus
□ Display Labs □ DynaColor □ Eastman Kodak □ EEV □ EEV Ltd. □ EG&G Optoelectronics □ EG&G Reticon
□ Electro-Optics □ Incom □ Instrument Systems □ Kollmorgen □ Kontron
□ Lighting Sciences □ Loral Fairchild
□ McMahan Electro-Optics □ MegaVision
□ Mekel Engrg. □ Milgray Electronics
□ Optical Radiation □ Optronics
□ Philips Components □ Photometrics
□ Pulnix America □ Raytheon □ Sarnoff Research Center □ Security Defense Systems □ Seiwa Optical □ Sony Display Device Group □ Symco □ Telesensory
□ Vanzetti Systems □ Wyle Electronics
□ Xybion

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Optics □ Sharp Digital Information Products □ Telesensory □ Voice Connexion □ Xerox Imaging Systems

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CLEANING AGENTS

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□ Borer Chemie AG □ **3M Product Information** □ Valtech

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industry directory

CRT DESIGN SERVICES

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□ IST □ **Jaco Electronics** □ Milgray
Electronics □ Planar Advance
□ Raytheon □ Sascal Displays
□ **Syntronic** □ Teltron □ **Thomas
Electronics** □ VDC (HQ) □ VDC
(Teltron) VDC (Z-Axis) □ Zenith
Electronics

CRT DISPLAYS

See also large-screen displays,
projection displays, simulator displays,
3D display systems, touch interactive
displays, deflection yokes, electron
guns, focus coils, glass for CRTs

CRT monitors, full color

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Corp. □ Barco □ Barco Chromatics
□ Barco Display □ Barco Video &
Commun. □ Burle Industries □ Calcomp
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Emporium □ Honeywell □ IBM
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□ Infodex □ Intecolor □ Interstate
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□ Keltron □ Kristel □ Lockheed Sanders
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America □ Sarnoff Research Center
□ Sascal Displays □ Siemens AG
□ Sony □ Sony Display Device Group
□ Sony Graphic Display □ Stanley
Palmer □ Symco □ Systems Research
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Components & Tubes □ Thomson-CSF
□ Thomson Tubes Electroniques
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□ Touch Controls □ Ultimate Display
Solutions □ Unigraf □ Vidwall □ Vivitek
□ Wells Gardner □ Wyle Electronics
□ VDC (Z-Axis)

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Sigmex □ Astronautics □ AVT □ Aydin
Corp. □ Barco □ Barco Chromatics
□ Barco Display □ Barco Video &
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□ Capetronic □ Cardion Electronics
□ **CELCO Pacific** □ **Clinton Electronics**
□ Cornerstone Technology □ CRT Intl.
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Communications Systems □ Manirton
Displays □ MicroTouch Systems
□ Milgray Electronics □ **Mitsubishi
Electronics America** □ Monitern □ MTL
Systems □ National Semiconductor
□ Nortech Engineering □ Nortech
Imaging □ Orwin Associates □ Panasonic
Computer Peripherals □ Panasonic
Industrial □ Pegasys Displays □ Philips
Consumer Electronics □ Philips Display
Components □ Pixelink □ Plessey Naval
Systems □ Precision Imaging
□ Rasterops □ Raytheon □ Relisys
□ Richardson Electronics □ Sampo
America □ Sarnoff Research Center
□ Sascal Displays □ Siemens AG
□ Sony □ Sony Display Device Group
□ Sony Graphic Display □ Stanley
Palmer □ Systems Research Labs
□ Tatung □ Tektronix □ Teltron
□ Thomson-CSF □ Thomson Tubes
Electroniques □ Toshiba America
□ Totoku Electric □ Touch Controls
□ Ultimate Display Solutions □ Unigraf
□ VDC (Z-Axis) □ Whittaker

CRT monitors, monochrome

□ ADT □ Advanced Video Products
□ Astronautics □ AVT □ Ball Aerospace
□ Burle Industries □ Calspan SRL
□ Capetronic □ Cardion Electronics
□ **Clinton Electronics** □ Cornerstone
Technology □ CRT Intl. □ **CRT Scientific**
□ Dage-MTI □ Data Plus □ Data Ray
□ Digitran □ Display Technologies
□ Dotronix □ Dynamic Displays
□ Electrohome □ Electronic Image
Systems □ El-Op Electrooptics Industries
□ ETC Computer □ General Electric
□ Ginsbury □ Gritz's Emporium
□ Honeywell □ IBM □ Ikegami
Electronics □ Image Systems □ Imaging
& Sensing □ Infax □ Infodex
□ Interstate Electronics □ IST □ **Jaco
Electronics** □ Keltron □ Kristel
□ Lockheed Sanders □ L-3
Communications □ Manirton Displays
□ Monitern □ National Semiconductor
□ Nortech Imaging □ Opto-Cal □ Orwin
Associates □ **Palomar Products**
□ Panasonic Industrial □ Pegasys
Displays □ Philips Consumer Electronics
□ Philips Display Components □ Pixelink
□ Plessey Naval Systems □ Precision
Imaging □ Rasterops □ Raytheon
□ Relisys □ Richardson Electronics
□ Sampo America □ SAMTEL USA
□ Sarnoff Research Center □ Sascal
Displays □ Siemens AG □ Sony Display
Device Group □ Stanley Palmer
□ Symco □ Systems Research Labs
□ Tatung □ Tektronix □ Teltron
□ Thomson Tubes Electroniques
□ Toshiba America □ Totoku Electric
□ TSD Display Products □ VDC (Z-Axis)
□ Wells Gardner

CRTs, beam-index

□ CRT Intl. □ Digitran □ Electronic
Image Systems □ Ginsbury □ Honeywell
□ Keltron □ L-3 Communications
□ Planar Advance □ Raytheon
□ Sarnoff Research Center □ Sony
Display Device Group □ **Thomas
Electronics** □ Thomson Components &
Tubes □ Thomson Tubes Electroniques

CRTs, conventional

□ ADT □ Aydin Corp. □ **Brimar**
□ Burle Industries □ Canadian Marconi
□ Cardion Electronics □ **Clinton
Electronics** □ CRT Intl. □ **CRT
Scientific** □ Digitran □ Dotronix □ EDL
Displays □ EEV Ltd. □ Electronic Image
Systems □ General Atronics □ General
Electric □ Ginsbury □ Honeywell
□ Ikegami Electronics □ Imaging &
Sensing □ ISE Electronics □ IST
□ Matsushita □ MicroTouch Systems
□ MII □ Milgray Electronics
□ **Mitsubishi Electronics Sales America**
□ Monitern □ MTL Systems
□ Panasonic Industrial □ Planar Advance
□ Pegasys □ Raytheon □ Richardson
Electronics □ Rockwell Intl. □ SAMTEL
USA □ Sarnoff Research Center □ Sony
Display Device Group □ Stanley Palmer
□ Tektronix □ Teltron □ **Thomas
Electronics** □ Thomson Components &
Tubes □ Thomson Tubes Electroniques
□ Toshiba America □ VDC (Chroma)
□ VDC (Data Display) □ VDC (Teltron)
□ VDC (Video Electronics) □ Vidwall
□ World Products □ Zenith Electronics

CRTs, flat

□ Advanced Video Products □ AVT
□ Aydin Corp. □ **Clinton Electronics**
□ CRT Intl. □ **CRT Scientific** □ Digitran
□ Dotronix □ EDL Displays □ EEV Ltd.
□ Electronic Image Systems □ Futaba
□ Ginsbury □ Honeywell Defense
Avionics □ Ikegami Electronics □ Infodex
□ **Jaco Electronics** □ MicroTouch
Systems □ MTL Systems □ Milgray
Electronics □ **Mitsubishi Electronics
Sales America** □ Panasonic
Communications & Systems □ Panasonic
Computer Peripherals □ Panasonic
Industrial □ Planar Advance □ Raytheon
□ Richardson Electronics □ Sarnoff
Research Center □ Si Diamond □ Sony
□ Sony Display Device Group □ Teltron
□ **Thomas Electronics** □ Toshiba
America □ VDC (Teltron) □ **ViewTEK**
□ Wyle Electronics □ Zenith Electronics

CRTs, miniature

□ ADT □ **Brimar** □ Burle Industries
□ CRT Intl. □ **CRT Scientific** □ Digitran
□ Dotronix □ EEV Ltd. □ Electronic
Image Systems □ General Atronics
□ Ginsbury □ Gritz's Emporium
□ Honeywell □ Hughes Lexington
□ Imaging & Sensing □ IST □ Litton
Electron Devices □ MicroTouch Systems
□ Panasonic Industrial □ Planar Advance
□ Raytheon □ Richardson Electronics
□ Sarnoff Research Center □ Sony
Display Device Group □ Stanley Palmer
□ Teltron □ **Thomas Electronics**
□ Thomson Tubes Electroniques □ VDC
(HQ) □ VDC (Teltron) □ Vivitek

CRTs, multibeam

□ CRT Intl. □ Digitran □ General
Atronics □ Ginsbury □ Honeywell
□ Hughes Lexington □ Infodex □ Litton
Electron Devices □ Raytheon
□ Richardson Electronics □ Sarnoff
Research Center □ Sony Display Device
Group □ Teltron □ **Thomas Electronics**
□ Thomson-CSF □ Thomson Tubes
Electronics □ VDC (Teltron)

CRT MATERIALS

See individual listings for filters,
getters, glass, magnetic shielding,
materials, optical coatings, phosphors,
polarizers

CRT TESTING LABORATORIES

□ Citronix □ Display Labs □ DynaColor
□ Ergonomics □ **Gamma Scientific**
□ MECC □ **Thomas Electronics** □ TÜV
Rheinland

DEFLECTION AMPLIFIERS

□ Astronautics □ **Brimar** □ **CELCO**
□ **CELCO Pacific** □ Citronix □ Ginsbury
□ Infodex □ MECC □ Motorola
□ National Semiconductor □ Orwin
Associates

DEFLECTION YOKES

□ **CELCO** □ Display Components
□ DynaColor □ EEV Ltd. □ Eldor
□ Ginsbury □ Infodex □ K & R Engrg.
□ Panasonic Industrial □ Philips Display
Components □ Sampo □ Sarnoff
Research Center □ Sony Display Device
Group □ Stanley Palmer □ **Syntronic**
Instruments □ Totoku Electric □ WinTron

DEPOSITION EQUIPMENT

□ Applied Films □ Applied Technology
□ Balzers Process Systems □ BOC
Coating Technology □ CRL □ Diamond
Tech One □ Edwards □ FAS
Technologies □ General Vacuum
□ Innotec □ Intevac □ Kurdex
□ Materials Research Corp. □ Si
Diamond □ Specialty Coating Systems
□ Spectrum Sciences □ Temescal
□ TSC

DEPOSITION SERVICES

□ Applied Films □ Dynapro □ Edwards
□ Florod □ General Vacuum □ Intevac
□ Kurdex □ Spectrum Sciences
□ Specialty Coating Systems □ Thin Film
Technology □ **Thomas Electronics**
□ VDC (Teltron)

DIGITAL FILM RECORDERS

□ **CELCO Pacific** □ CRT Intl.
□ Eastman Kodak □ ECRM Trust
□ Ektron Applied Imaging □ Hybrid
Micrographics □ Imapro □ Lasergraphics
□ Management Graphics □ Mekel Engrg.
□ Polaroid □ Tartan Technical □ 3M
Product Information

DIGITAL VIDEO SYSTEMS

□ Burle Industries □ Colorado Video
□ CRT Intl. □ Digital Vision □ Dynair
□ Eastman Kodak □ Eltime Vision
Systems □ Genesis Microchip □ Grass
Valley Group □ Honeywell □ Incom
□ Infodex □ Innovated Image □ Mekel
Engrg. □ Primagraphics □ PsiTech
□ Sarnoff Research Center □ Si
Diamond □ Simtech □ Teledyne
Electronic □ Texas Instruments □ 3M
Product Information □ Univision □ VDC
(Teltron) □ VDC (Z-Axis) □ Virtual Vision

DIGITIZING TABLETS

□ Calcomp □ Dynapro □ IBM
□ Numerics □ Scriplet □ SMART
Technologies □ Summagraphics
□ WACOM

DISABLED DISPLAY USER AIDS

□ Enabling Technologies □ Regisbrook
□ Telesensory

DISPENSER CATHODES

□ Electronics Sources □ Formosa
Advanced Tech. □ Raytheon □ Semicon
Associates □ Sony Display Device Group
□ **Thomas Electronics**

DISPLAY DRIVERS AND CONTROLLERS

Advanced Conversion □ Anorad
Astronautics □ Avalex □ AVED
Barco □ Barco Chromatics □ Barco Display
Cambridge Research □ Chips & Technologies □ Cirrus Logic
Computer Dynamics □ Craft Data, Inc.
Craft Data Ltd. □ CRL □ Densitron
Diagnostic/Retrieval Systems
Diamond Tech One □ Digital View
Digitran □ Display Systems □ Dolch Computer
DRS Military Systems
EG&G Power Systems □ Epsilon America
F-P Electronics □ Gennum
General Digital □ Honeywell
Innodex □ International Micro □ Jaco Electronics
Kent Displays
Lockheed Sanders □ Luminary Technologies
Marshall Industries
MECC □ Metheus □ Milgray Electronics
Mintronix □ Monitron
Motorola □ National Research Resources
National Semiconductor
Night Vision Corp. □ Omega Electronics
Photonics Systems
Pixelink □ Primagraphics □ PsiTech
Pulseview □ Racal-Mesl
Regisbrook □ RGB Spectrum
Rytrak □ Sage □ SI Diamond □ Smart Alec
S-MOS □ Supertex
Tektronix □ Texas Instruments Japan
Thomson-CSF Services □ Trident Microsystems
Unigraf □ Univision
Versatec □ Vidiwall □ ViewTEK □ Westar
Western Digital □ Wyle Electronics
Xentek □ Yamaha Systems Technology

DISPLAY HOUSING, RUGGEDIZED

ADT □ Astronautics □ AVED □ AVT
Barco Chromatics □ Barco Display
Burle Industries □ Calspan SRL
Craft Data, Inc. □ Crystaloid □ D&T
Diagnostic/Retrieval Systems □ Digital View
Digitran □ Display Systems
Dolch Computer □ DRS Military Systems
Eaton PSD □ Electrohome
El-Op Electrooptics □ Eurecran
General Digital □ Ginsbury
Honeywell □ Image Quest □ Infodex
Jaco Electronics □ LCSP-Deeco
L-3 Communications □ Marshall Industries
Milgray Electronics
Mushield □ Nortech Engineering
Photonics Systems □ Plessey Naval Systems
Precision Imaging □ Racal Acoustics
Raytheon □ Regisbrook
Retroscon □ SAIC □ SAI Technology
Sascal Displays □ Stanley Palmer
Tektronix □ Thomson-CSF Services
VDC (Data Display) □ VDC (Teltron)
ViewTEK

DISPLAY SIMULATION AND MODELING SYSTEMS

ADT □ ALCOM □ autronic
Coryphaeus □ Diagnostic/Retrieval Systems
DRS Military Systems
Evans & Sutherland Computer
Hitachi Denshi America □ Hughes LV Products
Infodex □ Liberty Mirror
Milgray Electronics □ MTL Systems
Optis □ Sarnoff Research Center
Shintech □ Star Technologies
Tektronix □ Visus

DISPLAY SUBSYSTEMS

AED □ Aerospace Display Systems
Astronautics □ AVED □ Babcock
Balzers AEG □ Balzers Thin Films
Barco □ Barco Chromatics □ Barco Display
Calspan SRL □ Cambridge Research □ Clinton Electronics

Computer Dynamics □ Craft Data, Inc.
Craft Data Ltd. □ CRL □ D&T
Densitron □ Diagnostic/Retrieval Systems
Diamond Tech One □ Digital View
Dimension Technologies
Display Systems □ Dolch Computer
DOME □ Eaton PSD □ EG&G Optoelectronics
Fakespace □ General Digital
Genesis Microchip □ Infinity Multimedia
Interface Products □ Jaco Electronics
Kent Displays □ Korry Electronics
Litton Systems Canada
Mark IV Industries □ Marshall Industries
Milgray Electronics
National Research Resources □ Night Vision Corp.
Nortech Engineering
Optical Devices □ Optical Radiation
Optotek □ Palomar Products
Performance Display Systems
Photonics Systems □ PixelVision
Positive Technologies □ Quantum Electronics
Racal-Mesl □ Raytheon
Regisbrook □ RGB Spectrum □ Sage
SAI Technology □ Silicon Light Machines
Teledyne Electronic □ Texas Instruments □ Thomas Electronics
Thomson-CSF Services □ UCE
UNIAX □ Univision □ ViewTEK
Vista Controls □ WACOM

DISPLAY SYSTEM INTEGRATORS

Astronautics □ AVED □ Barco Chromatics
Barco Display □ Calspan SRL □ Canadian Marconi
Carroll Touch □ Computer Dynamics
Craft Data, Inc. □ DBI □ Densitron
Diagnostic/Retrieval Systems □ Digital View
Digitran □ Display Systems
DRS Military Systems □ Eastman Kodak
Eaton PSD □ Elographics
El-Op Electrooptics Industries
Eurecran □ Fakespace □ F-P Electronics
General Digital
Honeywell □ Hoya Electronics □ Jaco Electronics
Kollmorgen □ LCSP-Deeco
Litton Systems Canada
Lockheed Sanders □ L-3 Communications
Mark IV Industries
Marshall Industries □ Milgray Electronics
National Research Resources
National Semiconductor
Performance Display Systems
Photonics Systems □ Planar Advance
Plessey Naval Systems
Quantum Electronics □ Retroscon □ Rockwell Intl.
SAI Technology □ Sanders Associates
Scriptel □ SEOS Displays □ SI Diamond
Smart Alec □ Tech-Corn
Thomson-CSF Services □ Transicoil
Unigraf □ Vidiwall □ ViewTEK
Vista Controls □ Westaim □ Whittaker

DISPLAYS

See listings under specific technology, i.e., CRT, plasma, electroluminescent

DISORTION CORRECTION DEVICES

Display Components □ Display Labs
DynaColor □ Eldor □ Ginsbury
Intronics □ K & R Engr.
Thomson-CSF

ELECTROCHROMIC DISPLAYS

Mito Fine Glass □ Polyvision □ 3M Product Information □ VDC (Teltron)

ELECTROLUMINESCENT DISPLAYS

Aydin Computer/Monitor □ Barco Chromatics
Barco Display □ Canadian Marconi
Capetronic □ Craft Data Ltd.
Densitron □ Digitran □ Durel □ Earth Computer
Eaton IDT □ Eldec

ELtech □ Electro-Optics □ Honeywell
Defense Avionics □ Hoya Electronics
IEC □ IEE □ Infodex □ Interface Products
Interstate Electronics
Kaiser Electronics □ Lamplighter
Luxell □ Marshall Industries □ Milgray Electronics
National Research Resources
Night Vision Corp. □ PEMM Services
Phosphor Products □ Planar Advance
Planar America □ Planar Intl.
Planar Systems □ PPM Photomask
Pulseview □ Quantex □ Racal-Mesl
Regisbrook □ Rogers Corp. □ Sarnoff Research Center
Seiko Instruments
Sharp Digital Information Products
Sharp Electronics □ Spire □ I. I. Stanley
Stanley Electric □ Swiss Controls
Thomson-CSF □ 3M Product Information
Transicoil □ UNIAX
VDC (Teltron) □ WAMCO □ Westaim
James Wilson □ World Products
Wyle Electronics □ XTEK

ELECTROMECHANICAL DISPLAYS

Astronautics □ Ametek Aerospace Products
Densitron □ Digitran
Displays Inc. □ Earth Computer □ F-P Electronics
Honeywell Defense Avionics
Infax □ Interface Products □ Korry Electronics
Mark IV Industries
Omega Electronics □ Pulseview
Regisbrook □ Rockwell Intl. □ Sharp Digital Information Products
Stan-Allen
Thin Film Technology □ 3M Product Information
Transicoil □ XTEK

ELECTRON GUNS

CRT Intl. □ General Atronics
Innotec □ Kurt J. Lesker Co. □ Matrix Components
Philips Components
Raytheon □ Sarnoff Research Center
SI Diamond □ Silicon Light Machines
Sony Display Device Group
Thomson-CSF □ 3M Product Information
VDC (Apex) □ VDC (Southwest Vacuum)
VDC (Video Electronics) □ Zenith Components Group
Zenith Electronics

ENCLOSURE DESIGN SYSTEMS

Eaton PSD □ Info-Lite □ Jaco Electronics
MicroTouch Systems
Mushield □ Retroscon □ Tech-Corn
3M Product Information

EYE AND HEAD MOVEMENT TRACKERS

Applied Science Labs □ El-Op Electrooptics Industries
Fakespace
Honeywell □ ISCAN □ Night Vision Corp.
Polhemus □ Rediffusion Simulation
Reynolds Industries
Sarnoff Research Center

FACSIMILE ("FAX") MACHINES

Canon, Inc. □ Eltime Vision Systems
IBM □ Mitsubishi Electronics Sales America
Relisys

FIBER-OPTIC FACEPLATES

Digitran □ Future Focus □ General Atronics
Incom □ Lumitex □ Raytheon
Schott Fiber Optics □ 3M Electronic Products
3M Product Information
Transicoil

FIELD-EMITTER DISPLAYS

Candescent Technologies □ CRL
Diamond Tech One □ Futaba America
Motorola FPD □ MRS Technology
Night Vision Corp. □ PixTech
Planar Advance □ SI Diamond
Spire

FILTERS

American Polarizers □ Astra Products
ADT □ Balzers AEG □ Balzers Thin Films
Brewer Science □ ColorLink
Crystaloid □ D&T □ Denglas
Denton Vacuum □ Dontech □ E for M
Flex Products □ Fosta-Tek □ Genesis Microchip
Ginsbury □ Hoffman Engr. □ Homalite □ Hoya Electronics
Hoya Optics □ International Polarizers □ ITG
Jaco Electronics □ Kaiser Optical
Lamination Technology □ Liberty Mirror
LMT □ Melles Griot □ Metavac
Milgray Electronics □ Mito Fine Glass
Nitto Denko □ NoRad □ O&S Research
OCA □ OCLI □ Optical Devices
Opto-Cal □ Panelgraphic
Panelview □ Planar Advance
Polaroid □ Precision Optical Filters
Raytheon □ RMF Products
Rockwell Intl. □ Romag Glass
Schott Glass □ Screen Shield □ Silver Cloud Mfg.
Southwall Technologies
Stanley Palmer □ Systems Research Labs
Thin Film Technology □ Toko America
3M Optical Systems □ 3M Product Information
TSP □ U.S. Precision Glass □ Viratec □ WAMCO

FLAT-PANEL DISPLAYS

See individual listings for backlights, electroluminescent displays, electro-mechanical displays, electrochromic displays, field-emitter displays large-screen displays, light-emitting diode displays, liquid-crystal displays, plasma displays, filters, projection displays, simulator displays, 3D displays, touch interactive displays, vacuum fluorescent displays

FLAT-PANEL MATERIALS

See individual listings for masks, filters, glass, magnetic shielding, materials, optical coatings, photolithography equipment, polarizers

FOCUS COILS

CELCO □ Del Electronics □ Display Components
Eldor □ Ginsbury
George D. Harris Associates □ K & R Engr.
Raytheon □ Sarnoff Research Center □ Syntronic Instruments
WinTron

GETTERS

Andrews Glass □ CRT Intl.
Raytheon □ SAES Getters

GLASS FOR COMPONENTS

Andrews Glass □ Applied Technology
Denton Vacuum □ Donnelly Applied Films
Hoya Optics □ Lamination Technology
Libbey-Owens-Ford
Nippon Electric Glass □ OCLI
Optical Devices □ Philips Components
Precision Glass Technologies
Raytheon □ Romag Glass □ Schott Glass
SEM-COM □ U.S. Precision Glass
VDC (Data Display) □ VIOX
Viratec

GLASS FOR CRTs

Corning Asahi □ Donnelly Applied Films
Hoya Electronics □ Hoya Corp.
Lamination Technology □ Metavac
MicroTouch Systems □ Mito Fine Glass
Nippon Electric Glass □ O&S Research
Precision Electronic Glass
Raytheon □ Schott Corp. □ Schott Glass
SEM-COM □ Techneglas
U.S. Precision Glass □ VDC (Video Electronics) □ Viratec

industry directory

GLASS FOR FLAT-PANEL DISPLAYS

□ Applied Films □ Bilco Mfg. □ Brewer Science □ Corning ADP □ Denglas □ Denton Vacuum □ Donnelly Applied Films □ EEV Ltd. □ E for M □ Flachglas AG □ Glaverbel □ Hoya Electronics □ Hoya Optics □ Lamination Technology □ **Libbey-Owens-Ford** □ Metavac □ MicroTouch Systems □ Mito Fine Glass □ National Research Resources □ Nippon Electric Glass □ O&S Research □ Optical Devices □ Planar Advance □ Planar Systems □ Romag Glass □ Rytek □ Scriptel □ Schott Corp. □ SEM-COM □ Three-Five Systems □ U.S. Precision Glass □ **VIOX** □ Viratec

GRAPHICS BOARDS AND PROCESSORS

□ American ELTEC □ Astronautics □ Avalex □ AVED □ Barco □ Barco Chromatics □ Barco Display □ Calcomp □ Calspan SRL □ Cambridge Research □ Chips & Technologies □ Computer Peripherals □ Coreco □ Crystal Vision □ Data Translation □ DOME □ DynaColor □ Eastman Kodak □ EPIX □ IBM □ Imagraph □ Kollmorgen □ Matrox Electronic Systems □ ORC Electronic □ Philips Components □ Primagraphics □ PsiTECH □ Sharp Digital Information Products □ Symco □ Univision

