

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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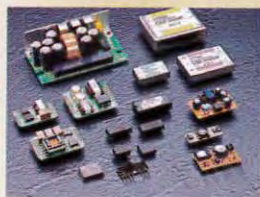
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AUGUST 1997
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COVER: One of the main attractions at CeBIT '97 was Panasonic's Panel PC CF55, scheduled for a September '97 launch. The compact housing contains a 14.5-in. 1024 x 768 (XGA) LCD monitor 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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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-

continued on page 86

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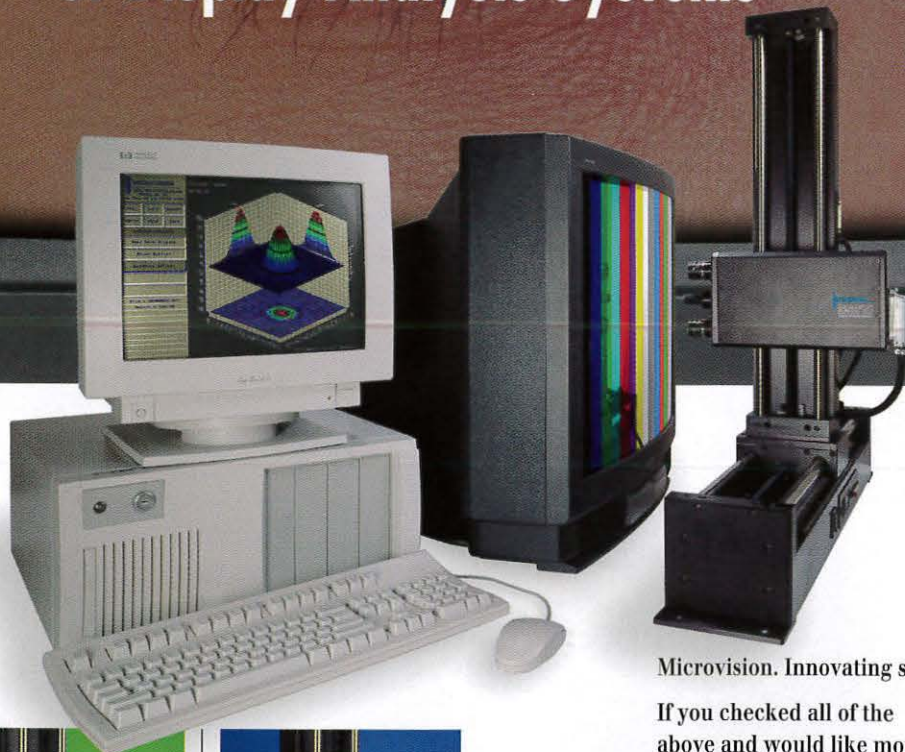
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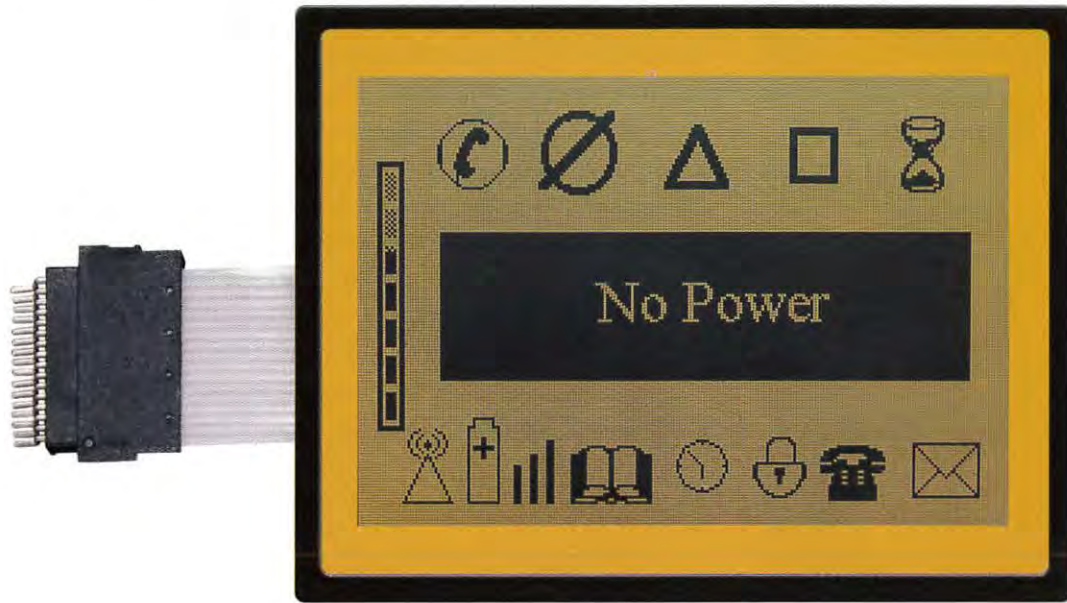
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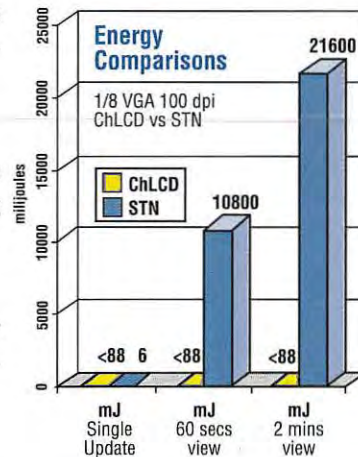
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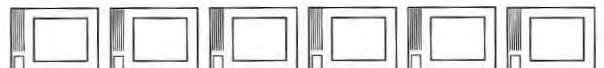
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Photocathode Displays

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-

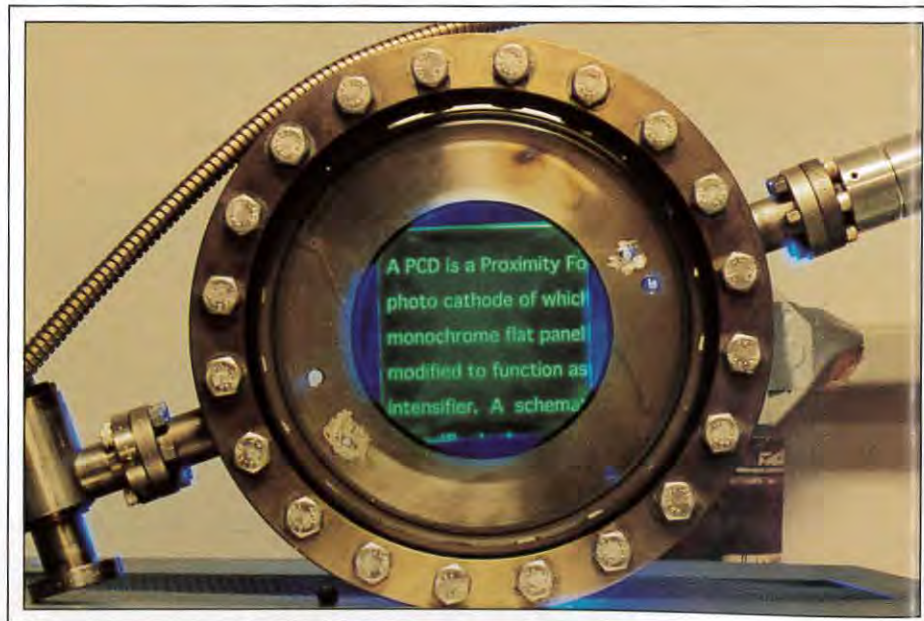


Fig. 1: Shown is a 3 × 3-in. photocathode display (PCD) prototype fabricated by New Logic International.

New Logic International

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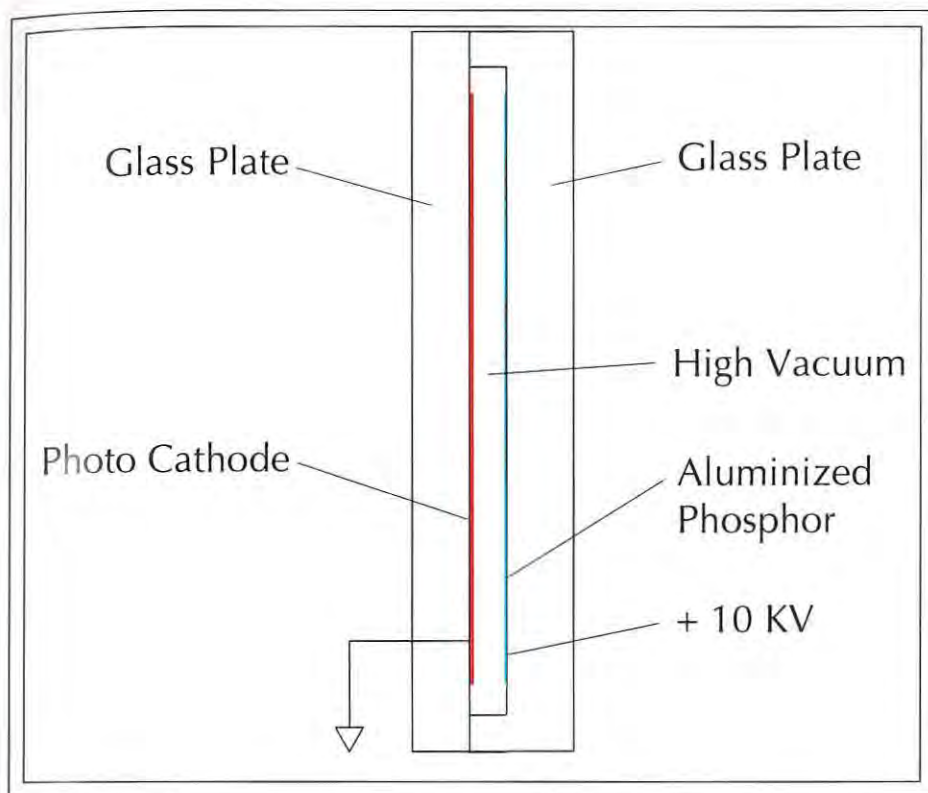


Fig. 2: A PCD is a proximity-focused diode intensifier, the photocathode of which is closely coupled to a monochrome flat-panel display.