□ American ELTEC □ Astronautics □ Avalex □ AVED □ Barco □ Barco Chromatics □ Barco Display □ Calspan SRL □ Cambridge Research □ Denitron □ Diagnostic/Retrieval Systems □ DOME □ Evans & Sutherland Computer □ General Electric □ Honeywell □ Hybrid Micrographics □ IBM □ Imagraph □ Imapro □ Kollmorgen □ Lasergraphics □ L-3 Communications □ Luminary Technologies □ Matrox Electronic Systems □ Metheus □ Nth Graphics □ Omnicomp Graphics □ Parallax □ Pixelink □ Polaroid □ Positive Technologies □ Primagraphics □ PsiTECH □ Racal-Mest □ Rasterops □ Richardson Electronics □ Simtech □ Sony □ Sony Graphic Display □ Star Technologies □ Tatung □ Thomson-CSF Services □ **3M Product Information** □ Trident Microsystems □ Unigraf □ Univision □ Vivitek □ Western Digital □ Yamaha Systems Technology

GRAPHICS SUBSYSTEMS

□ American ELTEC □ Astronautics □ AVED □ Barco □ Barco Chromatics □ Barco Display □ Calspan SRL □ Cambridge Research □ Denitron □ Diagnostic/Retrieval Systems □ L-3 Communications □ Positive Technologies □ Silicon Light Machines □ Thomson-CSF Services □ Univision

GRAPHICS WORKSTATIONS

□ Aydin Computer/Monitor □ Aydin Corp. □ Barco □ Barco Chromatics □ Barco Display □ Diagnostic/Retrieval Systems □ Eaton IDT □ Evans & Sutherland Computer □ Grass Valley Group □ Hughes LV Products □ IBM □ Laversab □ Lockheed Sanders □ Management Graphics □ McMahan Electro-Optics □ NuVision Technologies □ Primagraphics □ SAIC □ Sanders Associates □ Thomson-CSF □ **3M Product Information**

HARD-COPY DEVICES

See individual listings for digital film recorders, facsimile machines, plotters, printers (impact, ink-jet, thermal-transfer, electrophotographic, color graphic), printer supplies, printheads

HOLOGRAPHIC LIGHT-SHAPING DIFFUSERS

□ Physical Optics

IMAGE COMPRESSION

□ Genesis Microchip □ Imagraph □ PsiTech □ Schott Fiber Optic □ Symco □ **3M Product Information**

IMAGE STORAGE

□ Colorado Video □ CRT Intl. □ **Kent Displays** □ Stereomedia □ Symco □ **3M Product Information** □ VDC (Teltron)

IMAGE TUBES

□ Burle Industries □ CRT Intl. □ EEV □ EEV Ltd. □ Incom □ Kollmorgen □ Litton Electron Devices □ MII □ Panasonic Industrial □ Philips Components □ Sony Display Device Group □ Teltron □ Thomson Tubes Electroniques □ VDC (Teltron)

IMAGING BOARDS

□ American ELTEC □ Barco □ Computer Peripherals □ Coreco □ Crystal Vision □ Data Plus □ Data Translation □ DOME □ DynaColor □ Eastman Kodak □ EPIX □ IBM □ Imagraph □ Kollmorgen □ Matrox Electronic Systems □ ORC Electronic □ Philips Components □ Primagraphics □ PsiTECH □ Sharp Digital Information Products □ Symco □ Univision

IMAGING WORKSTATIONS

□ Advanced Video Products □ Decision Images □ Diagnostic/Retrieval Systems □ Genesis Microchip □ IBM □ Image Analytics □ Imagraph □ Kollmorgen □ Laversab □ Management Graphics □ McMahan Electro-Optics □ McMahan Research Labs □ MegaVision □ SAIC □ Sarnoff Research Center □ Sharp Digital Information Products □ **Syntronic** □ **3M Product Information** □ Visual Information Technologies

JOYSTICKS

□ ADT □ Digitran □ **Jaco Electronics** □ WICO

KEYBOARDS

□ ADT □ Computer Keyboards Systems □ Craft Data, Inc. □ Digitran □ Display Systems □ Futaba □ IBM □ IEC □ IEE □ Innovated Image □ Interface Products □ **Jaco Electronics** □ Korry Electronics □ Laversab □ Marshall Industries □ Panasonic Industrial □ Racal-Mest □ Regisbrook □ Silver Cloud Mfg. □ Three-Five Systems □ Transcoil □ Two Technologies

LAMPS AND LIGHT SOURCES

□ autronic □ BKL □ Dialight □ Diamond Tech One □ EG&G Optoelectronics □ EG&G Power Systems □ **Gamma Scientific** □ Gordon Instruments □ ILC Technology □ Info-Lite □ **Jaco Electronics** □ **LCD Lighting** □ LSI □ Lumitex □ Man & Machine □ National Research Resources □ OAI □ Opto-Cal □ Optronics Labs □ ORC Lighting □ Pacific Technologies □ SAIC □ Seiwa Optical □ Schott Fiber Optics □ SI Diamond □ Teledyne Electronic □ UCE □ Ushio America □ Visus □ WAMCO □ Welch Allyn

LARGE-SCREEN DISPLAYS, ALL TECHNOLOGIES

See also projection displays

□ Adaptive Micro Systems □ Advanced Display Systems □ AEG □ Aydin

Computer/Monitor □ Barco Projection □ Barco Video & Commun. □ Capetronic □ Comfuture □ Convac-APT □ Cornerstone Technology □ Crystop Display □ Davies □ Denitron □ Digitran □ Display Tech □ Dolch Computer □ Donteck □ Dotronix □ EDL Displays □ EEV Ltd. □ Electronic Image Systems □ Epson America □ Eurecran □ Evans & Sutherland Computer □ Flat Panel Display □ F-P Electronics □ Fresnel Optics □ General Digital □ General Electric □ Genesis Microchip □ Hitachi America □ Hitachi Denshi America □ Hudson Photographic □ Hughes-JVC □ Hughes LV Products □ IEC □ Incom □ Infinity Multimedia □ Innovated Image □ Infocel Corp. □ **Jaco Electronics** □ L-3 Communications □ Lamination Technology □ Man & Machine □ Micrion □ MicroTouch Systems □ Mito Fine Glass □ **Mitsubishi Electric Sales America** □ Monitern □ **MRS Technology** □ **NEC Electronics** □ Noritake □ Nortech Imaging □ nView □ Omega Electronics □ Optical Radiation □ Optical Solutions □ ORC Electronic □ ORC Lighting □ **Palomar Products** □ Panasonic Computer Peripheral □ **Panelight** □ Performance Display Systems □ Physical Optics □ Plasmaco □ PPM Photomask □ Prolux □ Proxima □ Pulseview □ Quantum Electronics □ Rasterops □ Raytheon □ Rediffusion Simulation □ Regisbrook □ Retroscan □ Rytrak □ SAI Technology □ Sarnoff Research Center □ SEOS Displays □ SI Diamond □ Silicon Light Machines □ Smart Alec □ SMART Technologies □ Sony □ Sony Display Device Group □ Stereomedia □ Systems Research Labs □ Tatung □ Tech-Com □ Tektronix □ Telesensory □ Telex Communications □ TDS □ Texas Instruments □ Thomson-CSF Services □ Thomson Tubes Electroniques □ Tru-Lyte Systems □ UCE □ Varitronix □ Video Display Corp. □ Vidwall □ Viratec □ World Products □ Zenith Components Group

LIGHT-EMITTING DIODES AND LED DISPLAYS

□ Acculex □ Adaptive Micro Systems □ Astronautics □ Comfuture □ Craft Data Ltd. □ Daktronics □ Data Display Products □ Dialight □ Digitran □ Display Systems □ Earth Computer □ EG&G Optoelectronics □ Electro-Optics □ F-P Electronics □ Future Focus □ General Electric □ H-P □ IBM □ IEE □ Incom □ Infocel Corp. □ Info-Lite □ Interface Products □ **Jaco Electronics** □ JKL Components □ Litton Systems Canada □ Mark IV Industries □ Marubeni □ Milgray Electronics □ Modutec □ Morrison Electronics □ Nichia America □ Night Vision Corp. □ Optotek □ PPM Photomask □ PRP Optoelectronics □ Pulseview □ Quantum Electronics □ Reflection Technology □ Regisbrook □ Seiko Instruments □ Smart Alec □ I. I. Stanley □ Stanley Electric □ Teledyne Electronic Technologies □ Three-Five Systems □ Univ. of Michigan □ Varitronix □ WAMCO □ James Wilson □ XTEK

LIGHT PENS/POINTING SYSTEMS

□ Interactive Computer Products □ Digitran □ IBM □ MicroTouch Systems □ Rikei Corp. □ Scriptel □ SMART Technologies □ **3M Product Information** □ WAMCO

LIQUID-CRYSTAL DISPLAYS, ACTIVE-MATRIX

□ Acculex □ ADT □ Applied Technology □ ASM America □ Astronautics □ Barco □ Canadian Marconi □ Casio LCD □ Convac-APT □ Craft Data, Inc. □ Craft Data Ltd. □ CRL □ **CTX Opto** □ Data Plus □ Davies □ DBI □ Denitron □ Digitran □ Display Systems □ Dolch Computer □ dpiX □ Dynamic Displays □ Earth Computer □ Eaton PSD □ EEV Ltd. □ Electrohome □ Electronic Image Systems □ Epson America □ Flat Panel Display □ Fujitsu □ GEC Hirst Research Centre □ General Electric □ BF Goodrich □ Hitachi America □ Honeywell Defense Avionics □ Honeywell □ Hosiden America □ Hyundai Electronics □ Image Systems □ **Image Quest** □ Incom □ Innovated Image □ Interface Products □ Interstate Electronics □ **Jaco Electronics** □ Kopin □ Kristel □ Laversab □ **LCD Lighting** □ Night Vision Corp. □ Litton Systems Canada □ Lockheed Sanders □ L-3 Communications □ Micrion □ Micro-Optics □ MicroTouch Systems □ Milgray Electronics □ Mintronix □ **Mitsubishi Electric Sales America** □ **Mitsubishi Electronics America** □ Miwa □ Modutec □ **MRS Technology** □ National Research Resources □ National Semiconductor □ **NEC** □ **NEC Electronics** □ Nippon Electric Glass □ nView □ OIS □ Omega Electronics □ **Palomar Products** □ Panasonic Computer Peripherals □ Performance Display Systems □ PixelVision □ Planar Advance □ Polytronix □ PPM Photomask □ Proxima □ Pulseview □ Racal-Mest □ RDI Computer □ Regisbrook □ Richardson Electronics □ Rikei Corp. □ Rytrak □ SAIC □ **Samsung Electronics** □ Sarnoff Research Center □ Sayett □ Sharp Electronics □ Shintech □ Silscape □ Stereomedia □ Systems Research Labs □ Technical Visions □ Tektronix □ 3-D ImageTek □ **3M Product Information** □ Timeline □ Toshiba America □ UCE □ Univ. of Michigan □ Varitronix □ Vivid Semiconductor □ World Products □ XTEK □ **ViewTEK** □ VL Electronics □ WAMCO □ Wyle Electronics

LIQUID-CRYSTAL DISPLAYS, CHOLESTERIC

□ **Kent Displays** □ Microtech

LIQUID-CRYSTAL DISPLAYS, COLOR

□ Advanced Display □ AEG □ ALCOM □ Applied Technology □ Arizona LCD □ Astronautics □ Barco □ Casio LCD □ Craft Data, Inc. □ Craft Data Ltd. □ CRT Intl. □ Crystaloid □ **CTX Opto** □ Data Plus □ DBI □ DCI □ Denitron □ Dolch Computer □ dpiX □ Dynamic Displays □ Earth Computer □ Eaton PSD □ Electrohome □ Electronic Image Systems □ Electro-Optics □ Epson America □ Flat Panel Display □ FPD Technologies □ Hantronix □ Hitachi America □ Hosiden America □ **Image Quest** □ Innovated Image □ Interface Products □ **Jaco Electronics** □ **Kent Displays** □ Kisco Santa Clara □ Kristel □ Kyocera □ Micrion □ MicroTouch Systems □ Milgray Electronics □ **Mitsubishi Electronics America** □ National Semiconductor □ **NEC Electronics** □ Nippon Electric Glass □ Night Vision Corp. □ NuVision Technologies □ nView □ OIS □ Optrex/Satori □ **Palomar Products**

□ Performance Display Systems
□ PixelVision □ Polytronix □ Proxima
□ Racal-Mesl □ RDI Computer
□ Regisbrook □ Richardson Electronics
□ Rikei Corp. □ SAIC □ Seiko
Instruments □ Sharp Electronics
□ Shintech □ Stanley Electric □ Stalaw
□ I. I. Stanley □ Systems Research Labs
□ 3-D ImageTek □ Three-Five Systems
□ Toshiba America □ UCE □ Uniglobe
Kisco □ Varitronix □ ViewTEK □ Vivid
Semiconductor □ Vivitek □ Wyle
Electronics □ XTEK □ VL Electronics

LIQUID-CRYSTAL DISPLAYS, FERROELECTRIC

□ ALCOM □ Arizona LCD □ AZ LCD
□ Canon, Inc. □ CRL □ Crystop Display
□ Digitran □ Display Systems □ EEV
Ltd. □ Electronic Image Systems
□ Euroscan □ GEC Hirst Research
Centre □ BF Goodrich □ Hornell
Elektrooptik □ Micro-Optics □ Night
Vision Corp. □ PPM Photomask
□ Regisbrook □ Rytrak □ Shintech
□ Varitronix

LIQUID-CRYSTAL DISPLAYS, PASSIVE

□ ADT □ Advanced Display Systems
□ AEG □ Aerospace Display Systems
□ ALCOM □ Ametek Aerospace Products
□ Applied Technology □ Arizona LCD
□ Astronautics □ AZ LCD □ Batron
□ Casio LCD □ Craft Data, Inc. □ Craft
Data Ltd. □ CRL □ CRT Intl.
□ Crystaloid □ Crystop Display □ CTX
Opto □ Data Plus □ DBI □ DCI
□ Densitron □ Dycrystal Images
□ Digitran □ Display Systems
□ Dynamic Displays □ Earth Computer
□ EEV □ EEV Ltd. □ EM
Microelectronic □ Epson America
□ Euroscan □ Excel Technology □ FPD
Technologies □ GEC Hirst Research
Centre □ General Electric □ Hantronix
□ Hitachi America □ Hornell Elektrooptik
□ Hosienden America □ IEE □ In Focus
Systems □ Interface Products □ Kent
Display Systems □ Kisco Santa Clara
□ Kyocera □ Kristel □ Kyocera □ LXD
□ Mark IV Industries □ MicroTouch
Systems □ Mito Fine Glass □ Mitsubishi
Electric Sales America □ National
Research Resources □ National
Semiconductor □ Night Vision Corp.
□ nView □ Ocular □ Omega Electronics
□ Optrex America □ Optrex/Satori
□ Polytronix □ Proxima □ Pulseview
□ Racal Acoustics □ Regisbrook □ Rikei
Corp. □ Rytrak □ SAIC □ Satori Electric
□ Seiko Instruments □ Sharp Electronics
□ Shintech □ S-MOS □ Solomon
Technology □ Sony Display Device Group
□ Standish Industries □ I. I. Stanley
□ Stanley Electric □ Stereomedia
□ Telex Communications □ Three-Five
Systems □ Timeline □ Toshiba America
□ Transcoil □ UCE □ Uniglobe Kisco
□ Varitronix □ VGI □ VL Electronics
□ World Products □ Wyle Electronics
□ XTEK

LIQUID-CRYSTAL DISPLAYS PASSIVE, ACTIVE ADDRESSING

□ Arizona LCD □ Astronautics
□ Densitron □ Display Systems
□ Hantronix □ Hitachi America
□ Hosienden America □ Interface Products
□ Instal □ Jaco Electronics □ Kent
Displays □ Luminary Technologies
□ LXD □ MicroTouch Systems
□ Milgray Electronics □ Motif □ National
Research Resources □ Night Vision Corp.
□ Optrex America □ Optrex/Satori

□ PEMM Services □ Polytronix
□ Regisbrook □ SAIC □ Sharp
Electronics □ Shintech □ Stanley Electric
□ Stalaw □ Stereomedia □ Three-Five
Systems □ UCE □ Varitronix □ Vivid
Semiconductor □ VL Electronics □ Wyle
Electronics □ XMR

LIQUID-CRYSTAL LIGHT-VALUE PROJECTORS

See projection displays

MAGNETIC SHIELDING

□ Ad-Vance Magnetics Magnetics
□ Amuneal □ Astronautics □ Barco
□ Chomerics □ Eagle Magnetics
□ E for M □ Fosta-Tek □ General
Atronics □ General Vacuum □ Gerome
□ Ginsbury □ Homalite □ Hoya
Electronics □ K & R Engrg. □ Lindgren
RF Enclosures □ Liberty Mirror
□ Magnetic Radiation Labs □ Magnetic
Shield □ Mushield □ NoRad □ Raytheon
□ Siemens Components □ Silver Cloud
Mfg. □ 3M Product Information
□ Vacuumschmelze □ Viratec

MANUFACTURING EQUIPMENT

□ Accudyne □ Advanced Display
Systems □ AeroTech □ Anorad
□ Applied Technology □ ASM America
□ autronic □ Aydin Computer/Monitor
□ AZ LCD □ Best Power Technology
□ Billco Mfg. □ BOC Coating □ Brewer
Science □ Brooks Automation □ CFM
Technologies □ Convac-APT □ CRT Intl.
□ Dark Field Technologies □ Display
Labs □ Donnelly Applied Films
□ DynaColor □ Eaton Corp. □ Eaton
IDT □ Fairchild Convac □ FAS
Technologies □ Florod □ Genmark
□ Gerber Systems □ Glen Technologies
□ Holographic Lithography □ Hornell
Automation □ Hornell Engrg. □ H-Square
□ Hybrid Micrographics □ Image
Processing Systems □ Innotec
□ International Micro □ Interserv
□ Intevac □ Kenix Industries □ Kisco
Santa Clara □ Kurdex □ Laversab
□ Kurt J. Lesker Co. □ Leybold
□ Lighting Sciences □ Materials
Research Corp. □ Micron □ Miwa
□ MRS Technology □ Nalpak Sales
□ Nanometrics □ Nikon Precision
□ Nippon Seiko K.K. □ OAI □ Optical
Radiation □ Orbotech □ ORC Electronic
□ Pacific Technologies □ Palomar
Products □ Photon Dynamics
□ Plasma-Therm □ PRI Automation
□ Semiconductor Systems □ Semitool
□ Sony □ Specialty Coating Systems
□ Spectrum Sciences □ Spire □ Teknek
Electronics □ Temescal □ 3M Electronic
Products □ 3M Product Information
□ Toddco □ Tokyo Electron America
□ Ultra t □ Uniglobe Kisco
□ Veeco/Sloan Technology □ VDC
(Apex) □ VDC (HQ) □ Viratec
□ Watkins-Johnson □ Wandu □ XMR
□ Young Technology

MARKET RESEARCHERS/PUBLISHERS

□ American Institute of Small Business
□ Dempa □ Display Technology Library
□ Electronic Trend □ Ergonomics
□ Ergosyst Associates □ FAI □ Future
Systems □ Joe Hallett & Associates
□ Walter Hett & Associates □ Interlingua
□ Kahn International □ Machover
Associates □ MIRC □ Multimedia and
Videodisc Monitor □ Nutmeg Publishing
Consultants □ O'Mara & Associates

□ Pacific Media Associates □ Photonics
Spectra □ Pixel Interconnect □ Ramey
Scientific □ SEMI-FPD □ Stanford
Resources □ Tyson Consulting Group

MASKS

□ Applied Image □ Convac-APT
□ Electrographics □ Eurecran □ Hoya
Electronics □ Image Quest □ Micronic
Laser Systems □ Microphase Labs
□ MRS Technology □ Photonics
□ Photonics-Colorado □ PPM
Photomask □ Process Technologies
□ Terapixel □ 3M Product Information

MATERIALS

electrochromic displays

□ Applied Films □ Brewer Science
□ Donnelly Applied Films □ E for M
□ Feldman Technology □ General
Vacuum □ Glaverbel SA □ IDM
□ Indium America □ Lamination
Technology □ Mushield □ Orbotech
□ Photonics □ Rexam Custom
□ Target Materials □ Tekra □ Terapixel
□ 3M Electronic Products □ 3M
Product Information □ U.S. Precision
Glass □ Vacuum Engineering

electroluminescent displays

□ American Polarizers □ Applied Films
□ Arconium □ Astra Products
□ Atomergic Chemetals □ BKL
□ Brewer Science □ Courtaulds □ D&T
□ Donnelly Applied Films □ Dontech
□ Durel □ E for M □ ELtech
□ Feldman Technology □ General Digital
□ General Vacuum □ Glaverbel SA
□ IDM □ Indium America □ Kisco Santa
Clara □ Lamination Technology
□ Marubeni □ National Research
Resources □ Nichia America □ Nitto
Denko □ Photonics □ Planar Systems
□ Rexam Custom □ Spire □ Stan-Allan
□ Target Materials □ Tekra □ Terapixel
□ 3M Electronic Products □ UCE
□ UNIAX □ U.S. Precision Glass
□ Vacuum Engineering □ VisPro □
WAMCO □ James Wilson

electromechanical displays

□ Brewer Science □ E for M □ F-P
Electronics □ IDM □ Mark IV Industries
□ Mushield □ Photonics □ Tekra
□ Terapixel □ 3M Electronic Products
□ U.S. Precision Glass □ Vacuum
Engineering

large-screen displays

□ Adaptive Micro Systems □ AEG
□ Applied Technology □ Barco Video &
Commun. □ Brewer Science □ Dana
Enterprises □ Donnelly Applied Films
□ Dontech □ Dynair □ E for M
□ General Vacuum □ Glaverbel SA
□ Incom □ Indium America □ Feldman
Technology □ General Digital □ Genesis
Microchip □ Hyacinth Technology □ IDM
□ Kaiser Optical □ Kisco Santa Clara
□ Lamination Technology □ National
Research Resources □ Nitto Denko
□ Optical Radiation □ Optical Solutions
□ Photonics □ Physical Optics
□ Plasmatronics □ Rantec □ Retroscon
□ Rexam Custom □ SI Diamond
□ Target Materials □ Tech-Corn □ Tekra
□ Terapixel □ Tosoh SMD □ U.S.
Precision Glass □ Vacuum Engineering
□ Viratec □ Visus

light-emitting diode displays

□ Adaptive Micro Systems □ American
Polarizers □ Arconium □ Astra Products
□ Brewer Science □ Display Systems
□ E for M □ F-P Electronics □ H-P
□ IDM □ Indium America □ Infotex
Corp. □ Marubeni □ Nichia America
□ Nitto Denko □ Photonics
□ Plasmatronics □ Quantum Electronics
□ Stanley Electric □ Tekra □ Terapixel
□ U.S. Precision Glass □ Vacuum
Engineering □ VisPro □ WAMCO
□ James Wilson

light pens/pointing systems

□ American Polarizers □ Photonics
□ Plasmatronics □ Scriptel □ Tekra
□ U.S. Precision Glass □ Vacuum
Engineering

liquid-crystal displays

□ Adhesives Research □ ALCOM
□ AlliedSignal □ American Polarizers
□ Applied Films □ Applied Technology
□ Arconium □ Arizona LCD □ Astra
Products □ AZ LCD □ BDH □ Brewer
Science □ CRL □ Crystaloid
□ Dainippon Ink & Chemicals □ D&T
□ Dana Enterprises □ Display Systems
□ Donnelly Applied Films □ Dontech
□ Earth Computer □ E for M □ EM
Industries □ Exxene □ Feldman
Technology □ F-P Electronics □ General
Digital □ General Vacuum □ Genesis
Microchip □ Glaverbel SA □ F. Hoffmann
La Roche □ Incom □ Indium America
□ Kaiser Optical □ Kenix Industries
□ Kent Displays □ Kisco Santa Clara
□ Lamination Technology □ LCD
Lighting □ Mark IV Industries
□ Marubeni □ Merck □ Nagase
California □ National Research Resources
□ Nitto Denko □ Optotek
□ Optrex/Satori □ Pacific Technologies
□ Photonics □ Plasmatronics □ Polaroid
Holographic □ Rexam Custom □ Rytrak
□ Solomon Technology □ Target
Materials □ Tekra □ Terapixel □ 3-D
ImageTek □ 3M Optical Systems □ 3M
Product Information □ Tosoh SMD
□ UCE □ Uniglobe Kisco □ Univ. of
Michigan □ U.S. Precision Glass
□ Vacuum Engineering □ Viratec
□ Visus □ WAMCO □ XTEK

plasma displays, ac

□ American Polarizers □ Applied Films
□ Applied Technology □ Astra Products
□ Brewer Science □ Donnelly Applied
Films □ E for M □ Feldman Technology
□ Genesis Microchip □ Glaverbel SA
□ IBM Canada □ IDM □ Kisco Santa
Clara □ Marubeni □ Nichia America
□ Photonics □ Rexam Custom □ SEM-
COM □ Target Materials □ Tekra
□ Terapixel □ Uniglobe Kisco □ U.S.
Precision Glass □ Vacuum Engineering
□ Viratec □ WAMCO

plasma displays, dc

□ American Polarizers □ Applied Films
□ Applied Technology □ Astra Products
□ Displays □ Donnelly Applied Films
□ E for M □ Feldman Technology
□ Genesis Microchip □ Glaverbel SA
□ IDM □ Kisco Santa Clara □ Marubeni
□ Micron □ Nichia America
□ Panasonic Industrial □ Photonics
□ Quantum Electronics □ Rexam Custom
□ Target Materials □ Tekra □ Terapixel
□ Uniglobe Kisco □ U.S. Precision Glass
□ Vacuum Engineering □ Viratec
□ WAMCO