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,

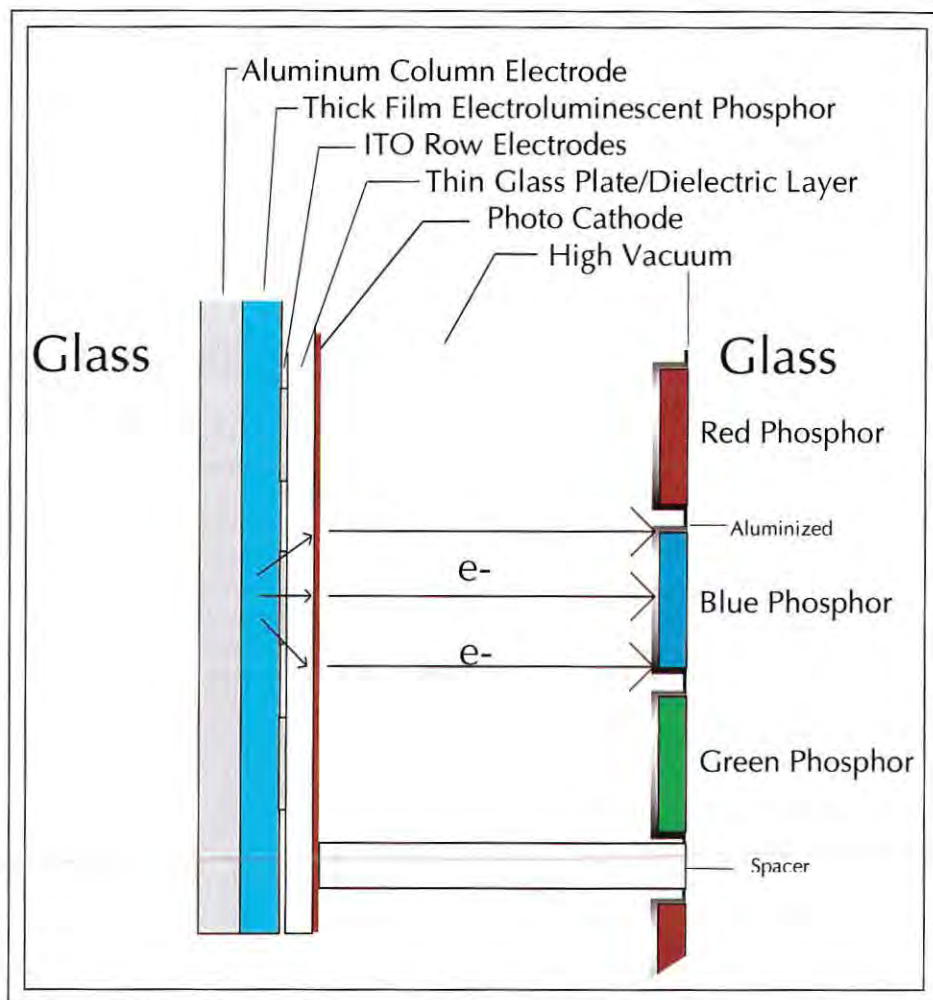


Fig. 3: One type of color PCD uses a monochrome ac powder EL image source that is closely coupled to the PCD's photocathode.

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-

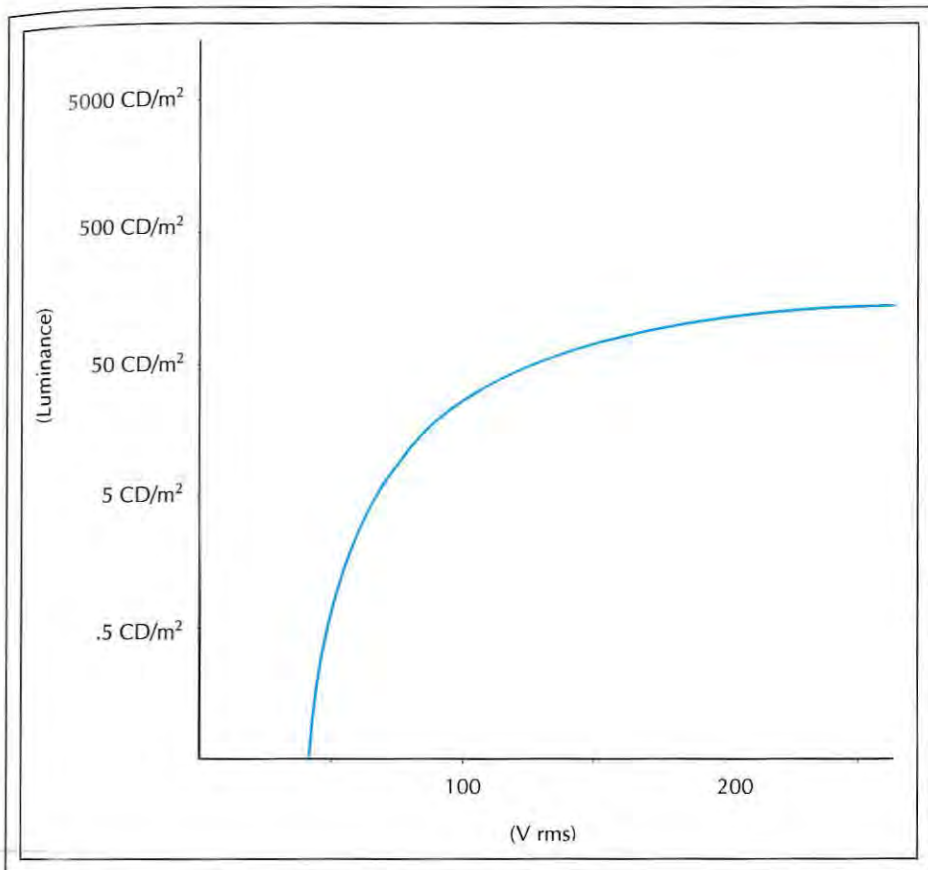


Fig. 4: Powder EL never achieved serious consideration for direct-view displays because the contrast ratio is very poor at high luminance due to insufficient output nonlinearity. This not a problem in PCDs because the powder EL display is operated in the low-luminance portion of its luminance-voltage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

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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

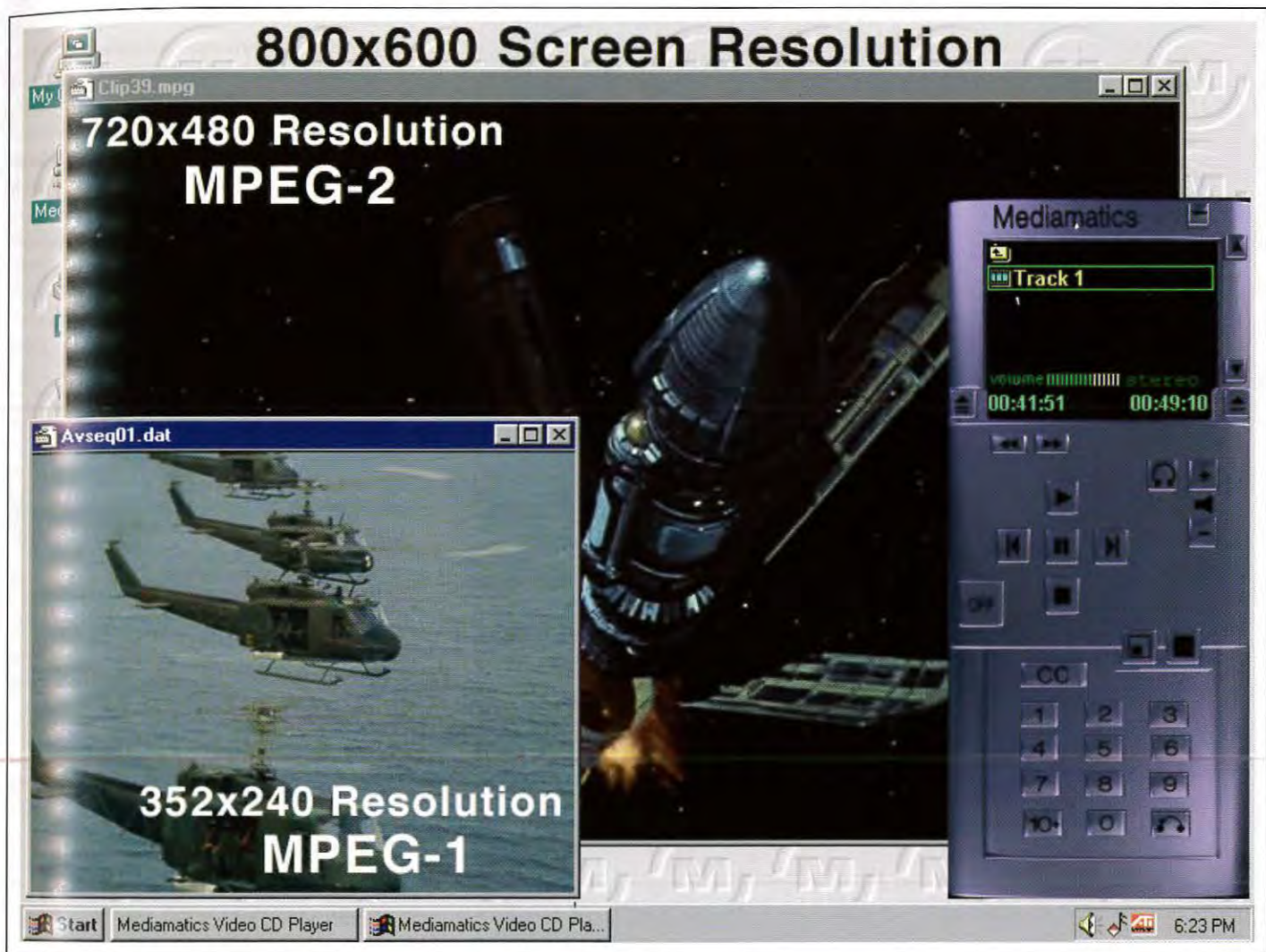
requires approximately 150 kbytes to store 1 second of MPEG-1 video and audio data.

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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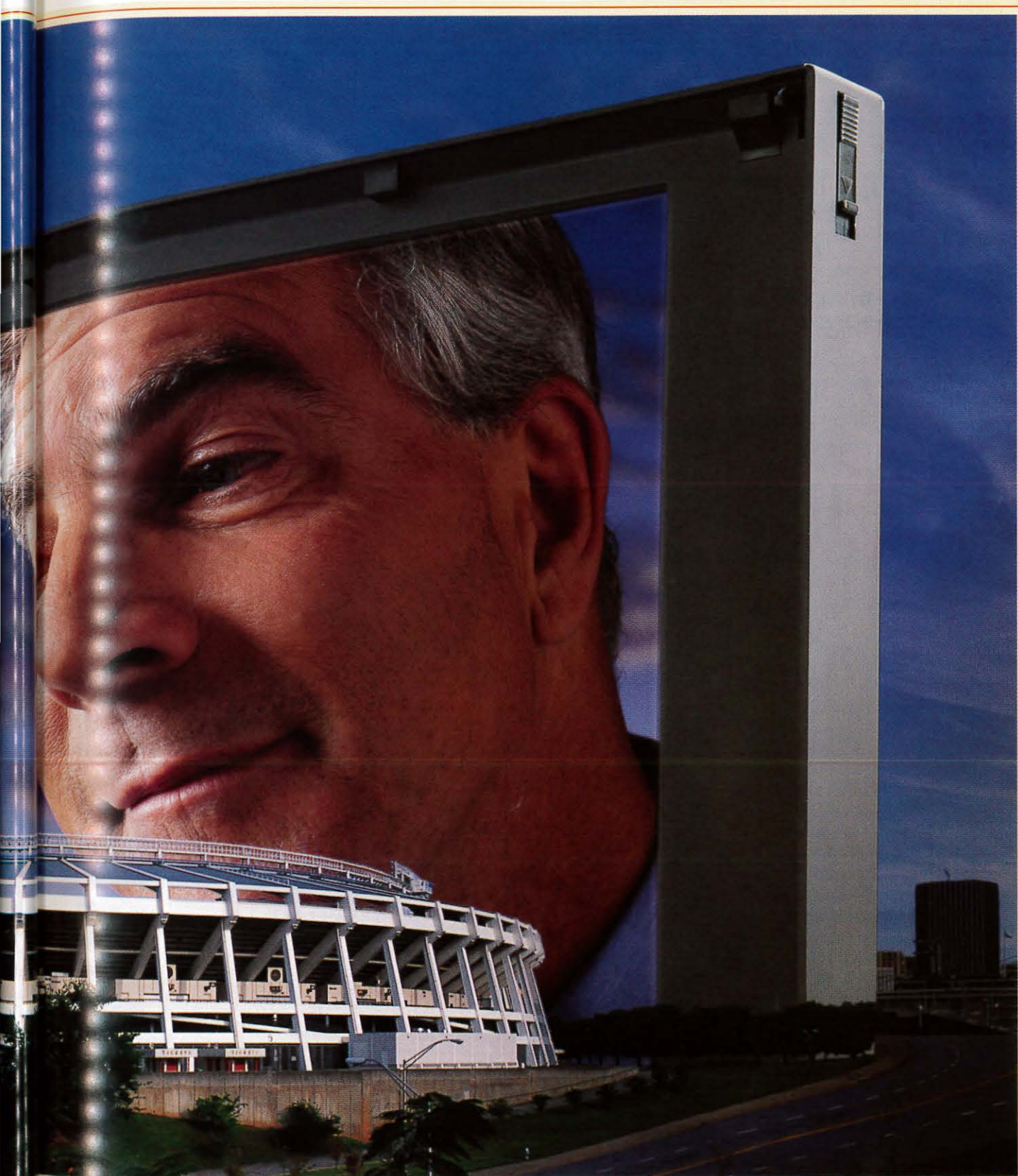
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And hey, with the desktop impending, can the coliseum really be far behind?

Onward and upward, guys.

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STILL A *Generation* AHEAD.

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

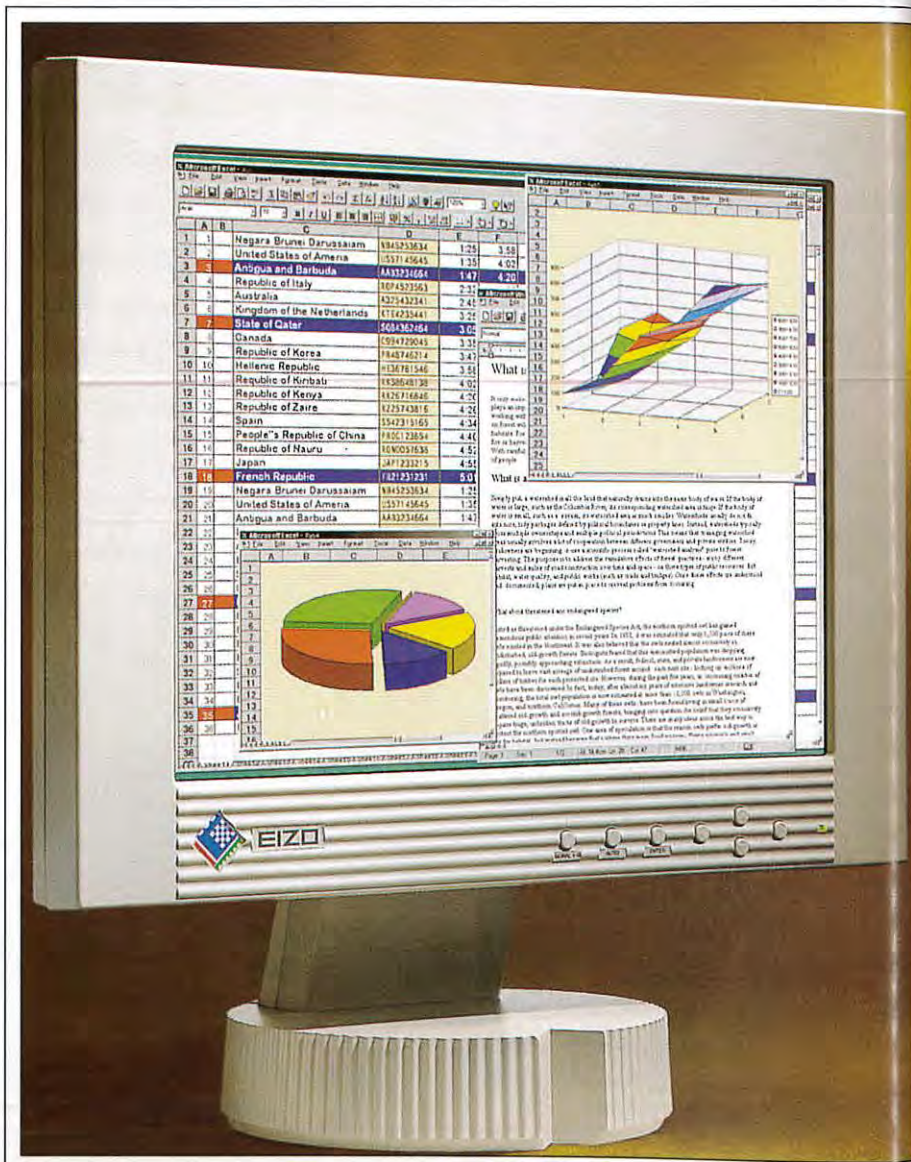
As the world's largest international IT trade fair, CeBIT is just too big to manage. How could it be otherwise? Nowhere else is so much information available in one week on one site.

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.