□ Lasertechnics □ Panasonic Industrial
□ QMS □ Raytheon □ Syntest
□ Tartan Technical □ Team Systems
□ Toyo Spectrum □ Versatec □ Xerox
Engrg. Systems

PRINTHEADS

□ Craft Data Ltd. □ DH Print □ GEC
Hirst Research Center □ Optotek
□ Stanley Electric

PROJECTION DISPLAYS

Liquid-crystal projectors

□ CTX Opto □ Electronic Image Systems
□ Epson America □ Fujitsu □ Genesis
Microchip □ Hitachi America □ Innovated
Image □ Palomar Products
□ Panasonic Computer Peripherals
□ Prolux □ Sarif □ Stalaw □ Symco
□ Tartan Technical □ Viratec

Liquid-crystal light-valve projectors

□ Astronautics □ Barco □ Barco
Projection □ CRT Intl. □ Davis A/S
□ Draper Screen □ Electrohome
□ Electronic Image Systems □ Eucrcan
□ Evans & Sutherland Computer □ Flat
Panel Display □ GEC Hirst Research
Centre □ General Electric □ Genesis
Microchip □ Gritz's Emporium □ Hitachi
America □ Hosiden America □ Hughes
LV Products □ Incom □ Keltron
□ Lamination Technology □ Micron
□ Micro-Optics □ National Research
Resources □ nView □ Optical Solutions
□ Panasonic Communications & Systems
□ Panelight □ Polytronix □ PPM
Photomask □ Proxima □ Regisbrook
□ Retroscon □ Rytrak □ Sarnoff
Research Center □ Sayett □ Silicon Light
Machines □ Sony Display Device Group
□ Tech-Com □ Telex Communications
□ 3M Product Information □ UCE

Projection CRTs

□ Barco □ Barco Projection □ Calspan
SRL □ CRT Intl. □ Digitrans □ Draper
Screen □ Dynair □ EEV Ltd. □ El-Op
Electrooptics □ Electrohome □ Electronic
Image Systems □ Evans & Sutherland
Computer □ General Atronics □ Genesis
Microchip □ Ginsbury □ Gritz's Emporium
□ Hitachi Denshi America □ Incom
□ IST □ Keltron □ Mitsubishi Electric
Sales America □ Optical Solutions
□ Raytheon □ Rediffusion Simulation
□ Retroscon □ Sarnoff Research Center
□ Sony Display Device Group
□ Stereomedia □ Symco □ TDSD
□ Tech-Com □ Thomas Electronics
□ Thomson Components & Tubes
□ Thomson-CSF □ Thomson Tubes
Electronics □ 3M Product Information
□ VDC (Novatron) □ Vidiwall
□ ViewTEK □ Viratec □ Zenith
Electronics

REPAIR AND MAINTENANCE

of computer systems

□ Astronautics □ Hitech Intl. □ IBM
□ Man & Machine □ Matrix Components
□ Recognition Concepts □ Tempest
Technologies VDC (Data Display)

of display systems

□ Astronautics □ AVT □ CRL □ D&T
□ Display Technologies □ Florod
□ General Electric □ Electrohome
□ Graseby Optronics □ IBM □ Incline
□ Klein Instruments □ LCD Lighting
□ Man & Machine □ Matrix Components
□ Micron □ Midwest Computer □ Miwa

□ Noritake Imaging □ Photonics Systems
□ Quantum Electronics □ Raytheon
□ Signatone □ Team Systems □ Tech-
Com □ Teltron □ TNP □ VDC (Data
Display) □ VDC (Teltron)

of high-voltage power supplies

□ American High-Voltage □ AstroSystems
□ Best Power Technology □ Display
Components □ F-P Electronics
□ Hyacinth Technology □ Keltron
□ Noritake Imaging □ Reynolds
Industries

SCAN CONVERTER TUBES

□ Raytheon

SCANNERS, DOCUMENT AND FILM (GRAPHICS)

□ Advanced Video Products □ Dark Field
Technologies □ Data Plus □ Digital
Vision □ Eastman Kodak □ ECRM
□ Howtek □ IBM □ Imapro □ Mekel
Engrg. □ Mitsubishi Electric Sales
America □ Pentax Technologies □ SEOS
Displays □ Summagraphics □ Tartan
Technical □ Telesensory □ Versatec

SCANNERS, DOCUMENT (TEXT)

□ Eastman Kodak □ IBM □ Pentax
Technologies □ Summagraphics □ Xerox
Imaging Systems

SCOREBOARDS

□ Adaptive Micro Systems □ Daktronics
□ EEV Ltd. □ F-P Electronics □ Futaba
America □ Hughes LV Products □ Infocel
Corp. □ Mark IV Industries □ National
Research Resources □ Quantum
Electronics □ Racal Acoustics
□ Regisbrook □ SI Diamond

SCRIBERS

□ Applied Technology □ Kenix Industries
□ Kisco Santa Clara □ TNP □ Uniglobe
Kisco □ Villa Precision

SEALANTS

□ Applied Technology □ Dainippon Ink &
Chemicals □ Kisco Santa Clara
□ Marubeni □ 3M Product Information
□ Uniglobe Kisco

SEMICONDUCTORS

□ Atomergic Chemetals □ Chips &
Technologies □ Eaton Corp. □ EM
Microelectronic □ Genesis Microchip
□ H-P □ HP Reid □ Intevac
□ International Micro □ Kenix Industries
□ Linfinity □ Panasonic Industrial
□ Spire □ 3M Electronic Products
□ 3M Product Information □ Vivid
Semiconductor

SIMULATOR DISPLAYS

□ Applied Science Labs □ Astronautics
□ Barco □ Barco Chromatics □ Barco
Display □ Barco Video & Commun.
□ Calcomp □ Coryphaeus □ Draper
Screen □ DRS Military Systems □ EDL
Displays □ Electrohome □ Electronic
Image Systems □ El-Op Electrooptics
Industries □ Evans & Sutherland
Computer □ Fakespace □ Kristel
□ Hughes LV Products □ Night Vision
Corp. □ Optical Radiation □ Optical
Solutions □ Palomar Products
□ Photonics Systems □ Precision
Imaging □ Primagraphics □ Rediffusion

Simulation □ Sanders Associates
□ SEOS Displays □ Shintech □ Ship
Analytics □ Simtech □ Tech-Com
□ Westair

SOFTWARE

□ Applied Simulation Technology

SOFTWARE FOR DISPLAYS

design & optimization software

□ ADT □ American Institute Small
Business □ autronic □ Breault
□ Cardion Electronics □ Contec CAE
□ Coryphaeus □ CSERIAC □ Display
Systems □ DRS Military Systems
□ El-Op Electrooptics Industries
□ Honeywell Defense Avionics □ IBM
□ Kent Displays □ Kollmorgen
□ Ligature Software □ Lighting Sciences
□ L-3 Communications □ n&k
Technology □ Optis □ Orbotech
□ Sarnoff Research Center □ Shintech
□ Sound Decisions □ Stereomedia

graphics systems software

□ ADT □ Astronautics □ Barco
Chromatics □ Barco Display □ Calspan
SRL □ Cambridge Research □ Cardion
Electronics □ Coryphaeus □ Dalim
Computer □ Data Translation □ Display
Systems □ Dynair □ Honeywell Defense
Avionics □ IBM □ Infax □ Infinity
Multimedia □ Kollmorgen □ L-3
Communications □ Polaroid
□ Primagraphics □ Racal-Mesl
□ Rediffusion Simulation □ Sarnoff
Research Center □ Ship Analytics
□ Thomson-CSF Services □ 3M Product
Information □ Trident Microsystems
□ Univision

image processing software

□ ADT □ Amerinex □ Applied Science
Labs □ Cardion Electronics □ Coreco
□ CRL □ Dalim Computer Graphic
System □ Data Translation □ Decision
Images □ Diagnostic/Retrieval Systems
□ DOME □ DRS Military Systems
□ DynaColor □ Eastman Kodak □ El-Op
Electrooptics Industries □ Eltime Vision
Systems □ EPIX □ Global Imaging
□ Honeywell Defense Avionics □ Howtek
□ IBM □ Kaiser Optical □ Kollmorgen
□ L-3 Communications □ McMahan
Electro-Optics □ McMahan Research
Labs □ MegaVision □ Orbotech
□ Photometrics □ Rediffusion Simulation
□ Sarnoff Research Center □ Security
Defense Systems □ Sharp Digital
Information Products □ 3M Product
Information □ Univision □ Versatec
□ Videotek Systems □ Vidiwall □ Xerox
Imaging Systems □ Carl Zeiss

optical analysis software

□ ADT □ Applied Science Labs
□ autronic □ Breault □ Eldim □ El-Op
Electrooptics Industries □ Eltime Vision
Systems □ Global Imaging □ IBM
□ Honeywell □ Kollmorgen □ Kontron
□ Lighting Sciences □ Contec CAE
□ n&k Technology □ Optis □ Orbotech
□ Photo Research □ Sarnoff Research
Center □ Shintech □ Sound Decisions
□ Telic Optics □ Carl Zeiss

signal processing software

□ Aydin Computer/Monitor □ Calspan
SRL □ Cardion Electronics □ Data
Translation □ Diagnostic/Retrieval
Systems □ Display Systems □ DRS
Military Systems □ DynaColor

□ Honeywell Defense Avionics □ IBM
□ Kaiser Optical □ Kollmorgen
□ McMahan Research Labs □ Racal-
Mesl □ Sarnoff Research Center

SPEECH INPUT/OUTPUT DEVICES

□ ADT □ IBM □ Regisbrook □ Stalaw

TEST AND MEASUREMENT EQUIPMENT

automatic convergence systems

□ Barco Projection □ Display Labs
□ DynaColor □ EeRise □ Electro-Optics
□ Gamma Scientific □ General Electric
□ Image Processing Systems □ Meylan
□ Microvision □ Minolta □ Photo
Research □ Telesensory □ 3M Product
Information □ Video Instruments

automated test equipment

□ AeroTech □ Anorad □ autronic
□ Calspan SRL □ Chroma ATE
□ Coreco □ CR Technology □ Cybeq
□ Crystop Display □ Data Plus □ Data
Translation □ DIS □ Display Labs
□ DynaColor □ EeRise □ Ergonomics
□ Gamma Scientific □ Eltime Vision
Systems □ Ergonomics □ Florod □ John
Fluke Mfg. □ GenRad □ Hoffman Engrg.
□ Hornell Engrg. □ Kenix Industries
□ Image Processing Systems □ Inter-
Logic □ KLA Acrotec □ KLA Instruments
□ Kontoy Products □ Landmark
Technology □ Lasertec □ Laversab
□ Leica □ Lighting Sciences □ MECC
□ Micromanipulator Co. □ Microvision
□ Minolta □ Miwa □ MTL Systems
□ Nanometrics □ Nippon Seiko K.K.
□ Optro-Mechanics □ Optronics Labs
□ Orbotech □ Photon Dynamics
□ Photo Research □ Rockwell Intl.
□ Rytrak □ SAIC □ Sencore
□ Signatone □ Spectron Engineering
□ Steag Micro Tech □ Team Systems
□ Teletrac □ Tencor Instruments □ 3M
Electronic Products □ 3M Product
Information □ TNP Instruments
□ Vanzetti Systems □ Veeco/Sloan
Technology □ Video Instruments
□ Wande □ Westar □ J. A. Woollam
□ Carl Zeiss

colorimeters

□ autronic □ Chroma ATE □ Data Plus
□ DynaColor □ Eldim □ Electro-Optics
□ Gamma Scientific □ Graseby
Optronics □ Hoffman Engrg. □ Image
Processing Systems □ Institute for
Photometry & Radiometry □ Leica
□ Lighting Sciences □ Microvision
□ Minolta □ n&k Technology □ Opto-
Cal □ Photo Research □ Sencore

convergence gauges

□ Chroma ATE □ DynaColor □ Klein
Instruments □ Minolta □ Quantum
Data

gonioreflectometers

□ autronic □ Gamma Scientific
□ Lighting Sciences □ LMT □ Optronics
Labs □ n&k Technology

hot stages

□ autronic □ Instec
□ Micromanipulator Co. □ Palomar
Products □ TNP □ Carl Zeiss

microscopes

□ autronic □ CELCO □ Gamma
Scientific □ Inter-Logic □ Leica
□ Lasertec □ Micromanipulator Co.

industry directory

- Nikon Precision □ Olympus America
□ Optro-Mechanics □ Seiwa Optical
□ TNP □ Carl Zeiss

photometers

- autronic □ Breault □ Gamma
Scientific □ Eldim □ Electro-Optics
□ Graseby Optronics □ Hoffman Engrg.
□ Institute for Photometry & Radiometry
□ Instrument Systems □ Labsphere
□ Lighting Sciences □ LMT □ McMahan
Research Labs □ Microvision □ Opto-
Cal □ Optron Lab □ Photo Research
□ Spectron Engineering □ Tektronix
□ Video Instruments □ Carl Zeiss

radiometers

- autronic □ Breault □ Electro-Optics
□ Gamma Scientific □ Hoffman Engrg.
□ Institute for Photometry & Radiometry
□ Instrument Systems □ Labsphere
□ McMahan Research Labs □ Minolta
□ OAI □ Opto-Cal □ Optron Lab
□ Photo Research □ Spectron
Engineering □ Tektronix

spectrometers

- autronic □ Breault □ Gamma
Scientific □ Instrument Systems
□ Laversab □ Leica □ Microvision □
MKS Instruments □ n&k Technology
□ Nanometrics □ Olympus America
□ Opto-Cal □ Optron Labs □ Spectron
Engineering □ Carl Zeiss

video generators

- Aydin Computer/Monitor □ Barco
□ Barco Chromatics □ Chroma ATE
□ Colorado Video □ Data Plus
□ Diagnostic/Retrieval Systems □ DRS
Military Systems □ DynaColor □ Eldim
□ Extron □ John Fluke Mfg. □ Image
Processing Systems □ MECC □ MTL
Systems □ Optro-Mechanics □ Quantum
Data □ Sencore □ Team Systems
□ Unigraf □ Video Instruments
□ Westaim

video oscilloscopes

- Colorado Video □ General Electric
□ Laversab □ Photon □ Sencore

THIN FILMS

- Applied Films □ Applied Technology
□ Atomergic Chemetals □ Balzers AEG
□ Balzers Process Systems □ Balzers
Thin Films □ Dontech □ Dynapro
□ Edwards □ E for M □ Feldman
Technology □ General Vacuum □ Hoya
Corp. □ Innotec □ Intevac □ Kaiser
Optical □ Lamination Technology □ Leica
□ Kurt J. Lesker Co. □ Materials
Research Corp. □ Melles Griot
□ Nanometrics □ OCA □ OIS □ Opto
Sigma □ Specialty Coating Systems
□ Spire □ Stan-Allen □ Technical
Visions □ TFD □ Thin Film Technology
□ 3M Product Information □ TNP
□ ULVAC Technologies □ Viratec

3D DISPLAY SYSTEMS

- Coryphaeus □ Dimension
Technologies □ Electrohome □ Electronic
Image Systems □ Evans & Sutherland
Computer □ Fakespace □ Flat Panel
Display □ General Electric □ Infinity
Multimedia □ Matrix Electronic Systems
□ McMahan Electro-Optics □ National
Research Resources □ Night Vision Corp.
□ NuVision Technologies □ Optical
Solutions □ Polhemus □ Reel 3-D
□ Sarnoff Research Center □ Security

- Defense Systems □ StereoGraphics
□ Stereomedia □ Tektronix □ 3-D
ImageTek □ 3DTV □ UCE □ Visonics
Labs

TOUCH-INTERACTIVE DISPLAYS

- Astronautics □ AVED □ AVT
□ Barco Chromatics □ Barco Display
□ Craft Data Ltd. □ D&T □ Densitron
□ Digitran □ Dolch Computer □ Eaton
PSD □ Eaton IDT □ EDL Displays
□ Eldec □ Electrohome □ Electro
Mechanical Systems □ Electro Plasma
□ Elographics □ ETC Computer
□ Excec □ Flat Panel Display □ General
Digital □ IBM □ Image Quest
□ Intecolor □ Interaction Systems
□ Jaco Electronics □ Kristel
□ Laversab □ Lockheed Sanders
□ MicroTouch Systems □ Nortech
Engineering □ Optical Solutions
□ Palomar Products □ Performance
Display Systems □ Phosphor Products
□ Photonics Systems □ Racal-Mesl
□ Regisbrook □ RGB Dynamics
□ Scriptel □ SMART Technologies □ I.
I. Stanley □ Thomson Tubes
Electroniques □ Touch Controls
□ Transicoil □ Varitronix □ ViewTEK
□ WACOM

TOUCH SCREENS

- ADT □ AVT □ Aydin Corp. □ CAM
Graphics □ Carroll Touch □ Craft Data
Ltd. □ Crystalloid □ D&T □ Dale
Electronics □ DBI □ Densitron □ Dolch
Computer □ Draper Screen □ Dynapro
□ Earth Computer □ Electro Mechanical
Systems □ Elographics □ Epson America
□ ETC Computer □ Excec □ John Fluke
Mfg. □ IBM □ Intecolor □ Interaction
Systems □ Jaco Electronics □ Kent
Displays □ Lamination Technology
□ Laversab □ MicroTouch Systems
□ Mintronix □ Mitsubishi Electronics
America □ O&S Research □ OCLI
□ Optical Devices □ Optical Solutions
□ Pacific Technologies □ Phosphor
Products □ Photonics Systems □ Racal-
Mesl □ Regisbrook □ RGB Dynamics
□ Richardson Electronics □ Scriptel
□ SMART Technologies □ Telesensory
□ Thin Film Technology □ TFD □ Touch
Controls □ Varitronix □ ViewTEK
□ WACOM □ XTEK

TOUCH TABLETS

- ADT □ Carroll Touch □ Excec
□ Jaco Electronics □ Scriptel
□ SMART Technologies □ WACOM

TRACKBALLS

- Computer Keyboards Systems
□ Digitran □ Intecolor □ Polhemus

VACUUM EQUIPMENT

- AeroTech □ Anorad □ Applied Films
□ Applied Technology □ ASM America
□ Balzers Process Systems □ Brooks
Automation □ Edwards □ General
Vacuum □ Hornell Automation □ Hornell
Engrg. □ Innotec □ Intevac □ Kontoy
Products □ Kurdex □ Leybold
□ Materials Research Corp. □ MDC
Vacuum Products □ MKS Instruments
□ OCLI □ SAES Getters □ TSC
□ ULVAC Technologies □ Viratec

VACUUM FLUORESCENT DISPLAYS

- Babcock □ Futaba America □ IEE
□ ISE Electronics □ LCSP-Deeco □ Kurt
J. Lesker Co. □ Noritake □ Morrison
Electronics □ Pulseview □ Regisbrook

VIDEO AMPLIFIERS

- CELCO Pacific □ Dynair □ Ginsbury
□ Kollmorgan □ MECC □ Motorola
□ National Semiconductor

VIDEO AND DISPLAY STANDARDS

- Color Technology Solutions
□ DynaColor □ Ergonomics □ SAIC
□ Team Systems □ 3M Product
Information □ VESA

VIEWING SCREENS

- Physical Optics □ Tech-Com

VIRTUAL IMAGING

- Future Focus □ Gritz's Emporium
□ Reflection Technology □ Reel 3-D
□ Silscape □ Stereomedia □ VDC
(Teltron) □ Virtual Vision

VIRTUAL-REALITY DISPLAYS

- Electrohome □ Fakespace □ Future
Focus □ Gritz's Emporium □ Incom
□ Night Vision Corp. □ Reflection
Technology □ Reel 3-D □ Silscape
□ Stereomedia □ Tech-Com □ 3-D
ImageTek □ 3DTV □ VDC (Teltron)
□ 01 Products

X-RAY IMAGE STORAGE SCREENS

- Incom □ Levy Hill □ Phosphor
Technology □ Quantex □ Security
Defense Systems

WIRE

- Caton Connector

Part II: Companies

Listings are in strict alphabetical order. Punctuation, spaces, and the initial definite article "The" are ignored. Numbers (3D, 3M, 01), symbols (&), and abbreviations (Co., Corp., Inc., Ltd.) are listed as though fully spelled out. Companies bearing the name of an individual are usually listed under his last name.

ABBIE GREGG, INC. (AGI), 5025 South Ash Ave., Ste. B-4, Tempe, AZ 85282
Providers of engineering and consulting services; cleanroom layout and facility design; fit-up semiconductor and FPD process, test, and assembly equipment; process, test, and cleanroom training; process analysis; factory simulation and modeling; CAD services; yield enhancement and troubleshooting. Michelle Martinez, Dir. Finance/Admin. 602/897-1162, fax: 602/897-1486

ACCUDYNE CORP., 1415 Foundation Park Blvd. S.E., Palm Bay, FL 32909
Manufacturers of flat-panel-display mid-line processing equipment: rubbing, cleaning, spacer applicators, spacer counters, assembly, filling, laser-based glass separation, and in-line material handling. All equipment is clean-room compatible and operator friendly. Jim Lawson, Pres. 407/724-6500, fax: 407/727-1632

ACCULEX CORP., 440 Myles Standish Blvd., Taunton, MA 02780

Manufacturers/distributors of industrial process monitoring and display products. Surface-mount technology designs; rugged digital panel meters (LCD and LED) for measuring temperature, pressure, voltage current, etc. Richard Mullen, Prod. Mktg. Mgr. 508/880-3660, fax: 508/880-0179

ACL, INC./STATICIDE, 1960 E. Devon Ave., Elk Grove Village, IL 60007

Manufacturers of STATICIDE topical anti-static solution, a highly effective method for long-term static control, which is non-toxic, non-flammable, non-staining, and completely biodegradable. Available in general-purpose and heavy-duty sprays or wipes for use on CRT screens. Tony Banks, V.P. Sls./Mktg. 708/981-9212, 1-800/782-8420, fax: 708/981-9278

ADAPTIVE MICRO SYSTEMS, INC., 7840 N. 86th St., Milwaukee, WI 53224

Manufacturers of high-quality indoor and outdoor color LED message displays, including PowerView, Beta-Brite, and indoor and outdoor Alpha lines and custom modules for OEM products. Single- and multi-line signs with characters from 1.5 to 7.2 in. high for displaying text, graphics, and logos. Curt Lillie, V.P. Alpha Sls. 414/357-2020 x223, 1-800/558-7022 fax: 414/357-2029

ADAPTIVE MICRO SYSTEMS, INC., SMART ALEC, 7840 N. 86th St., Milwaukee, WI 53224

Developers of intelligent messaging software that automatically messages real-time and scheduled information to PowerView LED message displays, e-mail, intranets, pagers, voice mail, PA systems, and more. Acquires information from virtually any source using DDE, serial, ASCII delimited files, MAPI compliant e-mail, or custom interface. Mike Rimrod, Smart Alec Sls. Mgr. 414/357-2020, 1-800/558-7022 fax: 414/357-2029

ADHESIVES RESEARCH, INC., P.O. Box 100, Glen Rock, PA 17327

Manufacturers of optically clear pressure-sensitive adhesive-coated products designed for use within touch screens, polarizers, filters, retarders, LCDs, and flat-panel displays. Pressure-sensitive tapes for electronics assembly, low-outgassing applications, EMI/RFI shielding, static control, grounding, sealing, and electrical interconnections, along with custom development capabilities also available. ISO 9001 certified. Dave Williams, Mkt. Devel. Mgr. 717/235-7979, 1-800-445-6240 fax: 717/235-8320

ADVANCED CONVERSION TECHNOLOGY, 2001 Fulling Mill Rd., P.O. Box 70, Middletown, PA 17057
Designers/manufacturers of military and commercial standard and custom high-voltage CRT power supplies for multi-output subminiature helmet-mounted units (7.5 kV) to very-high-power color units (35 kV). Also, low-voltage system supplies, flat fluorescent drivers, transformers, and circuit card assemblies. Mike L. Endy, Sales Admin. 717/939-2300, fax: 717/939-7170

critical displays with color-calibration software.
Piet Candeel, Sales Mgr.
+32-56-233-242, fax: +32-56-233-374

BATRON GmbH, Landsberger Str. 320, Munchen, 8000, Germany
Large-character alphanumeric and graphic LCD modules in STN technology with extended temperature range. Control boards for graphic LCD modules.
Axel Schaefer
+49-560-17-292, fax: +49-560-17-295

BDH, LTD., Advanced Materials Div., Broom Rd., Poole, Dorset, U.K. BH12 4NN
Manufacturers of LCs for electro-optic displays; thermochromic LCs; single crystals for UV and IR optics; scintillators; fluoride glass components for fiber optics; precursors for high T_c superconductors.
M. G. Pellatt, Bus. Mgr., Adv. Mater. Div.
+44-202-745-520, fax: +44-202-738-299

LEO BEISER INC., 151-77 28 Ave., Flushing, NY 11354-1548
Consultancy specializing in design of image and data laser scanning and recording subsystems. Advancing speeds and resolutions for printing, graphic arts, quality and defect inspection, microscopy, triangulation, and display. Expert witness and litigation research and guidance.
Leo Beiser, Pres.
718/353-7298, fax: 718/353-7098

BEST POWER TECHNOLOGY, INC., P.O. Box 280, Necedah, WI 54646
Manufacturers of uninterruptible power supplies ranging from 500 VA to 18 kVA. Trade names are FERRUPS and MICRO-FERRUPS. Protects sensitive electronic equipment from power problems.
Don Sue
608/565-7200, 1-800-356-5794
fax: 608/565-2221