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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. ■

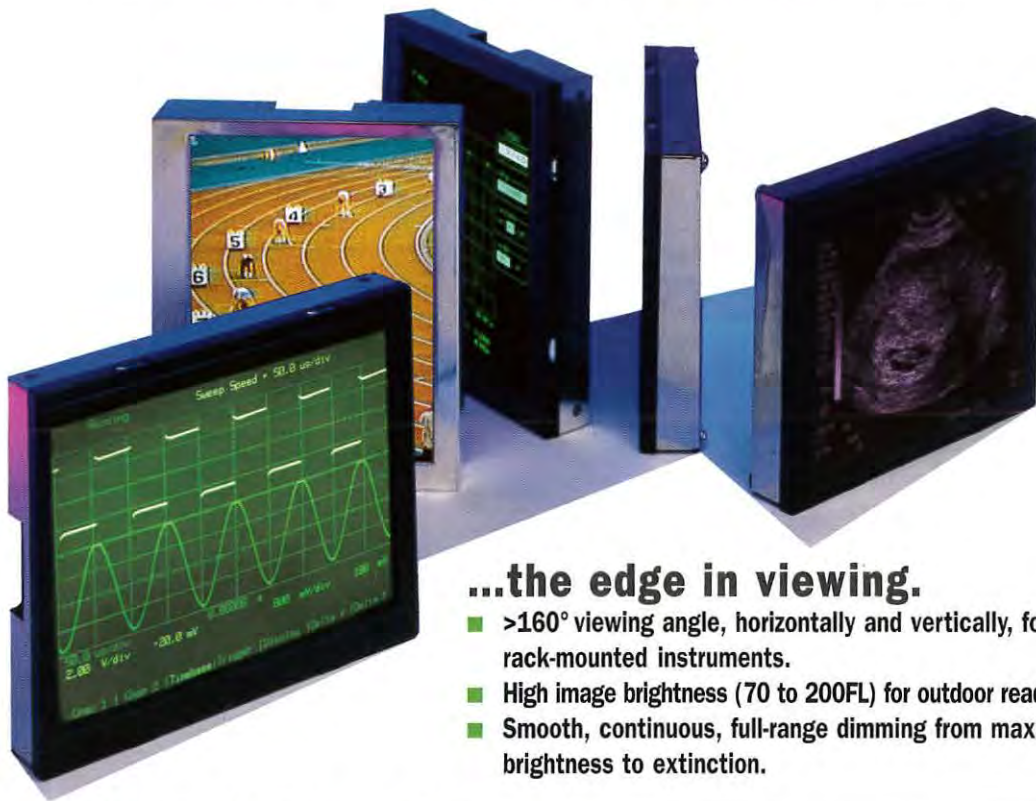


Sony

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 x 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



COLOR

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.

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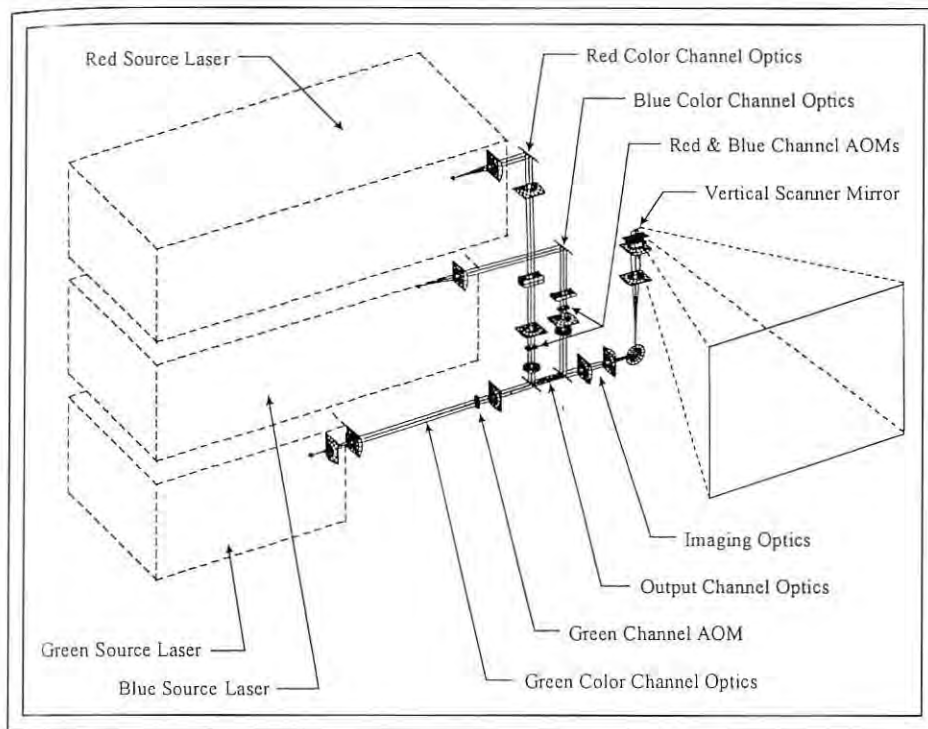


Fig. 2: In the laser projector developed by the Corporation for Laser Optics Research (COLOR) of Portsmouth, New Hampshire, a laser beam is formed into a thin, line-shaped beam that is modulated by a high-resolution AOM to contain one entire line of video information.

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

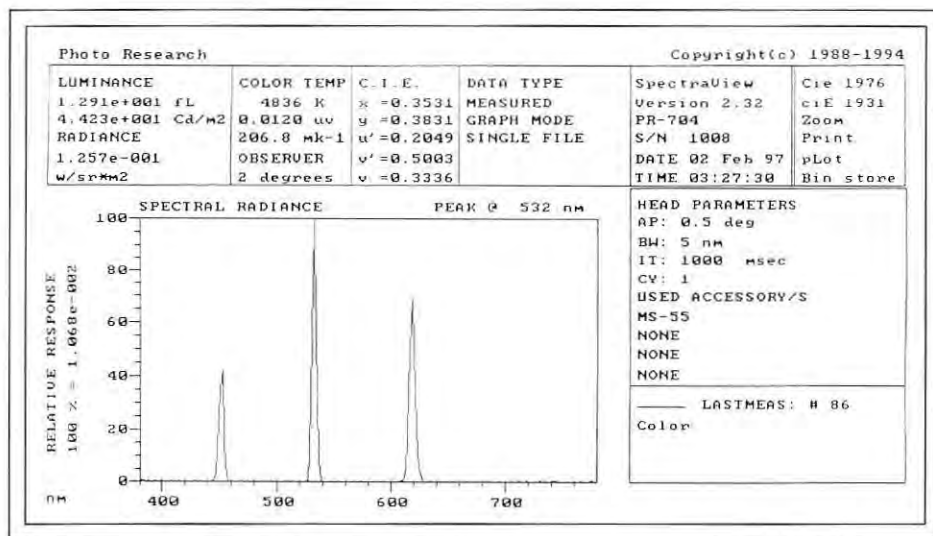


Fig. 3: "White" light from a laser projector is actually narrow-band red, green, and blue light that is mixed in the right proportions to be perceived as "white."

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 16.7-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 × 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 × 10-ft. screen should contain less than 0.03 m². We stopped the line-scanning function and measured the line at 0.78 × 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!

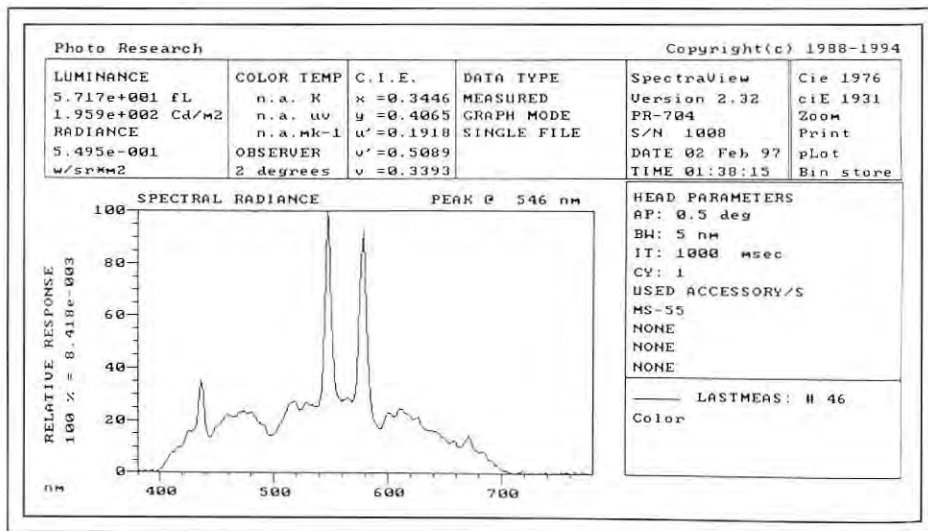


Fig. 4: The "white" light of an LCD projector has a complex spectrum that inherently limits the range (gamut) of colors that can be displayed and, in some cases, the purity of those colors.