BETA PRODUCTS, INC., P.O. Box 38, Millwood, VA 22646
Consultant and manufacturer's representative for color FPDs and monitors.
Norman M. Fine, Pres.
703/837-1436, fax: 703/837-3063

BILCO MANUFACTURING, 100 Grandview Blvd., Zellenople, PA 16063
Manufacturers of glass cleaning equipment for critically clean applications. Machines may be chosen from a standard line or engineered for specific requirements.
Bob Long, Sales Mgr.
412/452-7390 fax: 412/452-0217

BKL, INC., 421 Feheley Dr., King of Prussia, PA 19406
Manufacturers of EL lamps for back-lighting LCDs, instrumentation, watches/clocks, portable devices, membrane switches, etc. K Series screen-printed lamps for small lit areas, and continuous-roll lamps for medium-to-large square/rectangular lit areas. Lamps available with either magnetic resonating transformer inverters or IC chip inverters.
Rick Mental, Tech. Sls. Mgr.
610/277-2910, fax: 610/277-2956

BOC COATING TECHNOLOGY, 4020 Pike Lane, Concord, CA 94524
Manufacturers of in-line vacuum sputtering equipment for directly coating CRTs and FPD components. Coatings include anti-reflective, anti-static, contrast enhancing, and transport conductive, as

well as various metal coatings.
Richard E. Keough, Sls./Mktg. Mgr.
510/680-0501, fax 510/689-8468

BORER CHEMIE AG, Gewerbestrasse 13, Zuchwil, Solothurn CH-4528, Switzerland
Manufacturers of high-performance aqueous cleaning concentrates for all manufacturing phases of LCD production. ISO 9001 certified.
René Gasser, Mktg. Dir.
+41-(0)32-686-56-00,
fax: +41-(0)32-686-56-90

BREAU RESEARCH ORGANIZATION, INC., 6400 E. Grant Rd., Ste. 350, Tucson, AZ 85715
Developers of ASAP 5.1, a complete design and analysis package for LCD, entertainment, and projection systems. Its menu-driven interface propagates light through optical systems without costly prototypes.
Chris Campillo, Sls. Engr.
520/721-0500, 1-800-882-5085
fax: 520/721-9630

BREWER SCIENCE, INC., Optical Materials Div., 2401 Brewer Dr., Rolla, MO 65401
Manufacturers of specialty color resins, patterned color filter glass, front-end processing equipment for the sensor and display industries. Distributors for Nissan alignment and silicon hardcoat resins. Products include: PIC RGB, CMY, and black color filter resins; patterned color filter glass; Cee precision coat-bake equipment for large-area glass processing.
Jeffery Hunninghake, Mgr., Intl. Mktg./Sls.
314/364-0300 fax: 314/368-3318

BRIMAR, INC., 25358 Avenue Stanford, Valencia, CA 91355-1214
Manufacturers of high-performance special-purpose CRTs for military and civil aviation, telecine, medical, and photographic color print reproduction.
Glenn Barone, Pres./CEO
805/295-5770, fax: 805/295-5087

BRIMAR LTD., Greenside Way, Middleton, Manchester M24 1SN, U.K.
Manufacturers of high-performance special-purpose CRTs for military and civil aviation, telecine, medical, and photographic color print reproduction.
David P. Eldridge, Sls. Dir.
+44-161-681-7072, fax: +44-161-682-3818

BRITEVIEW TECHNOLOGIES, INC., 1810 Eber Rd., Unit C, Holland, OH 43528
Manufacturers of LCD-backlighting systems. The flat collimator uses total internal reflection to send all light from the backlight directly towards the viewer, resulting in very bright output. A stacked light-pipe assembly provides very bright backlighting for sunlight-readable displays and for day/night-vision modes of operation.
Chen-Yu Tai, Pres.
419/868-7290, fax: 419/868-7291

BROOKS AUTOMATION, INC., 15 Elizabeth Dr., Chelmsford, MA 01824
Manufacturers of cluster-tool platforms and other automation products that increase FPD production yields and decrease defects.
James T. Jenson, FPD Prod. Mgr.
508/262-2430 fax: 508/262-2500

BURLE INDUSTRIES, INC., Security and Tube Products, 1000 New Holland Ave., Lancaster, PA 17601-5688
Manufacturers of CCD cameras, alarm products, surveillance kits, monitors, video recorders, lenses, pan/tilts, scanners, indoor/outdoor housings, mounts, video switchers, video signal equipment, gates and turnstiles. Tubes, including power, photomultiplier, image, and display products.
Security: Rob Drob, Mgr. Sales
717/295-6123, 1-800-326-3270
fax: 717/295-6097
Tube: Luis Vera, Mgr. Tube Prod. Sls.
717/295-6031, 1-800-366-2875
fax: 717/295-6096

CALCOMP INC., P.O. Box 3250, Anaheim, CA 92803
Manufacturers of graphics subsystems that include boards and terminals using both raster-scan and vector-refresh technologies; computer graphics products include digitizers, plotters, and plotter/printers.
Debbie Corwin, Adv. Mgr.
714/821-2142, 1-800-CALCOMP,
fax: 714/821-2901

CALSPAN SRL, 2800 Indian Ripple Rd., Dayton, OH 45440
Manufacturers of a line of ruggedized/militarized avionics displays. Producers of avionics graphics processors for symbology generation and video mixing. Day/night HMDs for special mission applications.
Steve Nelson, Dir. Bus. Dev.
513/427-7364, fax: 513/427-7459

CAMBRIDGE RESEARCH SYSTEMS, LTD., 80 Riverside Estate, Sir Thomas Longley Rd., Rochester, Kent, U.K. ME2 4BH
Manufacturers of graphics systems for vision research. Precision color control (36 bit), photometric linearization, optional 36-MB framestore, and 42-bit grating generator. Configurable for many displays. Custom-software library for C, PASCAL, and BASIC.
Carol Luscombe, Mktg. Mgr.
+44-1634-720-707, fax: +44-1634-720-719

CAM GRAPHICS CO., INC., 15 Ranick Dr. W., Amityville, NY 11701
Manufacturers of state-of-the-art custom-designed membrane switches, value-added membrane switches, resistive analog and digital touch-view screens, front panels, and overlays. All touch screens can be customized to work with many FPDs including LED, LCD, EL and CRT displays.
Manny Cardinale, Pres.
516/842-3200, fax: 516/842-1005

CANADIAN MARCONI, Avionics Div., 415 Legget Dr., P.O. Box 13330, Kanata, Ontario, Canada K2K 2B2
Manufacturers/integrators of avionics products including control display units and multifunction display systems using thin-film EL displays, color CRT displays, and segmented LCDs. Display systems using active-matrix LCDs are available.
Al Letcher, Mktg. Mgr.
613/592-7454, fax: 613/592-7427

CANDESCENT TECHNOLOGIES, 6580 Via Del Oro, San Jose, CA 95119
Manufacturers of thin CRTs, a new class of flat-panel display that delivers full-motion true-color video-image quality in a low-power low-cost FPD, viewable in bright ambient light and from any viewing angle.

It features instant turn-on from -20° to $+70^{\circ}$ C.
Nicholas G. Sturiale, Dir. Mktg.
408/229-6150, fax: 408/229-0664

CANON, INC., 30-2, Shimomaru-ku 3-Chome, Ohta-ku, Tokyo 146, Japan
Manufacturers of cameras, videos, copiers, facsimile machines, word processors, desktop publishing systems, printers (LBP, BJ), ferroelectric LCDs, medical equipment, and semiconductor production equipment, including LCD production equipment.
Kazuo Minoura, Gen. Mgr.
+81-3-5482-8117, fax: +81-3-5482-5145

CANON U.S.A., INC., 3200 Regent Blvd., Irving, TX 75063
Manufacturers of the MPA-5000 mask aligner that can expose nine 12.1-in. LCD panels on an 830 x 650-mm substrate without stitching. It features a high-throughput all-reflective step-and-scan optical system with a resolution of 3 μ m and overlay accuracy of $3\sigma \leq 1.0 \mu$ m.
Phillip M. Ware, Dir. Tech. Mktg., Semiconductor Equip. Div.
972/830-9696 x2800, fax: 972/556-1620

CAPETRONIC COMPUTER USA, 140 Knowles Dr., Los Gatos, CA 95030
OEM supplier of displays. Products include 14-21 in., FS, Trinitron, conventional radius, or flat panel; microcontroller, multisampling, or fixed-frequency displays. Products address PC, workstation, x-windows, terminal, and multimedia markets.
Richard Mastana
408/364-2222, fax: 408/364-0395

CARDION ELECTRONICS, Long Island Expwy., Woodbury, NY 11797
Manufacturers of air-traffic-control indicators, shipboard radar graphics indicators, shipboard indicators, miniature airborne TV cameras, solid-state digital scan converters, BRANDS, air-traffic-control display systems, and high-resolution circunmilitarized monochrome and color CRT displays.
Francis Gareffa, V.P. Bus. Dev.
516/921-7300, fax: 516/921-7330

CARROLL CONSULTING CO., 20930 Panorama Dr., Los Gatos, CA 95030
Consulting and design services for all types of CRT monitors and video systems, especially high-resolution color multisync. Maintains a fully-equipped laboratory for accomplishing turnkey new product development projects, including fabrication of prototypes.
Gus Carroll, Pres.
408/353-5114, fax: 408/353-1203

CARROLL TOUCH, INC., (A Division of AMP) 811 Paloma Dr., Round Rock, TX 78664
Manufacturers of touch systems and operator interface systems utilizing scanning IR and guided-acoustic-wave touch technologies for a range of applications and market sectors.
Mike O'Brien, Inside Sls. Supervisor
512/388-5678, 1-800-386-8241
fax: 512/244-7040

CASIO LCD SALES (Div. of Kanematsu USA, Inc.), 543 W. Algonquin Rd., Arlington Hts., IL 60005
Manufacturers of LCDs/modules; passive- and active-matrix monochrome and color TFTs. Standard product offerings range

CORNING INCORPORATED,
Advanced Display Products, MP VX-1-3,
Corning, NY 14831
Manufacturers of 7059F and 1737F glass
substrates for advanced technology flat-
panel displays.
Ben J. Garbowski, Mgr./N.A. Sls.
607/974-4308, fax: 607/974-7097

CORNING INCORPORATED,
Corning Engineering, HP-ME01-003-C10,
Corning, NY 14831
Provider of worldwide turnkey services
for the design, supply of equipment,
training, and on-site assistance concen-
trating in glass components for enter-
tainment and display CRTs (b/w and color);
lighting (ribbon machine, Vello tubing);
pharmaceutical tubing; and consumer
products.
Zia Haider, Sls. & Mktg. Mgr.
607/974-6023, fax: 607/974-8354

CORYPHEAUS SOFTWARE, INC.,
985 University Ave., Ste. 31, Los Gatos,
CA 95030
Software developers of a comprehensive
line of real-time visual-simulation products,
including Designer's Workbench™ (DWB),
a 3D modeling and editing environment;
Easy™, a terrain-creation system; and
EasyScene™, a real-time scene-display
system.
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conductive; several are also optically
transparent. Standard products include ITO
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coatings on PET. In addition to standard
coatings, speciality coatings are also
available.
Bunny Russitti-Buckley, Sls. Mgr.
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AZ 85281
Manufacturers of high-resolution
100-MHz computer-video interfaces,
distribution amplifiers, switches, and
umbilical cables. Interfaces link PCs,
terminals, and graphics workstations to
RGB data projectors and monitors for
viewing on large displays.
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602/966-2221, 1-800-638-6104
fax: 602/966-6728

CRAFT DATA, INC., 27022 Cordero La.,
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Value-added distributor for Planar and
Panasonic. Distributor for Casio LCD.
Manufacturer of CD650 controller for
flat-panel displays. Modules assembled
with/without touch panels to customer
specifications.
Fred W. Holstein, Jr., Pres.
714/582-8284, fax: 714/248-2390

CRAFT DATA LTD, 92 Broad St.,
Chesham, Bucks., HP5 3ED, U.K.
Distributors of electronic displays:
monochrome and color LCDs, LEDs, ELs,
and plasma displays. Monitors, industrial
terminals, IR and guided-wave touch
systems; plus thermal printheads,
mechanisms, and standalone printers. Also,
all types of magnetic card readers.
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+44-1-494-778-235, fax: +44-1-494-773-645

CREW SYSTEM ERGONOMICS
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OH 45433-7022
Information and technology distributor of
a variety of products and services to help
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design and development of visual display
systems. Provides technical summary and
analysis support for human-factors-related
inquiries.
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513/255-4842

CRL, Dawley Road, Hayes, Middlesex, 4B3
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Suppliers of spatial light modulators and
ferroelectric LC shutters. Developers of
novel and prototype nematic and ferro-
electric LCDs, field-emission displays, and
electroless backlights. Consultancy, IPR
searches, and display repairs also
undertaken.
Alan Mosley
+44-181-848-6400, fax: +44-181-848-6653

CR TECHNOLOGY, INC., 27752 El Lazo
Rd., Laguna Niguel, CA 92677-3914
Suppliers of automated or manual vision
and x-ray inspection systems for fast,
accurate, and repeatable CRT, flat-panel
displays, and loaded board testing.
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714/448-0443, fax: 714/448-0445

CRT INTERNATIONAL CORP., 429 N
Street S.W., #S-106, Washington, DC
20024
Distributors of CRTs for photorecording,
special-application CRTs, e-guns, and
various flat-panel displays.
Boris L. Chervinsky, Pres.
202/863-0539, fax: 202/863-0539

CRT SCIENTIFIC CORP., 14746 Raymer
St., Van Nuys, CA 91405
Manufacturers of a wide range of mono-
chrome CRTs from 0.5 in. to 25V.
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Manufacturers of LCDs for commercial,
industrial, avionic, and military applications.
Technologies include TN, STN, RCTN, and
dichroic displays and modules.
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216/655-2429 x240, 1-800-888-BEST-LCD
fax: 216/655-2176

CRYSTAL VISION, INC., P.O. Box 3960,
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Manufacturers of video LCD controller
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310/316-1770

CRYSTOP DISPLAY GmbH, Hansastrasse
29 C, D-7500 Karlsruhe 21, Germany
Manufacturers of LCD modules and sys-
tems; pattern-recognition systems for auto-
matic test of LCDs and systems. Develop-
ment and prototyping.
Werner Pauls
+49-721-579-048, fax: +49-721-50-1116

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fax: 408/541-6068

CTX OPTO-ELECTRONICS CORP., 3F,
No. 22 Industry E. Rd. 9, Science-Based
Industrial Park, Hsinchu, Taiwan 300,
R.O.C.
Manufacturers of passive- and active-
matrix LCD monitors, custom-made LCD
backlights, and LCD projection panels.
Wilson Chan, Dir.
+886-35-772-000, fax: +886-35-772-530

CYBEQ, 150 Independence Dr., Menlo
Park, CA 94025
Manufacturers of flat-panel-display
robotic handler.
Ali Darvish
415/688-8921, fax: 415/326-2446

DABURN ELECTRONICS & CABLE
CORP., 224 Pegasus Ave., Northvale,
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Manufacturers of a full line of computer
cable, shrink tubing, modular cords, retrac-
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Howard Danzhgai, Dir. Mktg.
201/768-5400, fax: 201/768-9642

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Michigan City, IN 46360
Manufacturers of high-performance
high-resolution b/w CCTV cameras and
monitors.
Paul Thomas, V.P. Sls./Mktg.
219/872-5514, fax: 219/872-5559

DAINIPPON INK & CHEMICALS, INC.,
Imaging and Reprographic Products Div.,
7-20, Nihonbashi 3 chome, Chuo-ku, Tokyo
102, Japan
Manufacturers of a variety of LC materi-
als for LCDs and related products such
as sealants and color filters.
T. Takahashi, Gen. Mgr.
+81-3-272-4511, fax: +81-3-272-1565

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Designers and manufacturers of large-
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technologies include LEDs, incandescent,
and reflective in a wide variety of character
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605/697-4300, 1-888-325-8766
fax: 605/697-4700

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Manufacturers of resistive products along
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redemption equipment. Custom plasma or
touch-panel engineering support will adapt
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402/563-6308, fax: 402/563-6418

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Manufacturers of the Dalim Litho which
is both a graphic creation system as well
as a comprehensive retouching and image-
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all companies involved with the pre-press
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219/267-8101, fax: 219/267-7804

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Distributors of polarizers manufactured by
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Distributors of laser-inspection systems
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processes, float glass, and photoresist
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DATA DISPLAY PRODUCTS, 445
S. Douglas St., El Segundo, CA 90245
Manufacturers of LED indicators and
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applications.
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Ann Woodley, Dir. Sls./Mktg.
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Manufacturers of microcomputer analog I/O systems, image-processing products, and array-processing boards for the IBM PC/PS2, MicroVax II/Q-bus and Unibus, Mac II, VMEbus, Multibus, Multibus II. Neil Cronin, Sls. Mgr. 508/481-3700, fax: 508/481-8620

DAVALCO, 15506 Commerce La., Huntington Beach, CA 92649
Manufacturers of high-voltage power supplies for HUD/IV, target acquisition, and radar. David Neitberger, Sls. Mgr. 714/892-7631, fax: 714/897-1949

DAVIS A/S, P.O. Box 380, Drammen 3001, Norway
Manufacturers of LCD projection panels, LCD data and video projectors, and LCD monitors. The projectors are based on DLP technology. Jon Torvteit, V.P. Mktg. +47-3281-9500, fax: +47-3281-8115

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Manufacturers of rugged LCD monitors and touch screens, and 10.4- and 12.1-in. color AMLCDs less than 1.60 in. in depth. Also, a VT220 terminal that uses a TFT display for under \$2000. Bill Finch 503/654-6216, 1-888-654-4052 fax: 503/654-6486

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Product line includes panel meters, custom passive LCD modules, custom TN-LCDs, contract manufacturing services build to print and turnkey, microassembly, heat-seal equipment, and engineering services. Maureen Conran, Cust. Service/Inside Sls. 913/782-5672, fax: 913/782-5766

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Manufacturers of color resource image-processing software for image editing and enhancement, transforms, 3D perspective, and multispectral classification. Supports selective video cameras, scanners, printers, film recorders, and image boards. Robert Mills, Pres. 609/683-0234, fax: 609/683-4068

DEL ELECTRONICS CORP., 1 Commerce Park, Valhalla, NY 10595
Manufacturers of custom and standard high-voltage power supplies and transformers for the display industry. Jeremy Simon, Mgr. Mktg./Sls. 914/686-3600, fax: 914/686-5424

DEMPA PUBLICATIONS, INC., 275 Madison Ave., New York, NY 10016
Publishers of trade magazines (Display Devices, JEE, JEI, OEP, AEU, EBG, Almanac). Soo Sonntag, Subscription Mgr. 212/682-4755, fax: 212/682-2730

DENGLAS DIVISION OF DENTON VACUUM, INC., 8 Springdale Rd., Cherry Hill, NJ 08003
Manufacturers of antireflective coatings for antiglare screens, projection windows and instrument windows, clear and neutral density glass, neutral and nonabsorbing beam splitters, color-correction filters,

and hot and cold mirrors using soda-lime or borosilicate glass for dichroics. F. Lee Swillinger, Gen. Mgr. 609/424-1012, fax: 609/424-5105

DENSITRON, 3425 W. Lomita Blvd., Torrance, CA 90505
Manufacturers of standard and custom LCD modules and integrated VGA flat-panel subsystems. Products include character and graphics LCD modules with a wide range of options. Products combine FPDs, single-board computers, graphics controllers, and housings. Chuck Britten, Regional Sls. Mgr. 310/530-3530, fax: 310/534-8419

DENTON VACUUM, INC., 2 Pin Oak Ave., Cherry Hill, NJ 08003
Manufacturers of anti-glare filters for VDTs, broadband AR coatings on clear and absorbing glasses, dichroic filters, and beamsplitters. James Gavlas, Oprns. Mgr. 609/424-1012, fax: 609/424-5105

DH PRINT, Technical Research Park, Riverton, WY 82501
Manufacturers of 40-column dot-matrix printers. Also manufactures the Cypher series of demand barcode label printers. Howard Kingbury, Mgr. 307/856-4821, fax: 307/856-0412

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Manufacturers of LED circuit-board indicators; neon, incandescent, and LED panel-mount indicators; and illuminated switches. Also, LED surface-mount solutions and secondary optics products. Gary Baker, Mktg. Mgr. 908/223-9400, fax: 908/223-8788

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Providers of engineering and fabrication services for microelectronics packaging, FPD electronics, materials deposition, and back-end semiconductor-water processing, supporting an accelerating industry demand for high-performance systems requiring higher interconnect density, such as flip-chip packaging. Michael Feeley, V.P. Sls./Mktg. 512/331-6200 fax: 512/250-2730

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Manufacturers of high-tech dichroic and special TN displays. Ken Richardson, Pres. 214/562-3140, fax: 214/548-9890

DIGITAL VIEW, 20/F Kam Chung Communication Bldg., 19-21 Hennessy Rd., Wanchai, Hong Kong
Manufacturers of interface controllers for flat panels, including active- and passive-matrix LCDs, color and monochrome, for

connection to analog VGA to SXGA and PC bus. James Henry +852-2861-3615, fax: +852-2520-2987

DIGITAL VISION, INC., 270 Bridge St., Dedham, MA 02026
Manufacturers of Computer Eyes full-color and b/w video digitizers for PCs. Versions are available for IBM PC, Macintosh, Apple II, Atari, and Commodore computers. Paul Terrio 617/329-5400, fax: 617/329-6286

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Providers of display and data-input subsystem engineering, manufacturing, and integration services. Manufacturers of custom front-panel displays, keypads, and keyboards, and digital switch products including sunlight-readable, VIS-compatible, and secure-lighting displays. Frank Ganz, Sr. Prod. Engr. 909/391-4321, fax: 909/391-4558

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Engineers flat-panel displays, especially LCDs, into end products. Develops related technologies for displays such as LCD backlighting systems. Specializes in optics (including holographic technologies), mechanics, and materials for displays. Substantial international experience. Kevin J. Hathaway 415/329-0900, fax: 415/329-0912

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Manufacturers of display contrast-enhancement products; ruggedized and enhanced COTS AMLCDs, EL, and CRTs; full-backlit ruggedized and enhanced AMLCDs for military and commercial platforms; full NVIS compliance and testing. Leon B. Ledave, Pres./Dir. Mktg. 360/574-5000, fax: 360/573-4635

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Designers/manufacturers of custom LCD, LED, EL, and VF display modules. Also, controls for meters, process-variable controllers, and many types of industrial controls. Applications include security systems, medical, military, and industrial. Richard C. McComb, Pres. 203/726-1201, fax: 203/726-1202

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Manufacturers of electronic (LED) information displays, over 200 sizes available with "canned graphics," editable messages, full network capability, time scheduling, operated by keyboard or with IBM PC compatible. Dave Bridges, Sls. Mgr. 517/629-2670, 1-800-533-3477 fax: 517/629-3098

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Manufacturers of 5-21-in. monochrome and color CRT monitors, and large-screen monochrome 15- and 19-in. monitors in enclosures. Also, OEM custom monitors. Carl Cobb, West. Regional Mgr. 415/694-7411, 1-800-544-8823 fax: 415/694-7413

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Market researchers/publishers of a unique collection of documents from Japan on manufacturing, R&D, and market and technology trends in the electronic-display field. Tables of contents can be viewed at <http://www.japanese-translation.com>. David Andrews, CEO 310/792-3636, fax: 310/792-3642

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Manufacturers of medical-imaging hardware and software for the PCI, SBUS, and Hewlett-Packard workstations. Medical applications include PACS, teleradiology, mammography, CT, and nuclear medicine. Karen D. Miller, V.P. Sls. & Mktg.
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Manufacturers of substrates suitable for color STN, color EL, AMLCD, and FED product manufacturing. Also, substrates for TN-LCD and ITO coatings for electrochromic mirrors, and a variety of transparent conductive thin films for a wide range of product applications. Graeme L. Hennessey, V.P. Sls./Mktg.
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Designers/manufacturers of optical filters for anti-reflection/contrast-enhancement and EMI/RFI shielding of electronic displays. Line of rigid rear-projection screens (marketed under Optical Solutions). Jeffrey S. Reid, Dir. Mktg./Sls.
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Manufacturers of OEM video displays in both monochrome and color, specializing in medical imaging and multimedia presentation monitors. D. Michael Hunter, Natl. Sls. Mgr.
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Manufacturers of front- and rear-projection screens: manual, motorized, and permanently tensioned fixed; rigid rear screens; integrated systems furniture; video-projector lifts; laser pointers; rear-projection systems; video walls; media-wall systems. John D. Pidgeon, Mktg. Mgr.
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Manufacturers of high-technology, militarized and ruggedized display, signal processing, and trainer products for military and industrial applications. Joe Dunn, Sr. V.P.
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Manufacturers of display automation products. The D8000 can perform the measurement and alignment of geometry, convergence, focus, and purity for monitors and CRTs. With the addition of display-control ICs, total solutions can be provided. Charles Chuang, V.P.
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Manufacturers of PRISM, a large-format interactive video-wall display system that can simultaneously display output from four graphics workstations and four video formats in sizes up to 324 ft.² with 1024 x 1024-pixel resolution. Bob Jacobs, Sls.
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fax: 619/264-4181

DYNAMIC DISPLAYS, INC., 1625
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Manufacturers of color and monochrome CRT and flat-panel displays for the industrial, medical, and commercial/military markets. Len Stewart, V.P. Mktg./Sls.
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Manufacturers of VGA and graphic LCD controllers and subsystems. PC-based controllers in OEM quantities offered. Also, enclosures and VGA-input LCD monitors. Design assistance available. Jason Alkire, Oper. Mgr.
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Manufacturers of off-the-shelf imagers with video interline, full-frame, IR and linear CCDs. Color capabilities are available for both area and linear arrays. The Kodak professional digital camera, infrared camera, and KM-2 camera systems