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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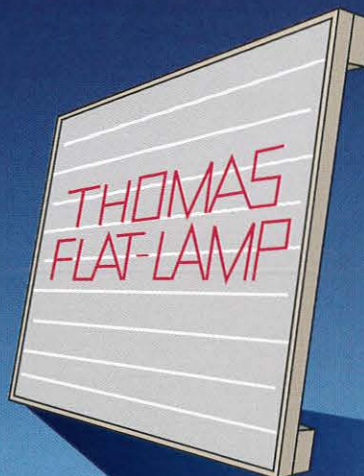
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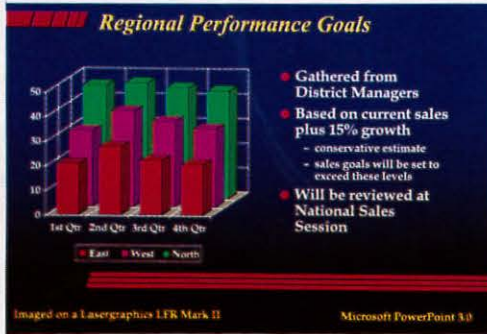
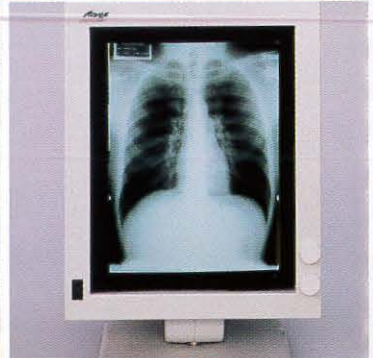
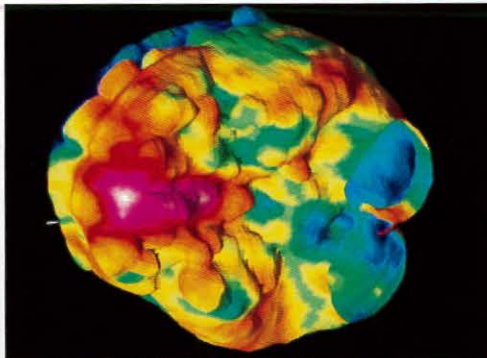
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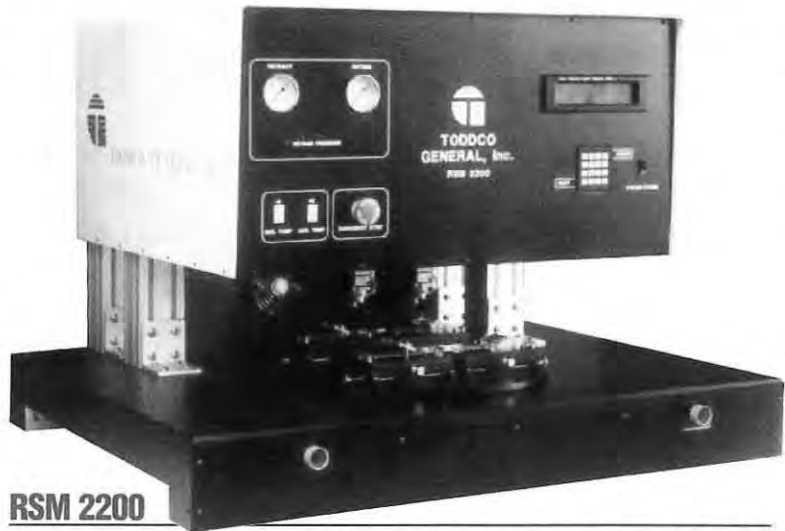
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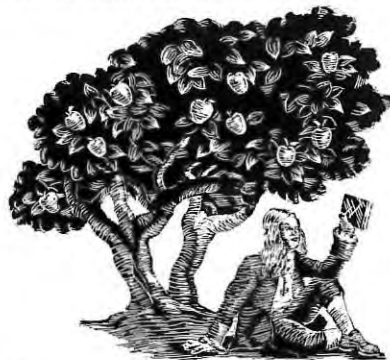
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Industry Directory

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**
□ UNIX □ Viratec

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□ Dolch Computer □ Dynamic Displays
□ CRL □ **CTX Opto** □ Diamond Tech One □ Dimension Technologies
□ Display Engrg. □ Display Systems
□ Earth Computer □ EG&G Optoelectronics □ Elform □ ELtech
□ Electro-Optics □ Eurecran □ Fiat Candle □ Fiat Panel Display □ Futaba America □ General Electric □ Ginsbury
□ H-P □ IEC □ **Image Quest**
□ Imaging & Sensing □ IST □ **Jaco Electronics** □ JKL Components □ Korry Electronics □ Lamination Technology
□ Lamplighter Industries □ Landmark Technology □ **LCD Lighting** □ Linfinity
□ Loctite □ LSI □ L-3 Communications
□ Lumitex □ Milgray Electronics
□ Modittec □ National Research Resources □ National Semiconductor
□ Pacific Technologies □ Performance Display Systems □ Precision Lamp

□ Racal Acoustics □ Racal-Mesi
□ Raytheon □ Regisbrook □ Reynolds Industries □ Rikel Corp. □ SAIG □ 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 □ Wedgelight
□ Winsor □ World Products □ Wyle Electronics □ XTEK

BALLASTS

□ WPI Electronics

BARCODE READERS

□ Electro-Optics □ **Minolta** □ Optical Electronics □ Panasonic Industrial
□ Pentax Technologies □ Percon
□ Spectra-Physics

CATHODE COMPONENTS

□ Eldor □ General Vacuum □ Incom
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□ Mushroom □ Philips Display Components □ SI Diamond □ UTI Corp.
□ VDC (Apex) □ VDC (Southwest Vacuum)

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□ 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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□ Raytheon

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

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industry directory

CRT DESIGN SERVICES

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 □ Electrohome □ Hughes Lexington
 □ 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
 □ Canadian Marconi □ Candescant
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 Electronics □ Citronix □ Craft Data, Inc.
 □ Data Ray □ Digitran □ Display
 Technologies □ Dotronix □ Dynamic
 Displays □ Eaton IDT □ EDL Displays
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 Electronics □ **Jaco Electronics**
 □ Keltron □ Kristel □ Lockheed Sanders
 □ L-3 Communications □ Mantron
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 □ Matsushita □ MicroTouch Systems
 □ Milgray Electronics □ **Mitsubishi
 Electronics America** □ Monitern □ MTL
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 □ Sony □ Sony Display Device Group
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 Palmer □ Symco □ Systems Research
 Labs □ Tatung □ Tektronix □ Thomson
 Components & Tubes □ Thomson-CSF
 □ Thomson Tubes Electroniques
 □ Toshiba America □ Totoku Electric
 □ 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.
 □ Dage-MTI □ Data Plus □ Data Ray
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 Displays □ EDL Displays □ Electrohome
 □ Electronic Image Systems
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 □ 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 □ Mantron 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
 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
 Electroniques □ 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 □ Scriptel □ 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
Infodex □ International Micro □ **Jaco Electronics** □ **Kent Displays**
Lockheed Sanders □ Luminary Technologies
Marshall Industries
MECC □ Metheus □ Milgray Electronics
Mintronix □ Monitern □ Motorola
National Research Resources □ National Semiconductor
Night Vision Corp. □ Omega Electronics
Photonics Systems
Pixelink □ Primagraphics □ PsiTech
Pulseview □ Racal-Mesi
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
Burl 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 □ Calspan 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-Mesi □ 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

DISTORTION CORRECTION DEVICES

Display Components □ Display Labs
DynaColor □ Eldor □ Ginsbury
Intronics □ K & R Engrg.
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-Mesi
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 □ Redifusion Simulation □ Reynolds Industries
Sarnoff Research Center

FACSIMILE ("FAX") MACHINES

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

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 Engrg. □ 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, electromechanical 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 Engrg.
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) □ **VIQX** □ 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 □ Billico 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 □ Rytak □ 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 □ DENSTRON □ 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 □ DENSTRON □ 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 □ Comifuture □ Convac-APT □ Cornerstone Technology □ Crystop Display □ Davies □ Denstron □ Digitran □ Display Tech □ Dolch Computer □ Donteck □ Dotronix □ EDL Displays □ EEV Ltd. □ Electronic Image Systems □ Epson America □ Eurocan □ 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 □ Infotex 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** □ Nortek □ Nortek 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 □ Comifuture □ 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 □ Infotex 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** □ WACOM

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 □ Denstron □ 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 □ Pixel/Vision □ 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 ImageTel □ **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 □ Denstron □ 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
 Rikel 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
 Digital Display Systems EEV
 Ltd. Electronic Image Systems
 Europan GEC Hirst Research
 Centre BF Goodrich Hornell
 Elektroptik 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
 Denstron Dicrostal Images
 Digital Display Systems
 Dynamic Displays Earth Computer
 EEV EEV Ltd. EM
 Microelectronic Epson America
 Europan Excel Technology FPD
 Technologies GEC Hirst Research
 Centre General Electric Hantronix
 Hitachi America Hornell Elektroptik
 Hosiden 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 Rikel
 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
 Denstron Display Systems
 Hantronix Hitachi America
 Hosiden America Interface Products
 Kristal Jaco Electronics Kent
 Displays Luminary Technologies
 LXD MicroTouch Systems
 Mitray 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-VALVE 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 Florad 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 i Uniglobe Kisco
 Veeco/Sloan Technology VDC
 (Apex) VDC (HQ) Viratec
 Watkins-Johnson Wande XMR
 Young Technology