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716/588-7612, fax: 716/477-4947

EATON CORP., Flat Panel Equipment, 35
Cherry Hill Dr., Danvers, MA 01923
Manufacturers of ion implanters for flat-panel-display manufacturing. James Stevens, Sls./Mktg. Mgr.
508/524-9233, fax: 508/524-9224

EATON CORP., Pressure Sensors Div.,
15 Durant Ave., Bethel, CT 06801
Manufacturers/suppliers of high-quality instrumentation and control equipment to the U.S. Navy. The VISION 500™ series of flat-panel displays are offered in various technologies, resolutions, and sizes. Jeffrey Kilgore, Sls. Manager
203/798-3122, fax: 203/798-3214

EATON IDT, INC., 173 Heatherdown Dr.,
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614/882-3282, fax: 614/875-7111

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Tewksbury, MA 01876-1631
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508/851-0207, fax: 508/851-7016

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513/429-7423 fax: 513/429-6985

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Wilmington, MA 01887
Manufacturers of a complete line of high-quality vacuum components and systems. Products include dry pumps, turbomolecular pumps, rotary vane pumps, vacuum instrumentation, leak detectors, thin-film coatings systems, and a wide range of vacuum accessories. George Courville, Mktg. Mgr. General Vacuum
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x3133, fax: 508/658-7969

EeRISE CORP., 7F, No. 1, Alley 16, Lane
235, Pao Chiao Rd., Hsin Tien City, Taipei
County, Taiwan, R.O.C.
Manufacturers of three-dimensional automatic measurement/alignment systems for digitally controlled monitors, including the ER 9300, a geometry measurement/alignment system; the ER 6700, a misconvergence measurement system; and the ER 2300, a one-dimensional white-balance measurement/alignment system. Joe Li, Sls. Mgr.
+886-2-914-5762, fax: +886-2-914-5763

EEV, INC., 4 Westchester Plaza, Elmsford,
NY 10523
Manufacturers of display systems and LCD transportation signboards for airport, rail, and bus applications; CCD sensors and CCD cameras for scientific, medical, and industrial applications. Stuart Hesselson, Dir. New Bus. Dev.
914/592-6050, fax: 914/682-8922

EEV LTD., Waterhouse Lane, Chelmsford,
Essex, U.K. CM1 2QU
Manufacturers of a range of specialized CRTs for defense systems, including miniature high-resolution and projection displays, LCDs of all technologies, and CCDs and solid-state cameras. D. Wickham
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E FOR M CORP., Polarizer Film Group,
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Manufacturers of standard and custom polarizers and retarder films, contrast-enhancement filters, and custom glass and acrylic laminations. William Bandel, Sls. Mgr.
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EG&G OPTOELECTRONICS, 35 Congress
St., Salem, MA 01970
Manufacturers of xenon lamps and light systems; power supplies for xenon and metal-halide lamps; AMLCD backlight inverters and lamp assemblies; CCD line scan and array imagers and cameras; and LEDs, laser diodes, and a complete range of detectors. Jim Reade, Sr. Prod. Spec.
508/745-3200, 1-800-775-6786
fax: 508/745-0894

EG&G OPTOELECTRONICS,
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EG&G RETICON, 345 Potrero Ave.,
Sunnyvale, CA 94086
Manufacturers of solid-state image sensors and solid-state cameras. Dianna Jones, Mktg. Mgr. Comp. Prod.
408/738-1009, fax: 408/738-6979

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Manufacturers of laser imaging recorder, Model 811, a high-resolution output device for generating continuous-tone 8-bit images onto dry-silver media. Input is via an

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IEEE-488 interface from user's host computer.
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617/275-0475, fax: 617/271-1977

ELASTOMERIC TECHNOLOGIES, INC.
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Manufacturers of STAX silver-based elastomeric connectors used to connect ITO traces on glass to PC boards, including thin-film EL (TFEL), gas plasma, vacuum fluorescent displays, and any display module to an external PC board.
Brad Lizotte, Mktg. Mgr.
215/672-0787, fax: 215/672-4633

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Designers, developers, and manufacturers of military flat-panel EL displays and custom high- and low-voltage power supplies for aerospace and industrial display applications, including CRT and FED requirements.
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fax: 206/743-8562

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Manufacturers of custom and standard glass-panel LCDs and LCD modules. Michiko Chen, Sls. Mgr. 908/874-4747, fax: 908/874-3278

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Manufacturers of computer-video interfaces, RGB switchers, distribution amplifiers, video test generators, and scan conversion equipment. Computer-video routing equipment is used to connect computers to large-screen displays and other presentation equipment. Jim Costigan, Natl. Sls. Mgr. 714/491-1500, 1-800-633-9876 fax: 714/491-1517

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5 Hangar Way, Watsonville, CA 95076
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Manufacturers of display components, electromagnetically hybrid flip disk/LED modules, and hybrid flip disk/fiber-optic LED modules for indoor and outdoor applications, including airport terminals, gasoline pump displays and price signage, time/temperature displays, and clock and advertising signs. Douglas Greenwood, Gen. Sls. Mgr. 905/624-3020, fax: 905/625-6197

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Manufacturers and distributors of graphic displays for automotive applications; electronic instrument panels utilizing VF technology; and multicolor displays. C.L. Slipek, Automotive Mktg. Mgr. 313/459-1177, fax: 313/459-1268

FUTABA CORP. OF AMERICA, Electronic Components Div., 1605 Penny Lane, Schaumburg, IL 60173

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Manufacturers of leading-edge digital video/image scaling ICs, digital video de-interlacing ICs, and filters. Product support includes evaluation software and boards.
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Mike DeWitt, Natl. Sls.
503/685-8888, fax: 503/692-8887

INFODEX, INC., 10 Venus Dr., Wolcott, CT 06716
Designers/manufacturers of a full line of monochrome and color CRT and flat-panel EL display monitors for the military, industrial, and medical markets.
Roger Lemire, Sls. Engr.
203/879-4944, fax: 203/879-4944 x230

INFOLEX CORP., 12 West 27th St., New York, NY 10001
Manufacturers of the multicolor, dynamic LED LightWall for indoor and outdoor applications, which displays graphics, animation, and multilingual text in brilliant colors, with special effects. The LightWall represents an energy efficient alternative, with the added advantage of rebates from local energy suppliers.
Ani Bedrossian, V.P. Mktg./Sls.
212/213-2622, fax: 212/213-3142

INFO-LITE CORP., 422 Cliff St., Fairview, NJ 07022
Manufacturers of large numeric displays and instruments, alphanumeric displays and message signs, backlit indicators and annunciators, matrix pinboard switches, and reed switches.
Joseph M. Cartelli, Tech. Mktg. Mgr.
201/941-4455, fax: 201/941-4919

INNOTECH GROUP, INC., 61W Moreland Rd., Simi Valley, CA 93065
Manufacturers of vertical in-line sputtering systems and in-line evaporation systems for the manufacture of flat-panel displays; rf, dc, and electron-beam power supplies; and vacuum components.
William T. Read, Dir. Sls./Mktg.
805/522-9040, fax: 805/522-6017

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Providers for presenters, trainers, and educators of LCD and DLP projectors and LCD panels from leading manufacturers, including nView, In Focus, Proxima, Telex, and NEC.
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916/894-3932, fax: 916/894-3847

INSTRUMENT SOCIETY OF AMERICA, 67 Alexander Dr., Research Triangle Park, NC 27709
Worldwide organization for instrumentation and control engineers and technicians. ISA also publishes videotape and interactive videodisc instruction products as well as applications software.
Gale Girer, Mgr. Media Pub.
919/549-8411, 1-800-334-6391
fax: 919/832-0237

INSTRUMENT SYSTEMS, 576 Golden Ave., Ottawa, Ontario, Canada K2A 2E9
Distributors of display test systems for automotive, avionic, NVIS, and general display testing. Scanning diode array and CCD-based spectrometers for spectro-radiometry, spectrophotometry, LED, and small lamp testing. Also, polarization analyzers and the IQCam, an imaging photometric camera.
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613/729-0614, fax: 613/729-9067

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770/623-9145, fax: 770/623-9163

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617/932-0700, fax: 617/932-3088

INTERACTIVE COMPUTER PRODUCTS INC., 23482 Peralta, Unit C, Laguna Hills, CA 92653
Manufacturers of light pens and complete light-pen systems for computer terminals, workstations (SUN, SPARC, and HP), and personal computers (IBM PCs, clones, and PS/2s). Available for monochrome and color CRT displays. Resolution to 1280 × 1024.
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714/770-5332, 1-800-392-0540
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INTERFACE PRODUCTS, INC.,
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Bill Lang, Mktg. Mgr.
760/945-0230, fax: 760/945-0239

INTERLINGUA (see DISPLAY TECHNOLOGY LIBRARY), 423 S. Pacific Coast Hwy. #208, Redondo Beach, CA 90277
Market researchers/publishers specializing in display-technology literature from Japan. Translated documents concerning manufacturing, R&D, marketing, new-product releases, competitive activities, and technology trends.
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310/792-3636, fax: 310/792-3642

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Thomas L. Angelucci, Sr., CEO
609/273-0200, fax: 609/273-4364

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Manufacturers of linear and circular polarizing sheet, wave-retarder films, and polarized products for displays. High-transmittance high-efficiency polarizers and very-high-efficiency polarizers. Wave-retarder films up to 17 in. wide. Polarizing filters.
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508/481-4943, fax: 508/481-0222

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fax: 612/888-0796

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fax: 714/758-4111

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Stacy H. Oresman, Mgr. FPD Sys. Mktg.
408/496-2214, fax: 408/988-8145

INTRONICS, 150 Dan Rd., Canton, MA 02021
Manufacturers of monolithic distortion correction devices that accurately correct for geometric or focus distortion in CRT displays.
Gene Stancato
617/828-4992, 1-800-367-0004
fax: 617/527-3310

ION SYSTEMS, 1005 Parker St., Berkeley, CA 94710
Designers/manufacturers of air/nitrogen ionizers and instrumentation for controlling damage and contamination caused by static charge. Products range from ultra-cleanroom ionization systems to point-of-use ionizing blowers.
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fax: 510/548-0417

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617/273-4455, fax: 617/273-0076

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Manufacturers of vacuum fluorescent displays; VFD module and sub-system; picture-element displays for large-screen information panel; and related products.
Kazuhiko Kasano, Gen. Mgr. Engr. Div.
+81-596-39-1111, fax: +81-596-39-0366

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fax: 413/737-0608

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Manufacturers of a full line of LCD-manufacturing equipment, including PI printer, rubbing machine, seal/Ag printer, dry-spacer applicator, align/assembly machine, press/cure, scribe/breaker, end-seal machine, polarizer laminator, LC fill machine, and related equipment.
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Dan Lyke, V.P.
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LORAL FAIRCHILD IMAGING SENSORS, INC., CCD Imaging, 1801 McCarthy Blvd., Milpitas, CA 95035

Manufacturers of line-scan and area sensors, line-scan development boards and modules, and line-scan and area cameras.
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Manufacturers of ruggedized and militarized cockpit and workstation display systems using CRTs and AMLCDs for

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fax: 908/850-6009

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301/341-4900, fax: 301/341-4078

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OMARA & ASSOCIATES, 2443 Ash St., Palo Alto, CA 94306
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OMEGA ELECTRONICS, S.A., P.O. Box 6, Rue des Prés 149, Bienne 2504, Switzerland
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OPTICAL CORP. OF AMERICA (OCA), 170 Locke Dr., Marlborough, MA 01752
Designers/manufacturers of optical components and filters for use in UV-visible-IR applications including display and photon-managed products.
Walter J. Lekki, V.P. Mktg./Slis.
508/481-9860, fax: 508/485-0526

OPTICAL DEVICES INCORPORATED, 805 Via Alondra, Camarillo, CA 93012
Manufacturers of linear and circular polarized film and contrast-enhancement filters utilizing polarized film. Also, glass and acrylic windows with matte and anti-reflection surfaces.
William Bandel, Slis. Mgr.
805/987-9993, 1-800-987-8801
fax: 805/987-5789

OPTICAL ELECTRONICS, Box 11140, Tucson, AZ 85734
Manufacturers of low-light-level video image processor. Enhancement including video tape.
Suzanne Gerdes, Pres.
Phone/fax: 520/889-8575

OPTICAL RADIATION CORP., 1300 Optical Dr., Azusa, CA 91702
Manufacturers of highly collimated UV-light exposure systems used to produce flat-panel displays. Systems range from manual load to fully automated in-line configurations.
Michael L. Yatsko, Dir. Mktg./Slis.
818/969-3344 x2428, fax: 818/969-3681

OPTICAL SOLUTIONS, INC., P.O. Box 889, 700 Airport Blvd., Doylestown, PA 18901

Manufacturers of patented rigid rear-projection screens for single-aperture light sources. Performance properties such as viewing angles, brightness, resolution, contrast, and control of surface reflections can be custom engineered. These new-technology screens are smooth surfaced, with an internal optical structure.
Jack A. Dorazio, V.P.
215/348-4649, fax: 215/348-9959

OPTICS 1, INC., 3050 Hillcrest Dr., Ste. 100, Westlake Village, CA 91362
Consultancy in the optical design, engineering, and production of imaging systems, from initial specifications through detailed lens design, analysis, tolerancing, fabrication, assembly, and alignment.
Milton Lee, V.P. Oper.
805/373-9340, fax: 805/373-8966

OPTIS, INC., 8230 E. Broadway, Suite E2, Tucson, AZ 85710
Distributors of two products to design and analyze information-display devices using software simulation. Newest product, SPEOS, has been used to analyze everything from LCD notebook displays to LED-lit cellular telephone displays.
Michael Gauvin, Pres.
520/721-1010, fax: 520/721-1221

OPTO-CAL, INC., 13891 Dearly Ct., Lakeside, CA 92040
Optical radiation calibration laboratories specializing in photometric and radiometric calibrations and measurements. Calibration of photometers, radiometers, power meters, and light sources; spectral transmission of filters and materials from 200 to 1700 nm; and MIL-STD-85762A NVIS testing.
Robert Ruff, Pres.
619/561-9983, fax: 619/561-8810

OPTO SIGMA CORP., 2001 Decec Ave., Santa Ana, CA 92660
Manufacturers of precision optical components, including lenses, mirrors, prisms, beam-splitter cubes, polarizers, and filters. Thin-film dielectric coatings including high reflection, high transmission, polarizing, non-polarizing, narrow band, broad band, and anti-reflection. Translation stages and opto-mechanical assemblies. All products available with OEM discounts.
Kevin Liddane, OEM Bus. Mgr.
714/851-5881, fax: 714/851-5058

OPTOTEK, LTD., 62 Steacie Dr., Kanata, Ontario, Canada K2K 2A9
Manufacturers of LED displays for visual and photoexposure applications. Package configurations include flat panel, alphanumeric, programmable switch, and linear bargraph displays. All are available in red, orange, yellow, green, and blue. Alpha-numeric and switch products are also available in multicolor configurations.
Steve Wilson, Mgr. Design Engrg. Svcs.
613/591-0336, fax: 613/591-0584

OPTREX AMERICA, INC., 44160 Plymouth Oaks Blvd., Plymouth, MI 48324
Manufacturers of a complete line of standard and custom LCDs in both character and graphic type.
Rob Harrison
313/416-8500, fax: 313/416-8520

OPTREX/SATORI, 3830 Del Amo Blvd., Torrance, CA 90503
Marketers of alphanumeric and graphic LCD panels and modules. Extended

temperature, EL, LED and CCT back-lighting, NTN, black-and-white, high-contrast fluids, passive color, VGA, and XGA options available.
Ken Yoshikama, Pres.
310/214-1791, fax: 310/214-1721

OPTRO-MECHANICS (USA) CORP., One Blue Hill Plaza, Pearl River, NY 10965-8667
Distributors of a line of microscopes and LCD inspection systems manufactured by Seiya Optical Co., Ltd., Tokyo, Japan.
Sal Miwa, Pres.
914/620-1999, 1-800-890-3333
fax: 914/620-1950

OPTRONIC LABORATORIES, INC., 4470 35th St., Orlando, FL 32811
Manufacturers of spectroradiometers, photometers, and custom systems for measuring light sources, displays, and material properties to military and commercial specifications. Also, provides traceable standard lamps, power supplies, amplifiers, and measurement services.
William A. Schneider, V.P. & Dir. Slis.
407/422-3171, 1-800-899-3171
fax: 407/648-5412

OPTRONICS ENGINEERING, 175 B Cremona Dr., Goleta, CA 93117
High-resolution high-sensitivity color video cameras for fluorescence and low-contrast surface inspection. The auto exposure system has a shutter range of 1/10,000-4 sec with light sensitivity as low as 0.0025 lux.
Doug Marker, Slis. Dir.
805/968-3568, fax: 805/968-2046

ORBOTECH, 44 Manning Rd., Billerica, MA 01821

Manufacturers of a comprehensive line of advanced automated optical inspection systems for flat-panel displays and CRT products. AOI systems provide highly accurate detection of all critical defects in the manufacturing process and act as a true quality guardian for process control during the ramp-up stages of operation and during full production.
Robert A. Wironen, Natl. Slis. Mgr., Display Prod.
508/667-6037 x207, fax: 508/667-9969

ORC ELECTRONIC PRODUCTS, 1300 Optical Dr., Azusa, CA 91702
Manufacturers of high-speed, fully automatic, and manual UV exposure systems for FPD, MCM, and etched lead-frame technologies. The systems utilize high-intensity short-arc mercury/xenon lamps, with highly collimated optics for fine-resolution printing.
Thomas Keddy, N. A. Slis. Mgr.
818/815-3130, fax: 818/815-3131

ORC LIGHTING PRODUCTS, 1300 Optical Dr., Azusa, CA 91702
Manufacturers of xenon and mercury short-arc lamps, fiber-optic lamps, modules, and complete illumination systems for use in information-display systems, LCD and large-screen projection systems, and miniature spotlight applications.
George Bacher, V.P. Slis.
818/815-3100, 1-800-755-LAMP
fax: 818/815-3074

ORWIN ASSOCIATES, INC., 88 Seabro Ave., Amityville, NY 11701
Designers/manufacturers of specific-purpose CRT monitors: high-bright color and monochrome for ATC towers, special large-screen high-resolution workstations,

gray scale/high resolution for medical diagnosis and image analysis.
Ben Iannotta
516/842-7177, fax: 516/842-7410

PACIFIC MEDIA ASSOCIATES, 1121 Clark Ave., Mountain View, CA 94040
Market researchers offering multi-client and custom studies on large-screen display markets. Publishers of the continuing Large-Screen Displays Industry Service (detailed market estimates) and conducts the annual North American Large-Screen Displays Reseller Survey.
William L. Coggsall, Pres.
415/948-3080, fax: 415/948-3092

PACIFIC TECHNOLOGIES, INC., 123 N.W. 13th St., Ste. 308, Boca Raton, FL 33432
Distributors/authorized representatives of Toshiba, Ishiyama, and Chuo Riken LCD-manufacturing equipment; NGI heat-seal connectors, FPCs, and electroluminescent lamps; Kandabashi Tek APR print mattes; and a wide variety of related FPD technologies.
Peter J. Opdahl, Managing Dir.
407/392-2555, 1-800-575-3560
fax: 407/392-0807

PALOMAR PRODUCTS, INC., 2051 Palomar Airport Rd., Carlsbad, CA 92009
Manufacturers of automatic die attach, wire bond, wedge bond, and TAB bond equipment with manual stations for hot-bar edge connectors and anisotropic film bonders. Manufacturing equipment supplier to TAB driver bonding machines for flat-panel displays, CRT gun welders, and lamp filament and lamp lead welding equipment.
Laurie S. Roth, V.P. Slis & Mktg. Mgr.
760/931-3427, 1-800-854-3467
fax: 619/931-5191

PALOMAR PRODUCTS, INC., Specialized Displays Group, 2051 Palomar Airport Rd., Carlsbad, CA 92009
Manufacturers of display systems: CRT, biocular, AMLCD (SolarStar™ and NovaStar™) high-resolution bright displays required in ground vehicles, helicopters, aircraft, and air-traffic-control towers.
Russ Schwarzer, V.P. Specialized Displays
760/931-3236, fax: 760/931-5198

PANASONIC COMMUNICATIONS & SYSTEMS CO., 2 Panasonic Way, 7D-2, Secaucus, NJ 07094
Manufacturers of the PanaFlat™, PanaSync™, PanaMedia™, and PanaSync/Pro 15-in. (14-in. visual image) to 28-in. (25.9-in. visual image) CRT color monitors with multiscan up to 113 kHz and dot pitches down to 0.25 μm. PanaMedia monitors feature Dome Speakers™. Also, polysilicon LCD color projectors and overhead panels.
Dave Kelly, Natl. Slis. Mgr.
201/392-4185, 1-800-742-8086
fax: 201/392-4504

PANASONIC COMPUTER PERIPHERAL CO., 2 Panasonic Way, 7D-2, Secaucus, NJ 07094
Manufacturers of entry-level E-Series, the business-class standard or S-Series, the high-end Pro or P-Series, and the multimedia-ready PanaMedia or PM-Series monitors.
Mike Marusic, Natl. Prod. Mgr.
201/348-7282, 1-800-348-8086
fax: 201/392-4504

PANASONIC INDUSTRIAL CO., Display Products Dept., 2 Panasonic Way, 7H-1, Secaucus, NJ 07094
Manufacturers of high-resolution monochrome and color CRTs in sizes from 5 to

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27 in.; high-resolution monochrome and color display monitors, cabinet style, in sizes from 14 to 21 in.; high-resolution dc plasma display panels in formats from 200 x 640 to 1152 x 900; and vidicon and newvicon camera tubes.
Mario Bartalotta
201/392-4502, fax: 201/392-4815

PANELGRAPHIC CORP., 10 Henderson Dr., West Caldwell, NJ 07006
Manufacturers of Chromafilter contrast-enhancing antiglare filter materials for all types of optoelectronic and CRT displays; antifog, antistatic Vueguard™ coatings to protect display readout windows from scratching and harsh chemicals
Jane Ryan, V.P. Mktg.
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PANELIGHT DISPLAY SYSTEMS, INC., 101 Embarcadero, #100A, San Francisco, CA 94105
Distributor of flat-panel display products for end-users.
So-hail Malik
415/772-5800, fax: 415/986-3817

PANELVIEW, INC., 7870 S.W. Nimbus Ave., Beaverton, OR 97008
Manufacturers of filters and windows for glare reduction, contrast enhancement, and environmental protection on all types of flat-panel displays and IR devices. Users of plastic and glass substrates, specializing in hardcoating and EMI/RFI suppression.
Rim Eltinge
503/643-9311, 1-800-788-4088
fax: 503/643-8923

PARALLAX GRAPHICS, INC., 2500 Condensa St., Santa Clara, CA 95051
Manufacturers of high-resolution video and graphics display controllers for Qbus, VMEbus, and PC/AT PC/XTbus.
Siu Taylor, V. P. Intl. Sls.
408/727-2220, fax: 408/980-5139

PEARSON & ASSOCIATES, INC., 11811 N. Tatam Blvd., Ste. P.129, Phoenix, AZ 85028
Consultancy specializing in personnel and business development in flat panels and CRTs.
Chuck Pearson, Pres.
602/953-9783, 1-800-541-3384
fax: 602/996-1261

PEGASYS DISPLAYS, INC., P.O. Box 1795, Eau Claire, WI 54702-1795
Designers/manufacturers of custom high-resolution color and monochrome monitors for medical imaging and other OEM markets, including custom ruggedization. Screen sizes range from 7 to 21 in., with resolutions up to 1600 x 1280.
Oscar Martinez, Dir. Engrg.
715/832-5170, fax: 715/832-5170

PEMM SERVICES, 1 Friars Tale Place, Staatsburg, NY 12580-5104
Consultancy specializing in display technologies, providing technology evaluation and comparisons, strategies, technology recommendations for a given application, and assessments of the viability, cost, and availability of various display technologies.
Peter Pleshko, Consultant
914/889-4246, fax: 914/889-4246

PENTAX TECHNOLOGIES CORP., 100 Technology Dr., Broomfield, CO 80021
Manufacturers of precision optical components and subassemblies for computer peripherals.
Robert Ariniello, Mgr. Opt. Prod. Mktg.
303/460-1600, fax: 303/460-1628

PERCON, INC., 1720 Willow Creek Circle, Suite 530, Eugene, OR 97402
Manufacturers and distributors of barcode reading equipment and accessories for many different computer/terminal systems, including IBM, Dec, Wyse, and Apple Macintosh. Five-year warranty on all input devices.
Beth Daniels, Dir. Mktg.
503/344-1189, 1-800-873-7266
fax: 503/344-1399

PERFORMANCE DISPLAY SYSTEMS, INC., 7 Waterside Crossing, Ste. 204B, Windsor, CT 06095
Manufacturers of flat-panel-display computer systems for bright environments, including direct sunlight. Models now use 10.4-, 13-, and 16-in.-diagonal displays.
Lawrence Guzowski, Pres.
860/683-8070, fax: 860/683-8073

PHILIPS COMPONENTS, P.O. Box 218, 5600 MD Eindhoven, The Netherlands
Worldwide manufacturers of electronic components, including display components and electro-optical components.
Jeannet Harpe, Press Off.
+31-40-724-173, fax: +31-40-724-825

PHILIPS COMPONENTS, 100 Providence Pike, Slatersville, RI 02876
Manufacturers of full-frame and frame-transfer CCD imagers and CCD camera modules. Also, custom CCD image sensors for high-speed high-resolution imaging.
Carlo Sabetti, Mktg. Mgr., CCDs
401/767-4428, fax: 401/767-4493