MARKET RESEARCHERS/PUBLISHERS

American Institute of Small Business
 Dempa Display Technology Library
 Electronic Trend Ergonomics
 Ergosyst Associates FAI Future
 Systems Joe Hallet & 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
 Plasmaterials 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
 Plasmaterials Quantum Electronics
 Stanley Electric Tekra Terapixel
 U.S. Precision Glass Vacuum
 Engineering VisPro WAMCO
 James Wilson

light pens/pointing systems

American Polarizers Photonics
 Plasmaterials Sceptel 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 Nagasa
 California National Research Resources
 Nitto Denko Optotek
 Optrex/Satori Pacific Technologies
 Photonics Plasmaterials 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

industry directory

plasma displays, color

□ American Polarizers □ Applied Films
□ Applied Technology □ Astra Products
□ Brewer Science □ E for M □ Feldman
Technology □ General Digital □ Genesis
Microchip □ Glaverbel SA □ IDM
□ Kisco Santa Clara □ Marubeni
□ **Mitsubishi Electronics America**
□ Nichia America □ Photronics
□ Rexam Custom □ Target Materials
□ Tekra □ Terapixel □ Uniglobe Kisco
□ U.S. Precision Glass □ Vacuum
Engineering □ Viratec □ VisPro
□ WAMCO

spacers

□ Adhesives Research □ Applied
Technology □ Bangs Labs □ Dana
Enterprises □ Kenix Industries □ Kisco
Santa Clara □ Marubeni □ Pacific
Technologies □ Photronics □ Sekisui
Fine Chemical □ SEM-COM □ Tekra
□ Uniglobe Kisco □ U.S. Precision Glass
□ Vacuum Engineering

thin films

□ Applied Technology □ Atomergic
Chemicals □ Balzars AEG □ Balzars
Thin Films □ **Courtaulds** □ Dontech
□ Edwards □ Feldman Technology
□ General Vacuum □ Indium America
□ Kaiser Optical □ Lamination
Technology □ Marubeni □ NIMTEC
□ Photronics □ **Spire** □ Stan-Allen
□ Target Materials □ Tekra □ TFD
□ **3M Product Information** □ Tosoh
SMD □ ULVAC Technologies □ U.S.
Precision Glass □ Viratec

touch screens

□ Adhesives Research □ American
Polarizers □ Astra Products □ AVED
□ Carroll Touch □ **Courtaulds**
□ Crystaloid □ D&T □ Dynapro □ Elo
TouchSystems □ General Vacuum
□ Genesis Microchip □ Glaverbel SA
□ Lamination Technology □ MicroTouch
Systems □ Pacific Technologies
□ Photronics □ Racal-Mesi □ Rexam
Custom □ Target Materials □ Tekra
□ TFD □ U.S. Precision Glass

MATERIALS HANDLING

□ Accudyne □ Applied Technology
□ Gerber Systems □ Progressive System
Technologies

MICE AND OTHER POINTING DEVICES

□ Digitran □ Hosiden America □ IBM
□ Innovated Image □ ISCAN □ **Jaco
Electronics** □ Proxima □ Scriptel
□ SMART Technologies □ **ViewTEK**
□ WACOM

MICROCHANNEL PLATES

□ Gallileo □ Intervac □ Philips
Components

MONITOR MOUNTING DEVICES

□ Ergotron

OPTICAL COATINGS

See also filters, polarizers

□ Adhesives Research □ ADT
□ AlliedSignal □ American Polarizers
□ Applied Films □ Applied Science Labs
□ ASM America □ Astra Products
□ Balzars AEG □ Balzars Thin Films
□ Brewer Science □ **Courtaulds** □ D&T
□ Denglas □ Denton Vacuum
□ Diagnostic/Retrieval Systems
□ Donnelly Applied Films □ Dontech

□ E for M □ Exxene □ Flex Products
□ Fosta-Tek □ General Vacuum
□ Hoechst Celanese □ Homalite □ Hoya
Electronics □ Hoya Optics □ IBM Canada
□ ITG □ Kollmorgen □ Liberty Mirror
□ LMT □ Lumitex □ Marubeni □ Melles
Griot □ Merck □ Metavac □ MicroTouch
Systems □ Mito Fine Glass □ Nitto
Denko □ O&S Research □ OCA □ **OCLI**
□ Optical Devices □ Opto Sigma
□ Optronic Labs □ Panelgraphic
□ Plasmaterials □ Plasma-Therm
□ Polaroid □ PPM Photomask
□ Precision Glass Technologies □ Racal-
Mesi □ Romag Glass □ Silver Cloud Mfg.
□ Southwall Technologies □ Tech-Com
□ TFD □ Thin Film Technology □ **3M
Product Information** □ TSP □ ULVAC
Technologies □ U.S. Precision Glass
□ Viratec □ WAMCO

OPTICAL COMPONENTS

□ Adhesives Research □ AlliedSignal
□ Astra Products □ Atomergic Chemetals
□ Balzars AEG □ Balzars Thin Films
□ ColorLink □ Fresnel Optics □ **Gamma
Scientific** □ Hoya Corp. □ Hudson
Photographic □ Incom □ Lumitex
□ Melles Griot □ OCA □ Opto Sigma
□ Optro-Mechanics □ Precision Glass
Technologies □ Rainbow Optics □ Seiya
Optical □ Teledyne Electronic
Technologies □ **3M Product Information**
□ U.S. Precision Glass □ Viratec
□ Visus □ WAMCO □ Carl Zeiss

OPTICAL DESIGN SERVICES

□ Breault □ Fresnel Optics □ Future
Focus □ Kaiser Optical □ Lumitex
□ Night Vision Corp. □ Optis □ Opto
Sigma □ ORC Lighting □ Physical Optics
□ ORC Electronic □ Rainbow Optics
□ Seiya Optical □ Shintech
□ Tech-Com □ Teledyne Electronic
Technologies □ Viratec □ Visus

OPTICAL DISCS AND SYSTEMS

□ Canon, Inc. □ Eastman Kodak
□ Honeywell □ IBM □ **Jaco Electronics**
□ Kisco Santa Clara □ Mito Fine Glass
□ Pentax Technologies □ Sony Display
Device Group □ **3M Product Information**

OPTICAL SEMICONDUCTOR DEVICES

□ Melles Griot □ **3M Product
Information** □ Seiya Optical

PC-BASED TEST EQUIPMENT

□ Anorad □ autronic □ Dark Field
Technologies □ Data Plus □ Display
Labs □ Florod □ Hornell Engrg.
□ **Image Processing Systems** □ **Jaco
Electronics** □ Laversab □ SAIC
□ **Team Systems** □ **3M Product
Information** □ Unigraf □ Veeco/Sloan
Technology □ **ViewTEK** □ Westar

PHOSPHORS

□ Atomergic Chemetals □ **Brimar**
□ CRT Intl. □ EEV Ltd. □ General
Atronics □ Hoya Electronics □ Intevac
□ **LCD Lighting** □ Marubeni □ Nichia
America □ Phosphor Products
□ Phosphor Technology □ Planar
Advance □ Quantex □ Raytheon
□ Sarnoff Research Center □ Sony
Display Device Group □ **Spire** □ ULVAC
Technologies □ Zenith Electronics

PHOTOLITHOGRAPHY CHEMICALS

□ Hoechst Celanese □ Hoechst
Celanese AZ □ **3M Product Information**

PHOTOLITHOGRAPHY EQUIPMENT

□ Canon USA □ Brewer Science
□ Convac-APT □ Fairchild Convac
□ FAS Technologies □ Gerber Systems
□ Holographic Lithography □ Holtronic
□ **Interserv** □ Kisco Santa Clara
□ **MRS Technology** □ Nikon Precision
□ OAI □ ORC Electronic □ Steag
MicroTech □ Karl Suss □ Tamarack
Scientific □ **3M Product Information**
□ Tokyo Electron America □ Ultra t
□ Uniglobe Kisco

PHOTOLITHOGRAPHY SERVICES

□ Brewer Science □ Holographic
Lithography □ Holtronic □ Process
Technologies □ Technical Visions □ Thin
Film Technology □ **3M Product
Information**

PHOTOMASKS

See masks

□ **Micronic Laser Systems** □ Photonics
□ Photonics-Colorado □ Process
Technologies □ Terapixel □ **3M Product
Information**

PLASMA DISPLAYS, AC

□ Craft Data Ltd. □ Densitron
□ Donnelly Applied Films □ Eaton PSD
□ Electro-Optics □ Electro Plasma
□ General Electric □ Interstate
Electronics □ Micron □ Milgray
Electronics □ Mito Fine Glass □ **NEC
Electronics** □ PEMM Services
□ Photonics Systems □ Plasmaco
□ Plessey Naval Systems □ Pulseview
□ SAIC □ Thomson Components &
Tubes □ Thomson-CSF □ Thomson
Tubes Electronics □ **ViewTEK**
□ Whittaker □ World Products

PLASMA DISPLAYS, DC

□ Babcock □ Cherry Electrical □ Craft
Data Ltd. □ Dale Electronics □ Densitron
□ Displays □ Donnelly Applied Films
□ General Electric □ IEE □ Micron
□ Milgray Electronics □ Mito Fine Glass
□ Panasonic Industrial □ PEMM Services
□ Pulseview □ Quantum Electronics
□ SAIC

PLASMA DISPLAYS, COLOR

□ Densitron □ Craft Data Ltd. □ Fujitsu
□ Hitachi America □ Man & Machine
□ Micron □ Milgray Electronics □ **NEC
Electronics** □ PEMM Services
□ Photonics Systems □ Plasmaco
□ SAIC □ **ViewTEK**

PLASTIC MOLDING EQUIPMENT

□ Applied Technology

PLASTIC MOLDINGS

□ Astra Products □ RMF Products

PLOTTERS

□ Calcomp □ John Fluke Mfg. □ Gerber
Systems □ IBM □ **Micronic Laser
Systems** □ Orbotech □ Summagraphics
□ Tempest Technologies □ Versatec
□ Xerox Engrg. Systems

POLARIZERS

□ ADT □ Advanced Display Systems
□ American Polarizers □ Applied
Technology □ Balzars AEG □ Balzars
Thin Films □ ColorLink □ D&T □ Da-Lite
Screen □ Dana Enterprises □ Dontech
□ E for M □ Fosta-Tek □ Hoya

Electronics □ Hoya Corp. □ Image
Analytics □ International Polarizer
□ **Jaco Electronics** □ Kisco Santa Clara
□ Marubeni □ Melles Griot
□ MicroTouch Systems □ National
Research Resources □ Nitto Denko
□ **OCLI** □ Optical Devices □ Opto
Sigma □ Panelview □ Polaroid
□ Precision Optical Filters □ Reel 3-D
□ Romag Glass □ Sanritz □ Silver
Cloud Mfg. □ **3M Product Information**
□ UCE □ Uniglobe Kisco

POLYMER FILMS

□ Adhesives Research □ AlliedSignal
□ Brewer Science □ E for M □ **Kent
Displays** □ Lamination Technology
□ Rexam Custom □ Si Diamond
□ Specialty Coating Systems □ Tekra
□ **3M Product Information** □ ULVAC
Technologies

POWER SUPPLIES, HIGH VOLTAGE

□ Advanced Conversion □ AHV
□ Astronautics □ AstroSystems □ Best
Power Technology □ Burle Industries
□ Cherry Electrical □ Data Plus □ Data
Translation □ Davalco □ Del Electronics
□ Digitran □ Display Components □ E
and M Electronics □ EEV Ltd. □ EG&G
Optoelectronics □ Eldec □ Electron
Tubes □ Endicott □ John Fluke Mfg.
□ Ginsbury □ HC Power □ Honeywell
□ Hyacinth Technology □ Innotech □ K
and M Electronics □ K & R Engrg.
□ Keltron □ Kisco Santa Clara
□ Linfinity □ Lorad Power Systems
□ National Semiconductor □ ORC
Lighting □ Panasonic Industrial □ Racal-
Mesi □ **Rantec** □ Regisbrook
□ Reynolds Industries □ Sampo America
□ Sanders Associates □ Schott High
Voltage □ **TDK** □ Wasatch High Voltage
□ **WinTron** □ Zyrtronics

PRINTER SUPPLIES

□ Acculex □ Computer Peripherals
□ Eastman Kodak □ Harris Corp. □ IBM
□ Lasertechnics □ QMS □ Tartan
Technical □ **3M Product Information**

PRINTERS, COLOR GRAPHIC

□ Data Plus □ IRIS Graphics
□ Lasergraphics □ Lasertechnics
□ Polaroid □ QMS □ Syntex □ Tartan
Technical □ Tempest Technologies
□ Texas Instruments □ **3M Product
Information**

PRINTERS, ELECTROPHOTIC (LASER AND LED)

□ Canon, Inc. □ Harris Corp. □ IBM
□ Lasertechnics □ NBS Southern
□ Pentax Technologies □ QMS
□ Raytheon □ Tartan Technical
□ Tempest Technologies

PRINTERS, IMPACT

□ DH Print □ IBM □ NBS Southern
□ Relisys □ SAIC □ Syntex
□ Tempest Technologies

PRINTERS, INK-JET

□ Canon, Inc. □ Howtek □ IRIS
Graphics □ Summagraphics □ Syntex
□ Tartan Technical

PRINTERS, THERMAL-TRANSFER AND DYE-SUBLIMATION

□ Acculex □ Calcomp □ Craft Data Ltd.
□ Data Plus □ DH Print □ Eastman
Kodak □ IBM □ Lasergraphics

□ Laser Optics □ 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
Center □ 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
□ Retroscan □ 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. □ Digitrax □ 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
□ Retroscan □ Sarnoff Research Center
□ Sony Display Device Group
□ Stereomedia □ Symco □ TDSD
□ Tech-Com □ **Thomas Electronics**
□ Thomson Components & Tubes
□ Thomson-CSF □ Thomson Tubes
Electroniques □ **3M Product Information**
□ VDC (Novatron) □ Vidwall
□ **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 □ Vidwall □ 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.
□ Opro-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
□ ImageTek □ 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 □ Optronics Labs □ 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 □ Optronics Labs
□ 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 □ Optronics 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 □ Balzars AEG
□ Balzars Process Systems □ Balzars
Thin Films □ Donteck □ 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 □ Matrox 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
□ Exzec □ 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
□ Transicoll □ Varitronix □ **ViewTEK**
□ WACOM

TOUCH SCREENS

□ ADT □ AVT □ Aydin Corp. □ CAM
Graphics □ Carroll Touch □ Craft Data
Ltd. □ Crystaloid □ D&T □ Dale
Electronics □ DBI □ Densitron □ Dolch
Computer □ Draper Screen □ Dynapro
□ Earth Computer □ Electro Mechanical
Systems □ Elographics □ Epson America
□ ETC Computer □ Exzec □ 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 □ Exzec
□ **Jaco Electronics** □ Scriptel
□ SMART Technologies □ WACOM

TRACKBALLS

□ Computer Keyboards Systems
□ Digitran □ Intecolor □ Polhemus

VACUUM EQUIPMENT

□ AeroTech □ Anorad □ Applied Films
□ Applied Technology □ ASM America
□ Balzars 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. □ Nortake □ Morrison
Electronics □ Pulseview □ Regisbrook

VIDEO AMPLIFIERS

□ **CELCO Pacific** □ Dynair □ Ginsbury
□ Kollmorgen □ 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-Corn

VIRTUAL IMAGING

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

VIRTUAL-REALITY DISPLAYS

□ Electrohome □ Fakespace □ Future
Focus □ Gritz's Emporium □ Incom
□ Night Vision Corp. □ Reflection
Technology □ Reel 3-D □ Siliscape
□ Stereomedia □ Tech-Corn □ 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

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

AOL, 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 de-
limited files, MAPI compliant e-mail, or
custom interface.*
Mike Rimrodt, 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

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

ADVANCED DISPLAY SYSTEMS, INC.,
10901 Airport Blvd., No. 1, Amarillo, TX
79111

Manufacturers of fast-response
multistable LCDs (FMLCDs), a new video-
rate-speed reflective low-power zero-field
memory LCD with ultra-fine resolution and
full-color capabilities. Product equipment for
passive-matrix LCD manufacturing.
James Lupino, Mktg. Dir.
806/335-2255, fax: 806/335-3322

ADVANCED VIDEO PRODUCTS,

2 Robbins Rd., Westford, MA 01886
Designers/manufacturers of ultra-high-
resolution monitors and display stations.
Resolutions range from 2048 x 2560 gray
scale to 4096 x 3300 single bit. Monitors
can be configured for a variety of plat-
forms including AT and MicroChannel.
Henry Kunicki, V.P. Display Sls.
508/692-2020, fax: 508/486-8488

ADVANCE MAGNETICS, INC.,

625 Monroe St., Rochester, IN 46975
Manufacturers of custom-fabricated
magnetic shields; magnetic shields for
CRTs; magnetic-shielding alloys, sheet,
and foil; magnetic-tape data protectors;
photomultiplier-tube shields; shielded
enclosures for computer floppy disks;
and computer-monitor shields.
Kay Nixon, V.P.
219/223-3158, fax: 219/223-2524

ADVANCED DISPLAY SYSTEMS, INC.,
10901 Airport Blvd., No. 1, Amarillo, TX
79111

Manufacturers of fast-response multi-
stable LCDs (FMLCDs), a new video-rate-
speed reflective low-power zero-field
memory LCD with ultra-fine resolution and
full-color capabilities. Production equipment
for passive-matrix LCD manufacturing.
James Lupino, Mktg. Dir.
806/335-2255, fax: 806/335-3322

ADVANCED VIDEO TECHNOLOGIES,
INC. (AVT), 34 Simarano Dr., Marlborough,
MA 01752

Specializing in the sales, marketing,
engineering, and implementation of
modifications for companies requiring
customized applications, including
rackmount, ruggedized, touch screen,
hemisphere conversion, and OEM
re-design.

Leisha Stevens, V.P. Sales
508/485-3380, fax: 508/485-3509

AEG M/S GmbH, Soefflinger Strasse 100,
Ulm D-890077, Germany

Manufacturers of LCDs for display
systems, avionics, instrumentation,
vehicles, and large-area information-
display systems, featuring chip-on-glass
interconnect technology.
Wolfram Wiemer, Sls. Mgr.
+49-731-9331-247, fax: +49-731-9331-601

AEROTECH, INC., 101 Zeta Dr.,
Pittsburgh, PA 15238

Manufacturers of air bearing and linear-
motor-based positioning systems featuring
submicron accuracy and extremely tight
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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 Leicher, 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, Shimomaruko 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, multisyncing, 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 circumscribed 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

industry directory

from small character displays to large graphic modules. Technologies include chip-on-glass, plastic-film LCDs, thin backlighting, and touch-panel integration. David Ross, Natl. Sls. Mgr. 708/981-5621, fax: 708/981-6764

CATON CONNECTOR CORP., 26 Wapping Rd., Kingston, MA 02364

Manufacturers of high-voltage connectors and cable assemblies for operation up to 60 kV. Single- and multi-conductor configurations. Standard designs are stocked, while custom designs are dependent on complexity. James Tantillo, Sls. Mgr. 617/585-4315, fax: 617/585-2973

CELCO, 70 Constantine Dr., Mahwah, NJ 07430

Manufacturers of deflection yokes, including the Discorn line of deflection yokes, focus coils, and magnetic assemblies for precision CRT displays, flight simulators, HUDs, cockpit displays, helmet displays, and medical monitors. Art Weirgin, Sls. Engr. 201/327-1123, fax: 201/327-7047