PHILIPS CONSUMER ELECTRONICS CO., 1 Philips Dr., Knoxville, TN 37922
Manufacturers of a broad range of CRT-based display products from 12-in monochrome through 21-in. FSQ color. Resolution levels up to 1600 x 1280 are supported by dedicated and multifrequency designs.
John Neilson
719/593-4297

PHILIPS DISPLAY COMPONENTS CO., P.O. Box 963, 1600 Huron Pkwy., Ann Arbor, MI 48106-0963
Manufacturers of color display tubes for TV and monitor applications, monochrome tubes and deflection units for monitor applications, flyback transformers, degaussing coils, various wirewound components, tuners for TV and satellite receivers.
Patrick Canavan, Sls. Mgr.
313/996-9400, fax: 313/761-2776

PHOSPHOR PRODUCTS CO., LTD., 1 Factory Road, Upton, Poole, Dorset BH16 5SJ, England
Manufacturers of DCEL displays and phosphors.
N. Bainton
+44-202-632-116, fax: +44-202-631-980

PHOSPHOR TECHNOLOGY LTD., Middle St., Nazeing, Essex EN9 2LP, England
Manufacturers of inorganic phosphors for CRTs, FEDs, PDPs, x-ray imaging screens, IR detection, UV detection, and other radiation-detecting scintillators.
Gerry Sorce, CEO
+44-1992-89-3424, fax: +44-1992-89-3729

PHOTOMETRICS, 3440 E. Britannia Dr., Tucson, AZ 85706
Manufacturers of digital imaging systems for research and industrial applications. CCD technology-based applications include life sciences, high-energy physics, astronomy, spectroscopy and deep-water imaging fields. Still-imaging cameras offer response linearity, geometric stability, and high dynamic range.
John Allard, Sls. Mgr.
602/889-9933, fax: 602/573-1944

PHOTON DYNAMICS, INC., 6325 San Ignacio Ave., San Jose, CA 95119
Manufacturers of systems to test, inspect, and repair FPDs during product development and commercial production. Supports display manufacturers.
Vince Solitto, CEO
408/226-9900, fax: 408/226-9910

PHOTONICS SPECTRA (LAUREN PUBLISHING CO., INC.), 2 South St., Pittsfield, MA 01201
Publishers of Photonics Spectra, a magazine devoted to photonics technology: optics, lasers, fiber-optics, electro-optics, imaging, and optical computing. Also, the four-book set of The Photonics Directory: The Corporate Guide, Buyers Guide, Handbook, and Dictionary.
Tomi Renee Ransom, Mktg./Sls. Coord.
413/499-0514, fax: 413/442-3180

PHOTONICS SYSTEMS, INC., 6975 Wales Rd., Northwood, OH 43619
Manufacturers of ac plasma displays and AMLCD gray-scale monochrome and full-color monitors with options including embedded computers and touch panels. Compatibility with VGA through emerging HDTV, various VESA and other standard computer workstation interfaces.
Donna Schantz, Admin. Asst.
419/666-6325, fax: 419/666-0875

PHOTON, INC., 1115 Space Park Drive, Santa Clara, CA 95054
Manufacturers of test instrumentation that records the energy distribution pattern of optical sources including imaged spot size.
Jim Darchuk, Mktg./Sls. Mgr.
408/492-9449, fax: 408/492-9659

PHOTO RESEARCH, INC., 9330 DeSoto Ave., Chatsworth, CA 91311
Manufacturers of a full spectrum of display measurement equipment including photometers, spectroradiometers, colorimeters, automated video-manufacturing test equipment, and optical calibration. Also, measurement services available.
Mike Klein
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PHOTRONICS, INC., 15 Sector Rd., Brookfield, CT 06804
Global supplier of photomask photographic and design center services as well as plasma etch systems. Photographic services include photomask fabrication, imaging on film, step-and-repeat, and large-area masks.
Nora McClelland, Acct. Mgr.
408/245-7342, 1-800-292-9396
fax: 408/733-2225

PHOTRONICS-COLORADO (Formerly Microphase Laboratories) 815 N. Wooten Rd., Colorado Springs, CO 80915
Manufacturers of masks for all types of FPDs, with linewidth precision of 2 µm on soda lime or quartz substrates with emul-

sion, iron oxide, or chrome coatings. Also, mask-design services.
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719/596-8899, fax: 719/596-8333

PHYSICAL OPTICS CORP., 20600 Gramercy Pl., Bldg. 100, Torrance, CA 90501-1821
Manufacturers of a line of holographic light-shaping diffusers which shape, direct, and homogenize light with high transmission efficiency. Technology can be used for front- and rear-projection screens, LCD backlights, LED displays, barcode readers, and light-source homogenizing.
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310/320-3088, fax: 310/320-8067

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Importers/resellers of high-resolution monitors, color and monochrome, for Philips, IDEK and others. Authorized depot repair center with parts inventory for quick turnaround on repairs. Custom mechanical and electrical modifications and graphic display controllers.
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508/562-4803, fax: 508/568-0514

PIXEL INTERCONNECT, 11040 SW 63rd St., Portland, OR 97219
Consultancy providing TAB/COF, heat seal, flex, and COG process engineering development and process improvement. Interconnect equipment and test. Design and equipment reliability improvement. Strategic and tactical marketing product planning and implementation.
Scott Cockey, Pres.
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PIXELVISION, 43 Nagog Park, Acton, MA 01720
Manufacturers of flat-panel core products designed for integration convenience. Display, touch sensor, and interface electronics combined in special bezel assembly for rack-mount, kiosk, or ruggedized monitor development. 16-in. SXGA compatible with most any computer source.
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Manufacturers of FEDs, emissive flat panels characterized by 160° viewing angles, low power consumption with high brightness (1 W at 70 IL), full video speed, and instant-on at -40 to +85°C. Currently delivering monochrome FEDs to qualified display integrators and OEMs. Larger sizes and color units available late in 1997.
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fax: 408/986-9896

PLANAR ADVANCE, INC., P.O. Box 4001, Beaverton, OR 97075
Manufacturers of a full range of high-quality high-performance displays for military, industrial, and commercial applications. Display types include electroluminescent, miniature, active-matrix electroluminescent (AMEL), AMLCDs, and monochrome and color CRT-based systems.
Bob Johnson, Mktg. Mgr.
503/614-4110, fax: 503/614-4101

PLANAR AMERICA, INC., 1400 N.W. Compton Dr., Beaverton, OR 97006
Manufacturers/distributors of high-performance flat panels using electroluminescence (EL) technology. Included

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barcoding, WP/OA, electronic publishing, CAD/CAE, and other applications.
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205/633-4300, fax: 205/633-0013

QUANTEX CORP., 2 Research Ct.,
Rockville, MD 20850
Manufacturers of electroluminescent displays and lamps, filmless x-ray storage screens, and imaging systems.
Ken Charbonneau, Sls. Mgr.
301/258-2701, 1-800-992-5149
fax: 301/258-9871

QUANTUM DATA, INC., 2111 Big Timber Rd.,
Elgin, IL 60123
Manufacturers of a complete line of programmable video test generators, distribution buffers, and convergence gauges for use in research, production, and quality control.
Al Jorgensen
847/888-0450, fax: 847/888-2802

QUANTUM ELECTRONICS, INC.,
31 Industrial Park Rd., Lewistown, PA 17044
Manufacturers of a wide range of standard and custom display systems using LED, plasma, incandescent, and mechanical flipper technologies. Unit size ranges from 4 x 6 in. up to 6 x 12 ft.
Kit C. Kennedy, Pres.
717/242-1132, fax: 717/248-8680

RACAL ACOUSTICS LTD., Waverley Industrial Park, Hailsham Dr., Harrow, Middlesex HA1 4TR, U.K.
Manufacturers of public-information display signs using guest-host LCD technology for indoor and outdoor applications.
Stephen Hatch, Sls. Controller
+44-81-427-7727, fax: +44-81-427-0350

RACAL-MESL LTD., Lochend Industrial Estate, Newbridge, Edinburgh EH28 8LP, Scotland
Designers/manufacturers of display modules aimed at professional and military applications. Technologies include LCD and electroluminescent modules and feature rugged construction, wide temperature range, touch panels, controllers, and interfaces.
Tony Bland, Sls. Mgr.
+44-1344-300091, fax: +44-1344-385880

RAINBOW OPTICS CO., 6 Countryside Lane, Salem, MA 01970-1768
Optical design association providing optical engineering and consulting services to manufacturers of LCD projectors. Designers of optics and mechanics of projection zoom lenses and of complete optical benches, including lamp, condenser, and keystone distortion corrector. Providers of tolerancing and radiometric analysis and builders of prototypes.
Leon Reznikov, Consultant
508/741-3906, fax: 508/741-8122

RAMEY SCIENTIFIC COMPUTING,
5 Mandeville Ct., Ryan Ranch Business Park, Monterey, CA 93940
Providers of contract scientific software, engineering, CAD, video animation, technical illustration and documentation services for FPD industry, and magnetic modeling. Also, library of training videotapes on plasma etching, plasma physics, and plasma chemistry. Custom windows software programming for machine and process control applications available.
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408/655-2772, fax: 408/655-4858

RANTEC MICROWAVE & ELECTRONICS, INC., 1173 Los Olivos Ave., Los Osos, CA 93402
Manufacturers of high- and low-voltage power supplies, dc/dc converters, and power systems designed, manufactured, and marketed to a broad range of industries worldwide for commercial, industrial, avionics, and full military applications.
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805/528-5858, 1-800-235-4148
fax: 805/528-6932

RASTEROPS, 2500 Walsh Ave., Santa Clara, CA 95051
Manufacturers of color display systems, accelerators, monitors, video image capture, and display hardware and multimedia accessories for the Apple Macintosh, IBM MicroChannel, and Sun SPARCstation platforms. Products designed primarily for the graphic arts, printing, publishing, and related industries.
408/562-4200, 1-800-SAY-COLOR
fax: 408/562-4065

RAYTHEON CO., Submarine Signal Div., 1847 West Main Rd., Portsmouth, RI 02871
Manufacturers of the Thermal Display Unit with true gray shades at high speeds and high resolution, producing recordings of near-photographic-quality full tonal images, capable of displaying digital data in graphic or alphanumeric forms.
John Lorea, Sls. Mgr.
401/847-8000 x2054, fax: 401/847-8002

RAYTHEON ELECTRONIC SYSTEMS,
465 Centre St., Quincy, MA 02169
Manufacturers of specialty CRTs for head-down and HUD avionics, air traffic control, and shipboard applications. Also developing high-brightness monochrome and color FEDs for use in avionics and vehicular applications.
Gary Smith, Engr. Mgr.
617/984-8529

RDI COMPUTER CORP., Little Haining, Brockenhurst Rd., Ascot, Berkshire SL5 9HB
Manufacturers of the PowerScreen, a stand-alone, high-resolution LCD in a compact, lightweight, design, with low emissions and low power consumption, and available with a 12.1-in. 1024 x 768 high-resolution active-matrix LCD.
Reg Broughton, Gen. Mgr. Eur. Oprns.
+44-1344-25999, fax: +44-1344-25652

RECOGNITION CONCEPTS, INC., 5200 Convoir Dr., Carcara, NV 89076
Manufacturers of real-time image processing system and video digital storage systems.
Ron Earwood, Ad. Mgr.
702/831-0473, fax: 702/831-8035

REDIFFUSION SIMULATION LTD., Visual Business Unit, Plant 5, Jenner Rd., Crawley, West Sussex, RH10 6JY U.K.
Manufacturers of monitor, projection, and laser-based large-area displays, primarily for the aviation industry. WIDE is a collimated projection display offering fields of view of up to 40 (V) x 200 (H).
A.P. Usher, Tech. Sls. Exec.
+44-293-518-941, fax: +44-293-560-231

SCOTT REDMOND, P.O. Box 14607, San Francisco, CA 94114
Specialized consulting for 3-D stereoscopic and immersive simulation display systems.
Scott Redmond, Consultant
415/978-2301

REEL 3-D ENTERPRISES, INC., P.O. Box 2368, Culver City, CA 90231
Mail-order retail suppliers of stereoscopic viewers for stereo-pair prints and slides, polarized and anaglyphic (red/blue) 3-D viewing glasses, books about 3-D photography, and books illustrated with 3-D images.
David Starkman, V.P./Tech. Dir.
310/837-2368, fax: 310/558-1653

REFLECTION TECHNOLOGY, INC., 230 Second Ave., Waltham, MA 02154
Manufacturers and designers of full-color and monochrome virtual displays for OEM customers and proprietary handheld telecommunications products that incorporate these displays. Low-cost miniature scanned linear array displays that provide resolutions up to full VGA with high image quality and extremely low power consumption compared to LCDs.
John Summers, Dir. Bus. Devel.
617/890-5905 x2, 1-800-890-5905
fax: 617/890-5918

REGISBROOK GROUP LTD., Units 1&2, Suffolk Way, Drayton Rd., Abingdon, Oxon OX14 5JY, U.K.
Manufacturers of a full range of vacuum fluorescent, liquid-crystal, and LED display modules, and sub-systems with ruggedized housings with/without touch-screen overlays. Extended-temperature products available.
Chris Williams, Director
+44-123-555-4433, fax: +44-123-552-8971

RELISYS, 320 S. Milpitas Blvd., Milpitas, CA 95035
Manufacturers of a line of popular monitors ranging from color, EGA, VGA, multisync, and super-multisync including a monochrome VGA at competitive prices.
408/945-9000, fax: 408/945-0587

RETROSCAN SCREEN, INC., 148 Madison Ave., New York, NY 10016
Distributors of DNP high-resolution Fresnel/lenticular rear-projection screens in sizes from 50—160 in. Manufacturers of rear-screen projection enclosures, rear projector/mirror mounts, and ancillary rear-screen products.
Charles Levitt, Pres.
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847/459-9189, fax: 847/215-6141

UCE, INC., 1580 Route 52, Hopewell Junction, NY 12533
Manufacturers of LCDs, application-specific displays, and custom and standard displays. Liquid crystals include nematic, scattering, dichroic, phase-change, and stored scatter. Also, optical light valves, shutters, attenuators for projection and direct-view, and optical switches.
Greg Borstelmann, Sls. Mgr.
914/892-1700, Fax: 914/892-1710

ULTIMATE DISPLAY SOLUTIONS, INC.,
1495 Hembree Rd., Ste. 900, Roswell, CA 30076

Distributors of new and reconditioned computer monitors (12, 14, 15, and 17 in.). CGA through 1280 x 1024 resolution. Also, repair of color and monochrome monitors.
Chuck Wood, Sls. Mgr.
404/664-1010, 1-800/221-1490
fax: 404/664-4103

ULTRA EQUIPMENT CO., 2391 Zanker Rd., #370, San Jose, CA 95131

Manufacturers of configurable photolithography cluster tools for coating, developing, and cleaning of substrates up to 34 in. on the diagonal. Also spin coaters for

uniform coating of square and rectangular substrates, high-pressure and megasonic spray cleaners, spray developers, and high-accuracy flip-chip bonders.
Fred Namek, V.P. Mktg./Sls.
408/955-7850, fax: 408/955-7878

ULVAC TECHNOLOGIES, INC.,
6 Riverside Dr., Andover, MA 01810
Manufacturers of a line of evaporators for the FPD industry. The END Series of cluster tools and the EI/ECH Series of in-line evaporation equipment for MgO deposition for PDP users and various metals for FED users.
Rob Gardner, Dir. Sls./Mktg.
510/226-0151, fax: 510/226-0167

UNIAX CORP., 6780 Cortona Dr., Santa Barbara, CA 93117
Developing low-power polymer electro-luminescent displays for use in hand-held electronic applications. Initial commercial prototypes will be ready for OEM evaluation by late 1997.
Nick Colaneri, Bus. Devel. Mgr.
805/562-9293, fax: 805/562-9144

UNIGLOBE KISCO, INC., 709 Westchester Ave., White Plains, NY 10604
Distributors of TN/STN-LCD cells from Japan/China/Taiwan/Malaysia on an OEM basis. Manufacturing materials and equipment for TN/STN/AMLCDs, including liquid crystal, polyimide, spacer, ITO glass, heat-seal connector, ACF, and systems for rubbing, alignment/lamination, spacer dispersion, LC injection, and scribe/break.
David Roseman, Mgr. Sls./Engrg.
914/949-5434, fax: 914/997-0195

UNIGRAF, Ruukintie 18, Espoo 02320 Finland
Manufacturers of industrial computers and monitors for process automation and mobile and military applications. Also, video test generators for video-monitor service and manufacturing.
Jouko Ala-Tuori, Mktg. Mgr.
+358-9-802-76423, fax: +358-9-802-6699

UNIVERSITY OF MICHIGAN, Display Technology & Manufacturing Center, 2360 Bonisteel Blvd., Ann Arbor, MI 48109-2108
University research facility offering R&D in FPD manufacturing and materials technologies. Capabilities in FPD devices, materials, and circuits; process control; microelectronics on low-temperature substrates; and factory optimization and control.
Linda K. Owens, Admin. Mgr.
313/764-4336, fax: 313/936-0347

UNIVISION TECHNOLOGIES, INC.,
3 Burlington Woods Dr., Burlington, MA 01803
Manufacturers of graphics display controllers and frame grabbers for VME, PC-ISA, VL, PCT, and IBMRISE 6000 computers. Supports CRTs and EL displays with resolutions from 640 x 480 up to 1600 x 1280 with 8, 12, 24, and 32 bits per pixel. Digital and analog video inputs are also supported.
Larry H. Taitelbaum, Dir. Sls. East
617/221-6700 x125, fax: 617/221-6777

USHIO AMERICA, INC., 10550 Camden Dr., Cypress, CA 90630
Manufacturers of metal-halide and halogen lamps for projection systems. Low-voltage dc and ac metal-halide lamps.
Lorena Chavez, Mktg./Cust. Relations
714/229-3147, 1-800-326-1960
fax: 714/229-7147

U.S. PRECISION GLASS, 1900 Holmes Rd., Elgin, IL 60123

Manufacturers of flat-glass components for a variety of touch screens and flat-panel-display manufacturers. Services include cutting, grinding, polishing, chemical tempering, optical coating, silk screening, and light assembly.
Greg Olson, Natl. Sls. Mgr.
847/931-6403, fax: 847/931-4144

UTI CORP., Colleagueville, PA 19426
Manufacturers of precision miniature metal components in 100 different alloys; specifically, oxide and dispenser cathode components.
P. J. Koehler, VP Mktg./Sls.
610/539-0700, 1-800-523-0441
fax: 610/489-2720

VACUUM ENGINEERING & MATERIALS CO., INC., P.O. Box 4480, Santa Clara, CA 95956-4480
Manufacturers of sputtering targets, evaporation materials, and backing plates. A large selection of high-purity metals, intermetallics, dielectrics, and cermets for PVD coatings. Sputtering targets and evaporation materials manufactured to customer's exact specifications of size and purity. Also, a complete line of cathodes and crucible liners.
Jack Kavanaugh, Sls. Mgr.
408/986-8900, fax: 408/986-8980

VACUUMSCHMELZE GmbH, Gruener Weg 37, Hanau D-6450, Germany
Manufacturers of magnetic shieldings from low-frequency ac fields through to earth's fields; customer-specified monitor shielding, standard monitor shielding, shielding sheets for monitors; foils, parts, and magnetically shielded rooms.
Hans-Dieter Naunheim, Dipl.-Ing.
+49-6181-38-2768, fax: +49-6181-38-2645

VALTECH CORP., 1011 Daisy Point Rd., Pughtown, PA 19465
Manufacturers of high-purity VALTRON® detergents formulated for precision cleaning of FPDs, available in acidic, neutral, and alkaline formulations, and effective in contact and non-contact cleaning equipment. Supplied in liquid concentrate for dilution with deionized water allowing various dilution rates for specific precision cleaning applications.
Robert T. Girard, Pres.
610/469-9634, fax: 610/469-9635

VANZETTI SYSTEMS, INC., 111B Island St., Stoughton, MA 02072
Manufacturers of MIDAS 8500 automatic optical inspection equipment for conductors on plasma display panels up to 30 x 30 in. (762 x 762 mm). Pixel size is 0.25 mil (6 µm) or 0.5 mil (12.5 µm). Inspection speed is 20 in.²/min. at 0.25 mil and 40 in.²/min at 0.5 mil. Gas purge of inspection area; 7.5-Mpixel/sec. image processing rate in a microcoded RISC-style architecture.
John P. Ward, Dir. Sls./Mktg.
617/828-4650, fax: 617/341-2084

VARITRONIX LTD., 4-F Liven House, 61-63 King Yip St., Kwun Tong, Kowloon, Hong Kong
Manufacturers of custom and standard LCDs, custom and standard dot-matrix and graphic LCD modules, touch-sensing customer input terminals, and touch screens.
S.M. Chung
+852-2389-4317, fax: 852-2343-9555

VARITRONIX S.A.R.L., 74 Avenue Charles de Gaulle, 91420 Morangis, France
Distributors of custom and standard LCDs, custom and standard dot-matrix and graphic LCD modules, touch-sensing customer input terminals, and touch screens.
Guy Cresson
+33-1-6909-7070, fax: +33-1-6909-0535

VARITRONIX LTD., King's Stable, 3/4 Osborne Mews, Wind., Berks SL4 3DE, U.K.
Distributors of custom and standard LCDs, custom and standard dot-matrix and graphic LCD modules, touch-sensing customer input terminals, and touch screens.
Wyn Griffiths
+44-753-833-060, fax: +44-753-833-040

VARITRONIX (UK) LTD., 3 Milbanke Ct., Milbanke Way, Bracknell, Berks RG12 1RP, U.K.
Manufacturers of both custom and standard liquid-crystal displays and modules. New products include graphics panels and direct-contact touch overlays.
Robert Hill, Appl. Engr.
+44(0)-1344-303-077, fax: +44(0)-1344-300-099

VDC, One Apple Hill, Natick, MA 01760
Business planning, product planning, and market research for the electronics industry: materials, components, subsystems, and systems level.
Marc Regberg, V.P.
508/653-9000, fax: 508/653-9836

ARON VECHT & ASSOCIATES,
95 Corringham Rd., London NW11 7DL, U.K.
Consultants specializing in displays: phosphors, EL, LCDs, etc. Also, super-pure chemicals, thin-film technology, CVD, financial and marketing, assessment of new technologies, technology transfer, and liaison between Europe and U.S.
Aron Vecht
+44-1-81-455-4361, fax: +44-1-81-316-8405

VEECO/SLOAN TECHNOLOGY, 602 E. Montecito St., Santa Barbara, CA 93103
Manufacturers of the Dektak line of flat-panel-display surface profilers that provide extremely accurate film-thickness measurements of RGB color filters, ITO, and TFTs on large flat panels up to 720 mm square.
Tim Ballinger, Mktg. Commun. Mgr.
805/963-4431, fax: 805/965-0522

VESA (Video Electronics Standards Association), 2150 N. First St., #440, San Jose, CA 95131
Worldwide video electronics standards association representing more than 300 members. Membership is drawn from hardware, software, PC, display and component manufacturers, cable and telephone companies, and service providers.
Cathy Egan, Member/Mktg. Services Mgr.
408/435-0333, fax: 408/435-8225

VGI, INC., 1800 Vernon St., Ste. 2, Roseville, CA 95678
Manufacturers of custom and standard TN- and STN-LCDs; graphic, dot matrix, and general-purpose LCD modules; LCD keypad assemblies; turnkey LCD product assembly. Singapore and Malaysia manufacturing locations.
Gary Johnson, V.P. Sls.
916/783-7878, fax: 916/783-7845

VIDEO DISPLAY CORPORATION, 1868 Tucker Industrial Rd., Tucker, GA 30084
International headquarters of parent company, guiding a group of eight divisions, manufacturing CRTs, camera tubes, electron optics, and custom monitors.
 A. J. Kenerleber, Pres./COO
 770/938-2080, 1-800-241-5005
 fax: 770/493-3903

VIDEO DISPLAY CORPORATION (APEX ELECTRONICS DIVISION), 100 8th St., Passaic, NJ 07055
Manufacturers of electron-optics equipment and manufacturing equipment.
 M. Dorota, Gen. Mgr.
 201/773-1220, fax: 201/838-1298

VIDEO DISPLAY CORPORATION (CHROMA VIDEO DIVISION), P.O. Box 119, White Mills, PA 18473
Manufacturers of entertainment and high-resolution data display color tubes from 10 to 35 in. Automated 150,000-ft.² in-line production facility.
 Ervin Kuczog, Gen. Mgr.
 717/253-3910, fax: 717/253-3912

VIDEO DISPLAY CORPORATION (DATA DISPLAY DIVISION), 1868 Tucker Industrial Rd., Tucker, GA 30084
Manufacturers of monochrome CRTs, avionics and military CRTs, and research and development.
 Robert S. Liss, Prod. Serv. Mgr.
 770/938-2080, 1-800-241-5005
 fax: 717/493-3903

VIDEO DISPLAY CORPORATION (NOVATRON DIVISION), 1416 Alpine Blvd., Bossier City, LA 71111
Manufacturers of projection tubes and assemblies from 5 to 9 in. Automated 35,000-ft.² in-line production facility.
 Charles Acurio, Gen. Mgr.
 318/747-0140, fax: 318/747-6690

VIDEO DISPLAY CORPORATION (SOUTHWEST VACUUM DIVISION), 4601 Lewis Rd., Stone Mountain, GA 30083
Manufacturers of electron-optics, components, custom cathodes, and custom gun mounts.
 Robert Wolfkiel, Gen. Mgr.
 770/934-2245, fax: 770/934-2286

VIDEO DISPLAY CORPORATION (TELTRON TECHNOLOGIES DIVISION), Ealtic Mews Corporate Center, 2 Riga Lane, Birdsboro, PA 19508
Manufacturers of general, military, and special-purpose image and cathode-ray tubes to the most stringent specifications. MIL-145208A qualified supplier to DoD, FAA, NASA, DESA, and government prime contractors.
 Arthur Mengel, Gen. Mgr.
 610/582-9450, fax: 610/582-0851

VIDEO DISPLAY CORPORATION (VIDEO ELECTRONICS DIVISION), Calle Zinc #99, Garza Garcia, Nuevo Leon 66210 Mexico
Manufacturers of monochrome CRTs from 7 to 24 in. Automated 150,000-ft.² in-line production facility.
 Rafael Garcia, Gen. Mgr.
 +52-8-336-1897, fax: +52-8-336-0578

VIDEO DISPLAY CORPORATION (Z-AXIS DIVISION), 15 Eagle St., Phelps, NY 14532
Manufacturers of specialty monochrome and color monitors.
 Carl Beecher, Gen. Mgr.
 315/548-5000, fax: 315/548-5100

VIDEO INSTRUMENTS (VI), 2155 Bellbrook Ave., Xenia, OH 45385-4043
Manufacturers of a comprehensive product line of precision video generators and performance-evaluation equipment for all types of video displays, video cameras, and recorders/image processors. Standard products, modified equipment, and special custom instrumentation are available.
 John Harshbarger, Sis. Coord.
 937/376-4361, 1-800-962-8905
 fax: 937/376-2802

VIDEOTEX SYSTEMS INC., 8499 Greenville Ave., Ste. 205, Dallas, TX 75231
Manufacturers of display terminals with digitized video pictures, featuring TV quality pictures. Sold as a complete terminal or software only (T-VIEW).
 Bob Gillman
 214/343-4500

VIDIWALL CORP., 30 Chapin Rd., Pinebrook, NJ 07058
Manufacturers of videowall processor, stackable projection cubes, and monitors, and a complete line of peripheral control products and software.
 Michael Serwe, Mktg. Dir.
 201/882-0584, fax: 201/882-0656

VIEWTEK, INC., 150 Executive Dr., Edgewood, NY 11717
Manufacturers of analog controller and interface cards for flat-panel LCDs. Complete line of flat-panel LCD monitors designed for industrial applications. Monitors are available in a range of diagonal sizes from 6.4 to 13.8 in.
 Don Buckout, Dir. Sis.
 516/243-6500, fax: 516/243-3308

VILLA PRECISION, INC., 3027 W. Indian School Rd., Phoenix, AZ 85017-4186
Manufacturers of fully automatic precision glass scribes and semi-automatic breaking equipment.
 Thomas Muir, Pres.
 602/266-2366, fax: 602/266-2926

VIQX CORP., 6701 Sixth Ave. South, Seattle, WA 98108
Manufacturers of electronic glass frits, powders, and preforms. Custom glass development of high-quality electronic glass materials from laboratory samples through large volume production. Offering economical melting with platinum crucibles.
 Tom Burnett, V.P. Mktg. & Engrg.
 206/763-2170, fax: 206/763-2577

VIRATEC THIN FILMS, INC., 2150 Airport Dr., Faribault, MN 55021
Manufacturers of high-performance sputter-deposited optical thin-film coatings for electronic visual displays. Patented multilayer coatings are designed to reduce glare and reflection, improve light transmission and contrast, and provide static dissipation and electromagnetic shielding. Applications include directly coated CRTs (Optium 2020™), anti-glare filters, LCD projection panels, industrial instrumentation displays, automotive dashboard displays, and navigational (electronic maps) displays.
 Bruce Kuhlman, Dir. Sis./Mktg.
 507/334-0051, fax: 507/334-0059

VIRTUAL VISION, INC., 7659 N.E. 178th Pl., Redmond, WA 98052
Developers/marketers of monocular, monochromatic 640 x 480 VGA digital head-mounted display systems that integrate either a 1-in.-diagonal AMLCD or an AMEL display for medical, manufac-

turing, military, and other highly customized professional applications.
 Sandra D'Adam, Mktg. Assoc.
 206/882-7878, fax: 206/882-7373

VISONICS LABS, 8401 E. Desert Steppes Dr., Tucson, AZ 85710
Manufacturers of 3-D oscillographic displays in real time; multiple viewers each see a unique view without glasses; autostereoscopic, autopalactic displays.
 Homer Tilton, Pres.
 520/885-5840, fax: 520/885-2922

VISPRO CORP., P.O. Box 6239, Beaverton, OR 97007-0239
Manufacturers of structural ceramic products typically used as envelopes for CRTs. Multilayer ceramic packages include LTCC, HTCC, and MCMs.
 Steven E. Annas, Pres.
 503/526-5268, fax: 503/644-9652

VISTA CONTROLS CORP., 27825 Fremont Ct., Santa Clarita, CA 91355
Manufacturers of helmet-mounted displays providing unrestrained inertial-sensed head-position and high-resolution stereoscopic video using active-matrix VGA FPDs. The family of products include the Vista Vision, See-Thru-Armor™, and the Wireless Stereo Vision System.
 Edie Hathaway, Sis./Mktg. Asst.
 805/257-4430, fax: 805/257-4782

VISUAL INFORMATION TECHNOLOGIES, INC., 3460 Lotus Dr., Plano, TX 75075
Designers and manufacturers of a second-generation image computer, targeted for high-end imaging functionality, that introduces supercomputer performance on a single-board architecture. The VITEC-50 Image Computer™ delivers more than 300 MOPS to incorporate image-based information.
 Karen Rodgers
 214/596-5600, 1-800-325-6467
 fax: 214/867-4489

VISUS LTD., 2A Katzir St., Tel-Hashomer, Ramat-Gan, 52656 Israel
Design, simulation, and production of backlights. CAD for optical/lighting systems design including simulation of light behavior, total internal reflection, and more. Design of low-profile planar light sources. Reflector design, and human factors and applications.
 J. Lorch, Dir. Mktg.
 +972-3-535-0968, fax: +972-3-534-1650

VIVID SEMICONDUCTOR, INC., 7400 W. Detroit St., #100, Chandler, AZ 85226
Designers of a patented extended voltage-range architecture that allows for the fabrication of enhanced-performance FPDs with 24-bit color and full-motion video. Direct-drive LCD panels with superior image quality and lowest power consumption compared to other solutions. Driver products optimized for CRT replacement, MLS/AA STN, and low-power notebook TFTs. Available for a range of panel resolutions up to SXGA.
 Dan Clarke, V.P. Mktg./Sls.
 602/961-3200, fax: 602/961-1135

VIVITEK CO., LTD., 27 Industrial East 9th Rd., 1st Fl., Science-Based Industrial Park, Hsinchu, Taiwan, R.O.C.
Manufacturers of field-sequential full-color LCDs. Sizes range from 1-, 5-, 7-, and 9-in. monitors for industrial and commercial applications. ASIC IC and video boards for conversion from computer (VGA) or video (NTSC/PAL) signals to field-sequential format.
 Henry Chern, Gen. Mgr.
 +886-3-5779-436, fax: +886-3-5779-449

VIVITEK CO., LTD./DELTA PRODUCTS CORP., 4905 S.W. Griffith Dr., Ste. 203, Beaverton, OR 97005
Manufacturers of a wide range of unique high-resolution small-size color displays, ranging from 1 to 10 in., using liquid-crystal color shutter (LCCs) technology. Also, large-area (21 in.) virtual-image displays and liquid-crystal shutter-based 3-D stereoscopic displays.

Sat Narayanan, Mktg. Mgr.
 503/641-6246, 1-800-959-3660
 fax: 503/641-7269

VL ELECTRONICS, INC., 3250 Wilshire Blvd., Ste. 1901, Los Angeles, CA 90010-1502
Manufacturers of custom and standard LCDs; custom and standard graphic, dot-matrix LCD modules; TN, STN, film-compensated b/w STN, b/w double STN, color-coded STN, guest-host, Heilmair, extended-temperature STN displays; touch-sensitive screens; turnkey complete product development and manufacturing.
 Christopher Kreslake, Oper. Mgr.
 213/738-8700, fax: 213/738-5340

VOICE CONNEXION, 17835 Skypark Cir., Ste. C, Irvine, CA 92714
Manufacturers of voice recognition and synthesis products for PCs. Also, handheld computers with voice I/O, keypad, and barcode.
 Shirley Dworak, V.P. Sls.
 714/261-2366, fax: 714/261-8563

VOLTARC TECHNOLOGIES, INC., 186 Lincoln Ave., P.O. Box 688, Fairfield, CT 06430
Manufacturers of custom-designed hot and cold-cathode fluorescent lamps for use in backlighting of liquid-crystal displays, and aperture lamps for use in scanning and inspection.
 Ellen Debs, Sis. Engr.
 203/256-4163, 1-800-962-6366
 fax: 203/259-1194

VOLTCOR TECHNOLOGY CORP., 501 S.E. Columbia Shores Blvd., Ste. 300, Vancouver, WA 98661
Manufacturers of digitizer pen tablets and pen input subsystems. The patented, battery-free, eraser-pen technology works with a variety of display devices, including TFT color LCDs. The low-frequency rf signal is fully compliant with host radio-communication systems, and is integrated into many ruggedized and commercial pen computers.
 Steve Sechrist, Technology Mktg. Mgr.
 360/750-8882, 1-800-922-6613
 fax: 360/750-8924

WACOM CO., LTD., 4-1-12 Ikebukuro, Toshima, Tokyo 171 Japan
Manufacturers of LCD integrated digitizers with a cordless stylus; LCD integrated data terminal with handwriting recognition.
 Masahiko Yamada, Dir. Intl. Div.
 +81-33-985-0097, fax: +81-33-985-8636

WAMCO, INC., 11555 A Coley River Circle, Ft. Valley, GA 92708
Developer and manufacturer of optical filters for all display applications. Filters optimized for contrast enhancement, color correction, and NVIS compatibility. Producer of customized NVIS diffuser/filter for AMLCD backlighting. On-site optical and environmental test capabilities. Exclusive U.S. distributor of Oshino sub-miniature incandescent lamps.
 Harry Reichardt, Sis. Engr.
 714/545-5560, 1-800-225-4810
 fax: 714/545-6093

industry directory

WANDE, INC., 4088 Lindberg Dr., Dallas, TX 75244

Manufacturers of a complete line of automated equipment for LCD production. The integrated system includes glass scribing/breaking/polishing, glass cleaning, imaging, developing/etching/stripping, printing/coating, buffing, spacer application, liquid-crystal filling, ITO sputtering subsystems, etc.

David Chen, V.P. Mktg./Bus. Dev.
972/701-8886, fax: 972/701-8885

WATKINS-JOHNSON COMPANY, Semiconductor Equipment Group, 440 Kings Village Rd., Scotts Valley, CA 95066

Manufacturers of high-throughput continuous process APCVD reactors for thin-film deposition in flat-panel-display array fabrication. The WJ 16CVD system provides high-quality deposition of SiO₂ dielectric films for large-size AMLCD substrates and most advanced TFT devices. High utilization capability and high throughput provide for extremely low total cost of ownership.

Linda Johnson, Sls./Mktg.
408/439-6265, fax: 408/438-6827

WELCH ALLYN, Lighting Products Div., 4619 Jordan Rd., Skaneateles Falls, NY 13153-0187

Manufacturers of miniature metal-halide arc lamps with arc gaps of 1-2 mm. Lamps are ideal for compact LCD projectors.

Jim Kiesa, Sls. Mgr.
315/685-4347, fax: 315/685-2854

WELLS-GARDNER ELECTRONICS CORP., 2701 N. Kildare Ave., Chicago, IL 60639

Manufacturers of monochrome and color CRT displays. Products range from CGA through SVGA. Custom and standard products are available. Video-related contract assembly also available.

Lawrence J. Brady, V.P., Sls. Mgr.
312/292-5640, fax: 312/252-8072

THE WESTAIM CORP., 10101 114th St., Ft. Saskatchewan, Alberta T8L 3W4, Canada

Manufacturers of thick dielectric electroluminescent (TDEL) displays and light sources, including 120-mm-diagonal monochrome and multicolor quarter-VGA panels, and high-brightness 90-mm-character-height numeric and alphanumeric displays. Super-bright fixed-format light sources are also available.

Don Carkner, Appl. Engr.
403/992-5320, fax: 403/992-5325

Westar Corp., 11520 St. Charles Rock Rd., Suite 208, St. Louis, MO 63044

Designers/manufacturers of AMLCD interface, test, and evaluation products. Systems are turnkey or customized, including drive electronics and video conversion and processing. Products include cell drivers, motion base systems, and functional testers.

Michael T. Madden, Prog. Mgr.
314/298-8748 x286, fax: 314/298-8067

WESTERN DIGITAL, 800 E. Middlefield Rd., Mountain View, CA 94043

Manufacturers of high-performance graphics display controllers and sub-systems for PC platforms for CAD/CAM, engineering, and desktop applications.

Charles H. Haggerty, CEO
415/960-3353, 1-800-433-5780
fax: 415/747-1398

WESTLAND ELECTRONICS LTD., P.O. Box 214, Old Chatham, NY 12136-0084

Consulting services for electronic information displays. Technology and marketing studies and reports on computer graphics, presentation systems, and flat-panel displays. Conferences and seminars on information displays. Patent reviews.

Sol Sherr, Pres.
518/794-8151

WHITTAKER ELECTRONIC SYSTEMS, 1785 Voyager Ave., Simi Valley, CA 93063

Manufacturers of MIL-SPEC high-resolution color and monochrome monitors for domestic and international naval applications that pass MIL-S-901C Grade B shock. Also provide plasma programmable entry panels for airborne applications.

Stephen C. Jones, Mgr. Product Dev.
805/584-8200, fax: 805/527-8332

WICO, 6400 W. Gross Point Rd., Niles, IL 60648

Manufacturers of analog and digital joystick controls for video arcade games and home computer entertainment systems.

Dave Ruber, Sls. Mgr.
1-800-323-4258, fax: 312/647-8526

JAMES WILSON, 1640 5th Street, Ste. 224, Santa Monica, CA 90401

Manufacturers of illuminated panels and keyboards.

Trevor Bray, Sales Mgr.
310/576-0783, fax: 310/393-6040

WINSOR CORP., Ceramic Lighting Div., 410 S. 96th St., #7, Seattle, WA 98108

Manufacturers of high-performance backlights for LCDs. These are typically flat monolithic fluorescent lamps using hot-cathode technology to achieve high output and high luminous efficacy.

John Pace, Mgr. Sls. Engrg.
206/767-4070, fax: 206/767-3747

WINTRON, INC., 250 Runville Rd., Bellefonte, PA 16823

Designers/manufacturers of custom deflection yokes, high-voltage power supplies, flybacks, transformers, width coils, linearity coils, degaussing coils, and specialty/custom coils. Engineering services also available. Both commercial and military products available.

Melissa Hein, Dir. Mktg.
814/355-1521, fax: 814/355-1524

J. A. WOOLLAM CO., INC., 650 J Street, Ste. 39, Lincoln, NE 68508

Providers of non-contact measurement of thin films (thickness and optical constants) used in the production of flat-panel displays. Manufacturers of a line of spectroscopic ellipsometers for use in R&D and QC of flat-panel thin-film processes.

Gerry Cooney, Engr.
402/477-7501, fax: 402/477-8214

WORLD PRODUCTS, INC., 19654 8th St. East, Sonoma, CA 95476

Distributors of NEC EL lamps and inverters; NEC ac plasma displays; STC/Displaytech custom LCDs; Goldstar LTD LCDs

Bruce Francisco, Sls.
707/996-5201, fax: 707/996-3380

WPI ELECTRONICS, INC., 40 Depot St., Warner, NH 03218

Manufacturer of electronic ballasts for metal-halide, halogen, and xenon projection systems. Standard, custom, and semi-

custom ballasts designed to worldwide standards requirements, with features such as hot restrike, remote ignitor, dimming, and auto line select

Steven B. Seivitch, V.P. Sls. & Mktg.
603/456-7111, fax: 603/456-2498

WYLE ELECTRONICS, 15370 Barranca Parkway, Irvine, CA 92618

Distributors of flat-panel displays by Sharp Electronics. Products include AMLCDs, passive color and monochrome displays, character displays, and EL displays. Integrates displays in ISO 9002 facility.

714/788-3720, 1-800-283-9953
fax: 714/789-1461

XANTEK, INC., A Taiyo Yuden Co., 1770 La Costa Meadows Dr., San Marcos, CA 92069

Manufacturers of low-profile dc to ac inverters are designed to drive CCFTs for LCDs. In addition, a line of super-compact dc/dc converters.

Scott Sato, Bus. Mgr.
619/471-4001, 1-800-493-6835
fax: 619/471-4021

XENITEK, INC., 1770 La Costa Meadows Dr., San Marcos, CA 92069

Manufacturers of low-profile dc/ac inverters designed for driving CCFLs. Offering a line of super compact dc/dc converters for use with LCDs.

Scott Sato, Bus. Mgr.
760/471-4001, 1-800-443-6835
fax: 760/471-4021

XEROX COLOR GRAPHICS, 5853 Rue Ferrar, Bldg. A, MS 3-12, San Jose, CA 95138

Manufacturers of engineering copiers, printers, Versatec plotters, and supplies for document management.

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Suggestions for new categories of products and services relevant to the display industry, or further subdivisions or clarification of existing categories, are welcomed.

• If your organization is not included in this year's directory and would like to be listed in next year's directory, the Twelfth Annual Directory, please write to Jay Morreale, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014; 212/620-3371, fax 212/620-3379.

Company divisions can be listed separately if they are at different locations with different product lines - please submit a separate application form for each division.

Application forms for the Twelfth Annual Directory of the Display Industry will be mailed with the February 1998 issue. ■

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TORONTO, CANADA
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 - Hard Copy & Storage, Input Systems
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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.

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17th International Display Research Conference
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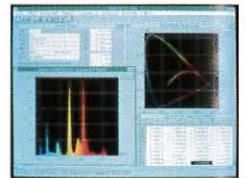
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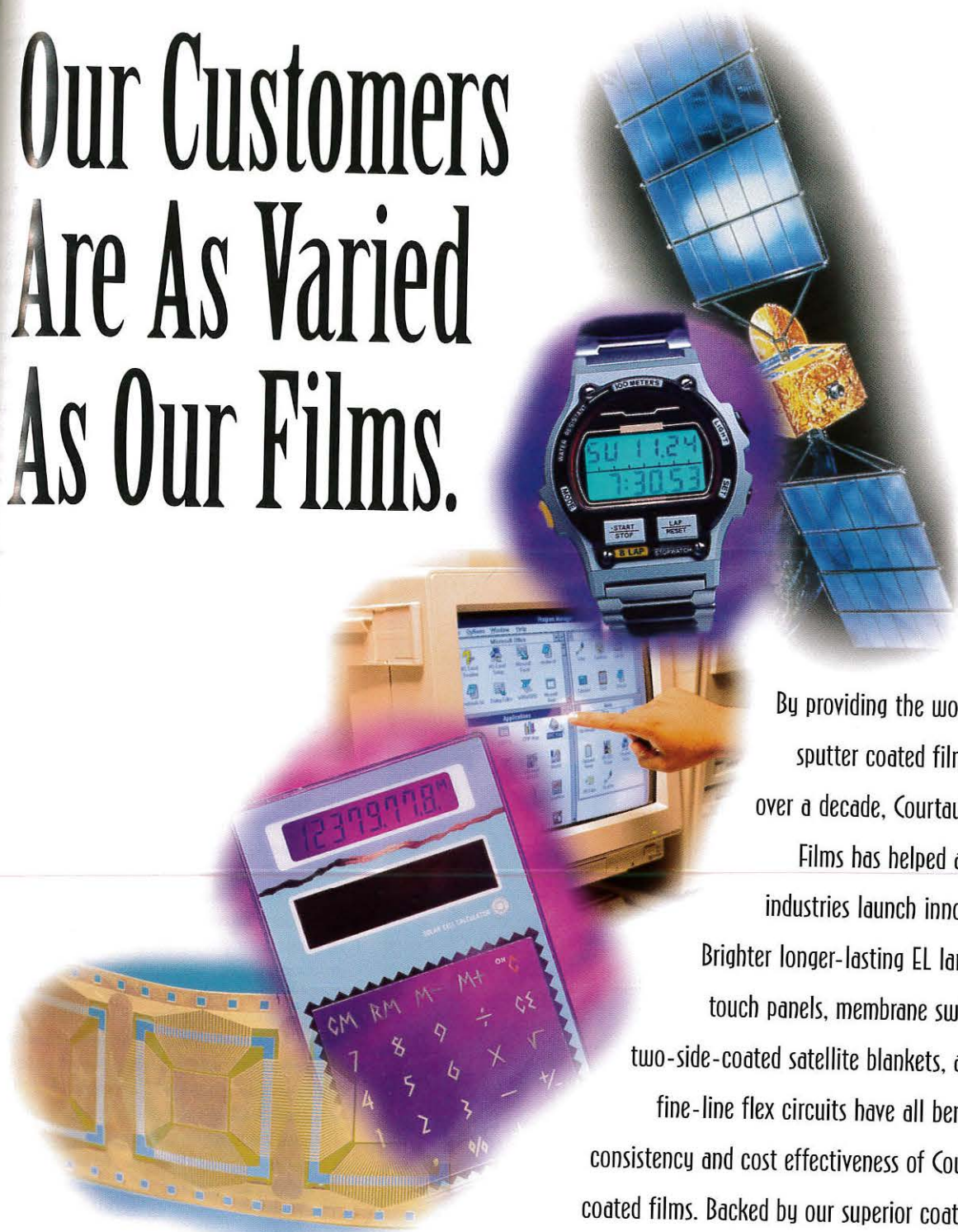


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display continuum

continued from page 4

by-side screens for simultaneous competition, the feeling of motion and depth is quite convincing because of the wide periphery-encompassing view.

So, can we honestly say that the Virtual Reality Chair happened on almost the day I predicted? Well, it kind of did and kind of didn't. The GameWorks version sure looks

like one, moves like one, and sounds like one, *but* they're not really a consumer product for the home. And most important, what happened to the 3-D display?

The consumer-product part we should and could have anticipated. New technological concepts often find their first introductions in commercial applications, and then, when production volumes grow enough to drive prices down, home sales develop. A good display-related example of this is projection television. It developed its initial successful market for group viewing in sports lounges and only later appeared as a lower-priced product for home use.

But 3-D? When are we going to see really good 3-D? Doesn't the very concept of virtual reality demand that we have realistic 3-D images into which we can immerse ourselves?

Not ever having seen a compelling demonstration of 3-D, I decided to do a bit of exploring on my own. What would it take to create a 3-D image that is as good as my eyeballs? I decided that the first step would be to get two images with resolution better than my eyeballs and then to keep these images free from visible blemishes. So out came the 6 x 7-cm format camera, and, with careful alignment on a sunny and calm day, I photographed positive-transparency stereo-image pairs of scenes around our house and neighborhood. These larger transparency photographs did indeed produce images that were as perfect as my eye could discern. All the color, tonal depth, and dimensionality were there - *but the scenes didn't look real*. They looked like I had photographed accurately rendered models of our house and neighborhood. So much for this try at virtual reality!

But what had gone wrong? There were certainly more pixels than my eye knew what to do with. The stereo separation was just right. There was no "noise" in the information content of the picture. But why the look of artificiality? Why didn't my images look or feel like the scenes I had photographed? It couldn't be the lack of motion, since I had taken the photos on a calm day and buildings and furniture don't move around much anyway. The stereo effect was accurate and every object was in sharp focus.

Subsequent observations and discussions with colleagues at Sarnoff and an over-dinner discussion with Rick Knox of Compaq have led me to the following conclusions: *Our perception of reality is not only made up by pro-*

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cessing the two images as seen by our corresponding eyeballs – or sometimes one eyeball as we move through a scene – but is also affected by our slightest head movements and changes in the focus plane as our eyes continuously scan a scene.

As I tried these experiments for myself using the familiar settings I had photographed, at first I couldn't believe how sensitive the human visual system is to such effects. I found that I could sit at my desk, look out at the house across the street, and detect changes in parallax several hundred feet away just by moving my head a *fraction* of an inch. How will we ever create an interactive virtual scene that can simulate this level of positional sensitivity on an instantaneous and interactive basis? And even if we could, that is only for a single viewer. Wow, I had no idea that adding 3-D to virtual reality would be this tough. No wonder the folks who created GameWorks decided on a nice easy-to-implement projection TV system.

We engineers love challenges and I must admit that I also like a bit of a stretch once in a while. Furthermore, I hate to ever admit that something can't be done – or at least that I haven't a clue as to how to do it. Nevertheless, when I combine the challenges of two high-resolution images (as a minimum, at the limit of eye resolution) with the need to dynamically and instantaneously change these images in response to a person's slightest head movement, along with the need to anticipate and accommodate where our eyes are focusing within a scene, I admit it: I haven't a clue as to how we can accomplish all that with an external imaging system. The only way I can even imagine making this work is perhaps by direct projection onto the retina or direct coupling into the optic nerve. At least we could then take advantage of the very small high-resolution and color-sensing imaging area within our eyes so as to limit the amount of information that needs to be processed to create the sense of reality.

Perhaps the direct coupling to an optic nerve sounds a little too drastic for now. But direct projection of high-quality images onto the retina may not be such a stretch. In fact, it's being done right now with a research instrument called a scanning ophthalmoscope. This may be the one application that encourages this technology to develop – as the only conceivable way to implement the virtual-reality dream.

In the meantime, what is to become of all the current attempts at 3-D imaging? I believe that today's virtual-reality "glasses" (in both stereo and mono versions) will find use in

specialty areas such as medical imaging, where a sensor-acquired and computer-processed image can be interactively superimposed on the actual patient during surgery, in



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display continuum

dangerous or remote environments where only a robot can be sent to act as the "eyes" for a human, or for creating 3-D models of new product concepts and trying out their function

and/or assembly sequences. There are so many of these interesting applications that it will be years before we approach maturity or saturation in exploring them. And sure, we

will have some games and other entertainment experiences that purport to be 3-D, such as the one I proposed in my December 1994 column, "The Tour Bus with a Thousand Eyes."

But realistic 3-D images for group viewing, where an audience can become immersed in a replicated scene? I believe this will only happen "A long, long time from now and in a galaxy far far away ..." In other words, not in my lifetime and not in yours.

Fortunately, we humans don't need all that much reality to experience deep emotions. We do quite well with the limited and unreal images of movies, live theater, operas, and even books. Our imaginations nicely fill in the missing pieces and maybe even protect us by keeping us from getting too involved.

The need to adjust our expectation for what is likely to be the reality part of virtual reality seems to be occurring already within the display community. The many efforts to produce small displays, which were initially intended for 3-D eyeglass products, have now mostly been redirected to other product opportunities such as cell phones and pagers with e-mail viewers. These small displays, which are going to be built right into the phone or pager, are demonstrating VGA-like resolutions and the ability to display full pages of text in sizes no greater than a couple of centimeters. The implementation can be either as a small handheld viewer or as an attachment to a lightweight eyeglass frame. It looks like we have managed to create yet another way to overwhelm ourselves with information as we move about. It just won't be the realistic, three-dimensional kind that might cause us to lose contact with our real reality.

It was great to have the opportunity to interact with many of you during the SID Symposium in Boston. Thanks for all the good words and constructive suggestions. To keep the information flowing, you can reach me by e-mail at silzars@ibm.net, by phone at 425/557-8850, by fax at 425/557-8983, or by the original virtual-delivery medium - the post office - at 22513 S.E. 47th Place, Issaquah, WA 98029. ■



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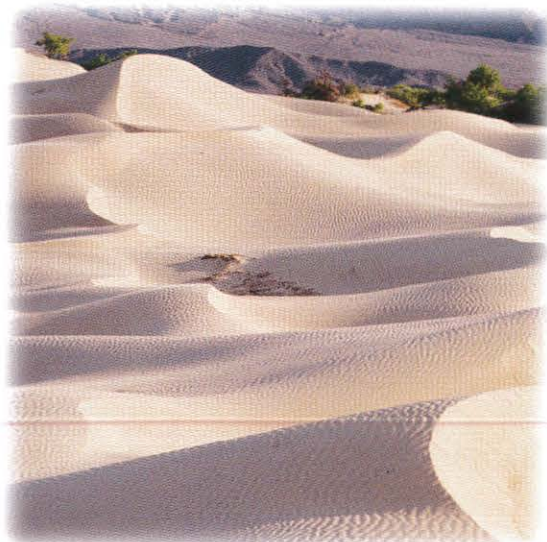
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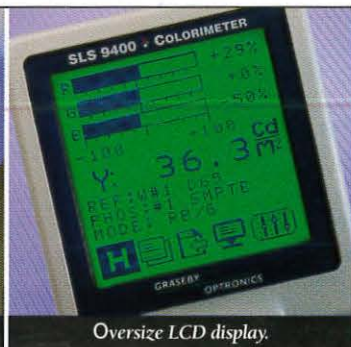
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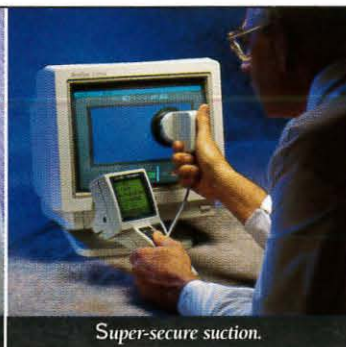
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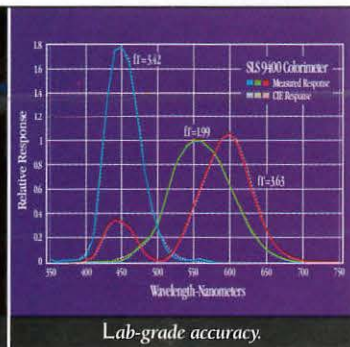
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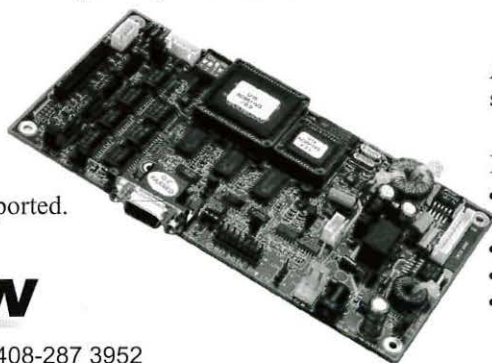
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Detroit Chapter to Sponsor FPD Strategic Forum and Technical Symposium

The Metropolitan Detroit Chapter of the Society for Information Display (SID) and the University of Michigan's Center for Display Technology and Manufacturing are sponsoring the Flat Panel Display Strategic Forum and Technical Symposium on September 22 and 23, 1997, at the Marriott Hotel in Ypsilanti, Michigan. The symposium incorporates the successful Vehicle Displays Conference, which was run as a separate event in 1995 and 1996.

This symposium features two days of sessions on topics of strategic importance to the global and U.S.-based display industry. On the first day, the important issue of next-generation display manufacture will be discussed by the current leaders of the flat-panel-display industry. Challenges in technology, manufacturing, markets, location, and timing will be considered. The U.S. role in displays, including the often overlooked areas of infrastructure and electronics, as well as panel manufacture, will be discussed by key U.S. players.

The second day will begin with a session on the important and growing vehicle displays market, including strategic perspectives by the major automobile makers. Two technical sessions will follow: the first on issues in civilian and military vehicle displays, the second on emerging new technologies. A poster session is also to be included in the program. As in last year's Vehicle Display Conference, an exhibit area is available to show items of interest to the display community.

To obtain more information about attending, contact Robert Donofrio, Display Device Consultants (DDC), Ann Arbor, Michigan; telephone 313/665-4266, fax 313/665-4211 or consult SID's Web site at <http://www.sid.org>.



SID Publications on the Web

Are you trying to remember where you saw that article on optics for helmet-mounted displays or on how you have to modify the modulation transfer function when it's applied to LCDs? Help is at hand.

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In fact, there is a wealth of information on SID's Web site at <http://www.sid.org>, including information on SID conferences, links to many display-oriented companies, and a wide variety of display information, activities of local SID chapters around the world, employment ads, and the contents of forthcoming issues of *Information Display*. SID's Web site is a great place to catch up on new developments, as well as to optimize the use of your SID hardcopy publications. ■

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97

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letters to the editor

Tom Holzel's guest editorial, "The Emperor and His Flat-Panel Displays," which appeared in our March issue, excited the most written and verbal response to an ID editorial in recent memory – and there may be some very interesting consequences. Here are four samples, and a general comment from the author.

– Ken Werner, Editor

To the Editor:

For years I have been looking at the optical response specifications for AMLCDs, saying to myself that those specs did not seem consistent with the speed demands of full video, and assuming that there was something basic I didn't know. I am grateful to Tom Holzel for letting me – and probably a great many other people – know that this is a real issue the industry needs to address.

– Robert L. Saxe
President
Research Frontiers, Inc.
Woodbury, NY

To the Editor:

Please never stay away from work again! Was your "jest" editorial intended for April First? Certainly, I fully understand the necessity of the disclaimer on page 2 of the March issue and am sure that you will be inundated by mail explaining (better than I can) the absurdities of the self-serving nonsense from your writer (who just happens to be from an FED company).

My affiliation is omitted here, not because I am in fear and trembling about my employer's reaction, but rather to emphasize that this is a personal response to the diatribe which you published.

– Frank V. Allan
Ossining, NY

P. S. Fish are quite unable to ambulate, somn- or otherwise!

To the Editor:

The theme of Tom Holzel's March editorial, "The Emperor and His Flat-Panel Displays," is that active-matrix LCDs, plasma displays, and micro-mirror arrays will never

replace CRT technology because they can not render movies that look good. He says the culprit is the eye and the poor understanding of its requirements by the manufacturers of these devices.

According to Holzel, the new displays do not produce the "dynamic contrast" – the speed by which a picture element can go from one brightness level to another – required for motion. The switching time for active-matrix devices using TN liquid-crystal technology is around 30 msec, STN devices require more than 100 msec, and the CRT phosphor rise and fall time is about 4 msec. Current STN devices are too slow to render motion, but can this be said of today's TN-based AMLCDs?

The details in an image are in the high spatial frequency components of the image's Fourier spectrum. We lose sensitivity to these

frequencies when images move. A display can slightly blur a moving image without the blur being noticed. Why did Holzel see the moving tiger lose its stripes? He believes the AMLCD was too slow. But the mechanisms of vision that see spatial details best are slow too. The mechanisms sensitive to motion are poor at detailed vision. This suggests that we should look for another cause to explain the vanishing stripes; unless, of course, the eye's insensitivity to detail in moving images is a sufficient explanation. A likely candidate is the image-processing system that processed the image data stream prior to its reconstruction on the display device.

Liquid-crystal materials take longer to switch when the change in the electric field is small. This sluggishness is most apparent at the transition from one grayscale level to

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letters

another close by in intensity. The small step problem is equally unlikely to be detected by human vision, since the fast temporal mechanisms of vision do not see detail at all well. The overall contrast range, on the other hand, is a significant contributor to image quality.

Plasma and micro-mirror displays are typically faster than conventional CRTs. Holzel notes a problem with moving images and fades on some of these devices. He is referring to the stair-stepping that occurs during motion in image regions with shallow intensity gradients. This could be due to the elevated sensitivity of the eye to low spatial frequencies when objects move. Or it could be due to the way the grayscale is created by pulse-width modulation. The latter possibility is more likely, and has been discussed extensively at technical conferences and in the literature.

The effect can be eliminated by dithering. Dithering moves the quantization noise to higher spatial frequencies where the eye is less sensitive. Dithered plasma and micro-mirror devices do not exhibit the stair-stepping artifact.

— Jim Larimer
NASA Ames Research Center
MS 262-3
Moffett Field, CA 94035-1000

Note: A more detailed version of this letter may be found at <http://www.ba-sid.org>.

To the Editor:

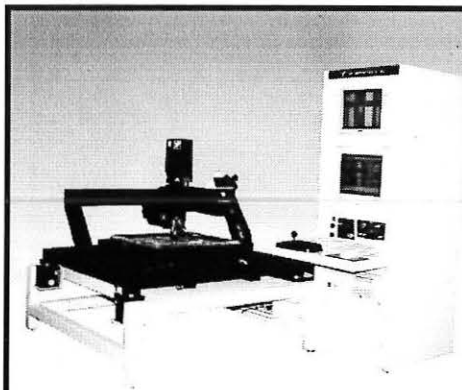
The situation with regard to comparing direct-view display technologies is even more complicated than Tom Holzel indicates, but

he is nonetheless raising a significant and often neglected issue.

I believe the Society for Information Display and the information display industry should confront this question, as well as many others, head on by establishing a direct-view display technology "shootout." This direct comparison of different technologies and different technology implementations could be modeled somewhat after the projection display shootout that has been a popular feature of the InfoComm show for years.

I have discussed this idea with Ken Werner, Editor of *Information Display*, and I understand that he and Phil Heyman, SID Convention Chairman, are seriously investigating the concept.

—Fred Kahn
Kahn International
Palo Alto, CA



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Mr. Holzel responds:

I am delighted that my remarks in the March issue of *Information Display* have stimulated so much lively discussion on what I believe is an important question for the display community. That question can be posed this way: Which 40-inch flat panel would make the best television display, and how do FPDs compare to the "venerable" CRT. Defenders of the True Faith (CRTs) claim that when showing moving scenes, AMLCDs are too slow and plasma panels too jerky. These anomalies will cause unconscious eyestrain. The Young Lions (flat-panel admirers) respond with counterclaims that any such minor faults are well known and can be solved merely by tweaking electronics. Who is right?

I propose a simple test to answer the question. But please note which question is being asked: Which *available* 40-inch TV display is preferred by average viewers watching average TV content over a period of two hours. (By average TV content, I mean a movie such as *Top Gun* or afternoon football - not CNN talking heads or the static visages of soap-opera divas sullenly glaring at each other.)

Thus, this TV test is *not* about testing one aspect of each type of TV display - say, motion artifacts or contrast ratio - and would *not* therefore "equalize" all other parameters.

Test procedure: Set up two 40-inch displays side-by-side at a proper distance from a single viewer seat. Adjust each TV for its own optimum picture quality. Tell the non-engineer viewers that you will be simultaneously showing them a film on both displays and afterwards asking a few questions about the number of times the heroine lisps (or any other camouflage question), the point being to distract the viewers from the technology and point them toward image content. A video camera records the eye direction of the viewer and records (picture-in-a-picture?) the scene the viewer is watching.

We could learn several things from this simple experiment:

- A. Do viewers begin with one screen and later switch to another screen?
- B. Do they oscillate back and forth at random or choose a screen and stick with it?
- C. Do they watch one screen for static images and switch to the other for motion?
- D. Does a screen position - being on the left or right - make a difference?

Such a macro-level test should answer the burning question most of us want answered without explaining why viewers selected one technology over another. This ambiguity will actually satisfy both sides. The winner will have the luxury of struggling to avoid saying "I told you so," while the losers will have sufficient fodder to conduct scores of human factors studies, after which the test can be run again with "new and improved" flat-panel displays. It could become an annual event. It would certainly improve the breed.

- Tom Holzel
V.P., Marketing and Sales
PixTech, Inc.
Santa Clara, CA

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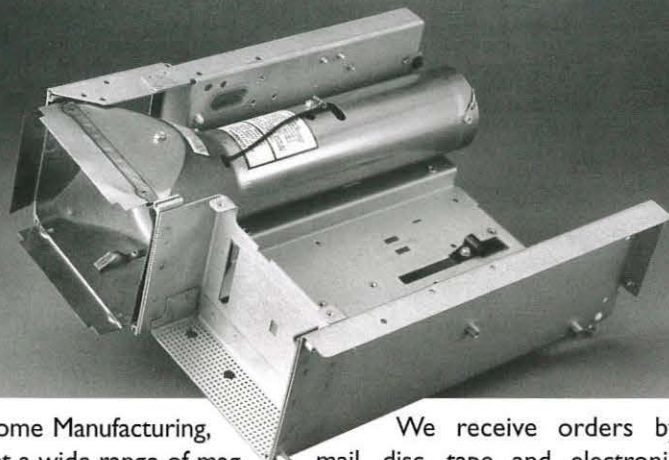
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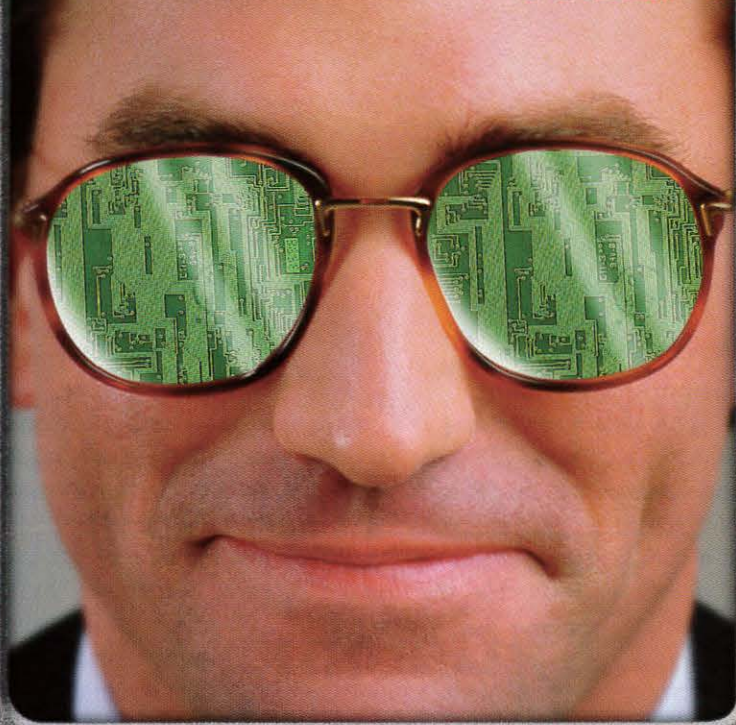
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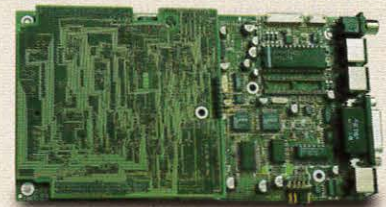


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1997 Flat-Panel Display Strategic Forum and Technical Symposium. Co-sponsored by the University of Michigan, Center for Display Technology and Manufacturing. Contact: R. Donofrio, Display Device Consultants, 6170 Plymouth Rd., Ann Arbor, MI 48105; 313/665-4266, fax -4211.
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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.
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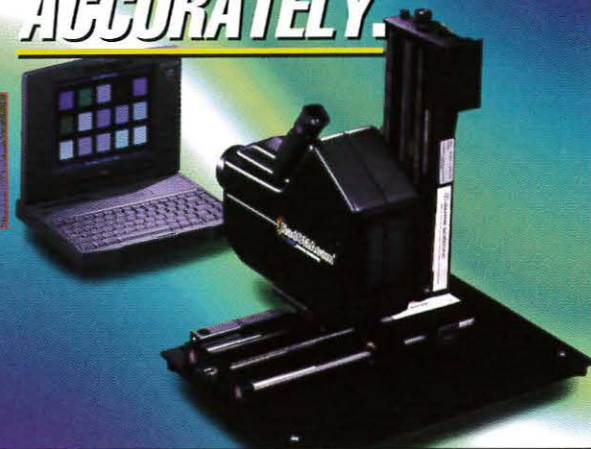
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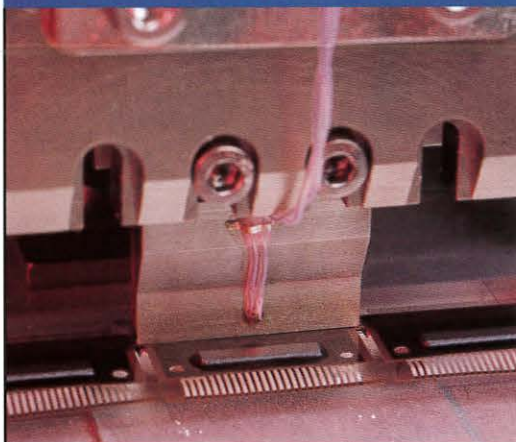
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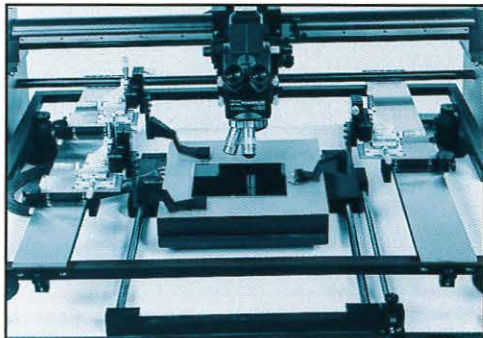
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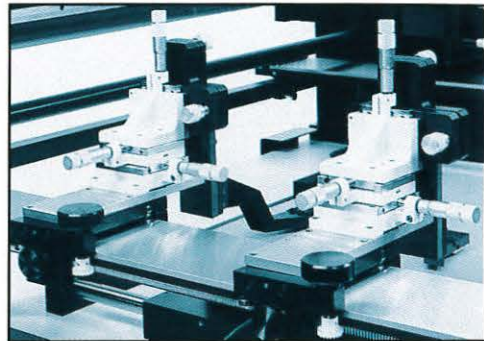
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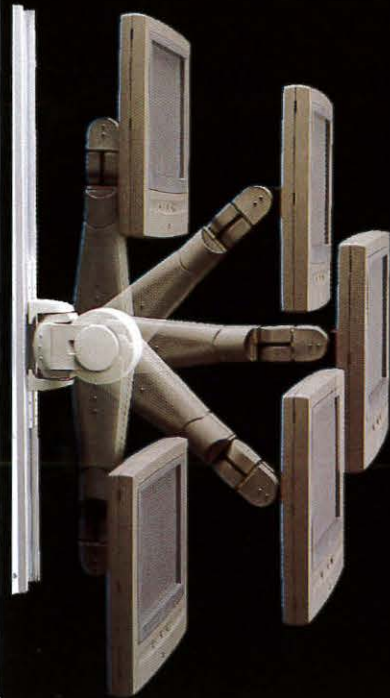
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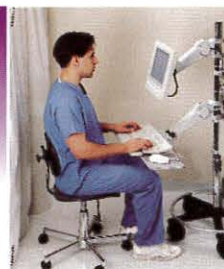
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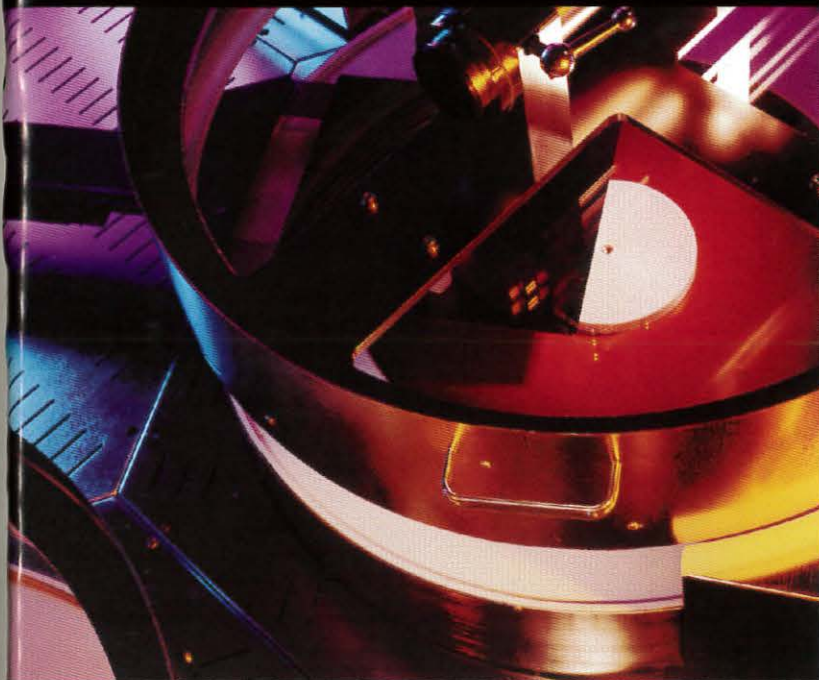
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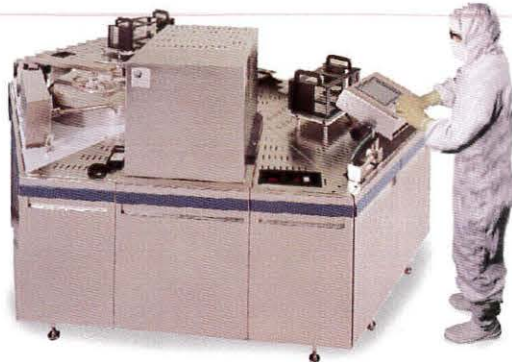
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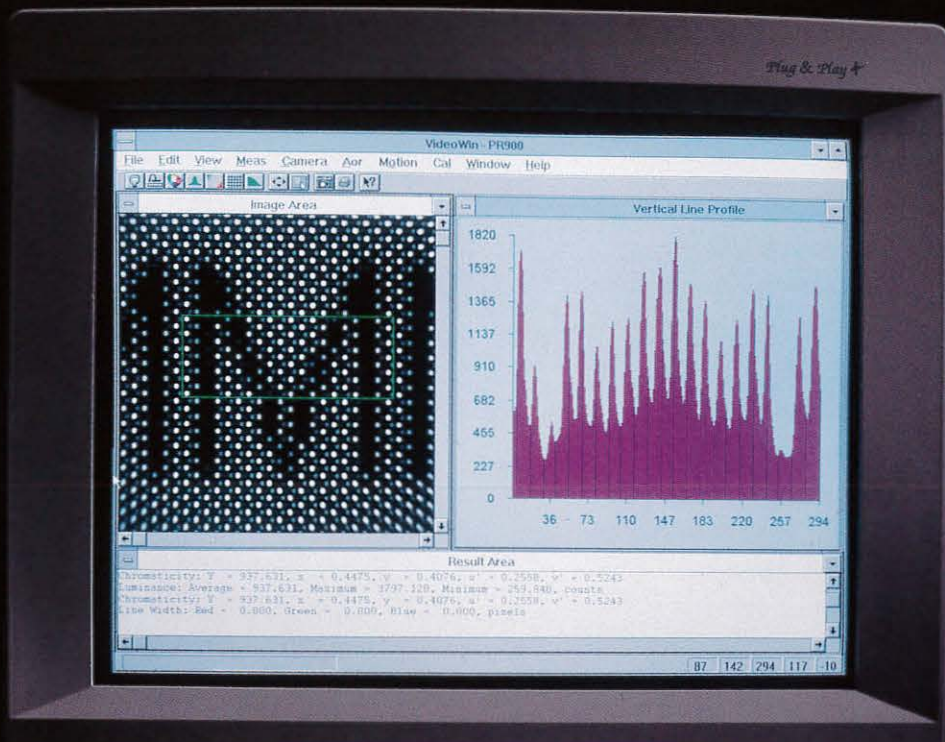
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Palisades Institute for Research
 Services, Inc.
 201 Varick Street, Suite 1006
 New York, NY 10014
 Jay Morreale, Managing Editor
 212/620-3371 Fax: 212/620-3379

Sales Office

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