CELCO Pacific Division, 1150 E. 8th St., Upland, CA 91786

Suppliers of the eXtreme MPX motion-picture digital color film recorder to the film industry. Manufacturers of a wide range of direct-drive deflection amplifiers, precision CRT systems, and CRT test equipment. John Constantine, Mktg. & Sls. 909/985-9868, fax: 909/982-2464

CFM TECHNOLOGIES, INC., 1336 Enterprise Dr., West Chester, PA 19380

Manufacturers of the FPD Full-Flow™ system that executes cleaning, etching, stripping, and drying of various-sized FPDs. The patented Direct-Displace™ processing and drying method uses a totally enclosed processing vessel for high performance. Peter Hauser, V.P., FPD Equipment 610/696-8300, fax: 610/696-8309

CHERRY ELECTRICAL PRODUCTS, 3600 Sunset Ave., Waukegan, IL 60087

Manufacturers of segmented bargraphs and dot-matrix dc plasma displays and display systems. PLASMADOT™ display systems offered with high-voltage drivers, dc-dc converters, and display refresh controllers with parallel and serial interface. Also, keyboards, switches, and automotive products. Brad Taylor, Product Mktg. Mgr. 708/360-3434, fax: 708/360-3566

CHIPS AND TECHNOLOGIES, INC., 2950 Zanker Rd., San Jose, CA 95134

Manufacturers of flat-panel graphics/video accelerators for portable and desktop display systems. The HiQVideo™ family provides high-performance graphics, full-motion video, and other advanced display capabilities. Recently announced products incorporate HiQColor™ technology to improve color and image fidelity of low-cost passive displays. Mike Endris, Dir. Distrib. Sls. 408/434-0600, fax: 408/894-2085

CHOMERICS, Division of Parker Hannifin Corp., 77 Dragon Ct., Woburn, MA 01888

Manufacturers of low-cost EMI-shielding laminates for display shields, made of copper or aluminum foil which is adhesive-bonded to polyvinyl chloride (PVC) film.

The conductive foil layer provides 20-60 dB of EMI shielding. William Lionetta, Natl. Sls. Mgr. 617/935-4850, 1-800-225-1936 fax: 617/933-4318

CHROMA ATE, INC., 43 Wu-Chuan Rd., Wu-Ku Industrial Park, Wu-Ku, Taipei Hsien, Taiwan, R.O.C.

Manufacturers of programmable video pattern generators for monitor and LCD testing; CRT color analyzers; and monitor auto-alignment systems. Jack Hsu, Mktg. Mgr. +886-2-2983855, fax: +886-2-2983596

CID Technologies, Inc., 101 Commerce Blvd., Liverpool, NY 13088

Manufacturers/marketers of a full line of high-resolution solid-state monochrome video cameras incorporating patented charge injection device (CID) sensors. In-house design and fabrication of custom or application-specific sensors and cameras. Tony Chapman, Tech. Mktg. Mgr. 315/451-9410, fax: 315/451-9421

CIRCON ACMI CORP., 480 Ward Dr., Santa Barbara, CA 93111

Manufacturers of the Endo Video-V™ CCD camera. Featuring over 400 lines of horizontal resolution, this camera is ideal for all endoscopy applications. David Calvin, Mktg. Mgr. 805/967-0404

CIRRUS LOGIC, INC., 1463 Centre Pointe Dr., Milpitas, CA 95035

Manufacturers of graphics controller semiconductors for CRT and LCD displays, providing full VGA (including mode 13), EGA, CGA, MDA and HGC computability. William Caparelli 408/945-8300, fax: 408/263-5682

CITRONIX, INC., 5342 Halsted Ave., Carmichael, CA 95608

Designers and manufacturers of magnetic deflection amplifiers for high-resolution CRTs. The display format is in either calligraphic, raster, or both. Typical uses include projection displays for flight simulators. Al Pletz, Pres. 916/489-9858, fax: 916/481-0288

CLINTON ELECTRONICS CORP., Contract Assembly Div., 6701 Clinton Rd., Loves Park, IL 61111

Consignment to build full turnkey color and monochrome CRT and flat-panel products. Design service and follow-through engineering support, including agency packaging and direct-to-customer distribution. Lary Johnson, Product Mgr., Display Prod. 815/633-1444, fax: 815/633-8712

CLINTON ELECTRONICS CORP., Cathode-Ray Tubes, 6701 Clinton Rd., Loves Park, IL 61111

Manufacturers of 3-23-in. ultra-high-resolution monochrome CRTs for display, medical, and photographic applications. Extensive selection of phosphors and anti-glare treatments for customizing optical performance available. David Salamone, Dir. Sls. & Mktg. 815/633-1444, fax: 815/633-8712

CLINTON ELECTRONICS CORP., Monitors, 6701 Clinton Rd., Loves Park, IL 61111

Designers and manufacturers of high-resolution monochrome displays for document and medical imaging using embedded microprocessor control. Multifrequency operation from VGA to 1280 lines. Hi-Brite and custom products available. Lary Johnson, Product Mgr., Monitors 815/633-1444, fax: 815/633-8712

COLORADO VIDEO, INC., 6235 Lookout Rd., Ste. G, Boulder, CO 80301

Manufacturers of a line of specialized video instruments, including test and measurement, image analysis, unique frame stores, and slow-scan TV communications equipment. Larry McClelland, Pres. 303/530-9580, fax: 303/530-9569

COLORLINK, INC., 4730 Walnut St., Suite 105, Boulder, CO 80301

Manufacturers of solid-state switchable RGB color filters for color-sequential solutions in imaging and display applications. Filters provide high brightness, color saturation, and resolution for converting monochrome into color. Also, manufacturer and licensor of tunable optical filter technologies. Thomas Boysen, Op. Mgr. 303/545-5843, fax: 303/545-5802

COLOR TECHNOLOGY SOLUTIONS, 2894 NW 127th Ave., Suite 101, Portland, OR 97229

Consulting services in color technology and applications for electronic imaging systems, color displays, television/video, multimedia, printing, instrumentation, and color-management systems. Technology/product evaluations, benchmarking, application of color standards, market research, and color quality assurance. Joann M. Taylor, Pres. & Chief Consultant 503/645-5129, fax: 503/645-5129

COMFUTURE LTD., 7 Habonim St., Ramat Gan, Israel 25251

Manufacturers of alphanumeric or graphic displays and sunlight-visible color graphic displays, with animation of 24 frames/second. All products driven by PC compatibles. Eilon Ginsburg, CEO +972-3-751-0940, fax: +972-3-752-2935

COMPUTER DYNAMICS, 7640 Pelham Rd., Greenville, SC 29615

Manufacturers of a broad line of complete flat-panel computers (286's through Pentiums) and flat-panel monitors, both with optional touch screens, for OEM and end-user operator interface applications. +864/627-8800, fax: +864/675-0106

COMPUTER KEYBOARDS SYSTEMS, 3250 Ocean Park Blvd., Suite 370

Santa Monica, CA 90405
Manufacturers of standard and custom sealed keyboards, illuminated and stainless-steel keyboards, trackpads, and trackballs. Laura Rudnitsky, Mktg. Commun. 310/664-9272, fax: 310/664-1072

COMPUTER PERIPHERALS, INC., 667 Rancho Conejo Blvd., Newbury Park, CA 91320

Manufacturers of font cartridges and expandable memory for the HP LaserJet printer and enhancement board products

for IBM's, PC/XT/AT/XT286/PS2, and true compatibles.

Susan Humphing, Mgr. Inside Sls. 805/499-5751, 1-800-854-7600 fax: 805/498-8848

CONRAC DISPLAY PRODUCTS, INC., 1724 S. Mountain Ave., Duarte, CA 91010-2746

Manufacturers of color and monochrome monitors for computer graphics, process control, medical, broadcast, ruggedized products for hostile environments, simulator systems, and other custom applications. Monitor screen sizes range from 9 to 27 in. Ali Hussein, Dir. Mktg. & Sls. 818/303-0095, fax: 818/303-5484

CONSTELLATION, P.O. Box 117, West Olive, MI 49460

Consultancy specializing in the design, installation, and turn-on of high-volume LCD and FPD production lines, including TN, STN, active-matrix, and PBCT. Upgrading of existing production lines available. Specialist in ITO deposition. Jerry Garies, Managing Dir. 616/786-9988, fax: 616/786-9160

CONTEC CAE, 2188 Bering Dr., San Jose, CA 95131

Providers of a software system which can be used as a tool to facilitate the design and optimization of flat-panel displays using AMLCD technology. The system provides tools for simulation and modeling of all the components of the electronic modules in an FPD. Fred Balistreri, Sls. Mgr. 408/434-6767 x120, 1-800-888-8884 fax: 408/434-6884

CONVAC-APT, 24 Third Ave., Burlington, MA 01803

Manufacturers of photolithographic process equipment for the automatic processing of large glass substrates 200 x 200 mm (8 x 8 in.) up to 400 x 400 mm (16 x 16 in.). Mark Mason, Dir., Eastern Reg. 617/229-7772, 1-800-622-8060 fax: 617/272-8079

CORECO, INC., 6969 Trans Canada Hwy., Ste. 113, St. Laurent, Quebec, Canada H4T 1V8

Designers/manufacturers of board level frame grabbers and digitizers compatible with the IBM PC bus taking any video input for vision-related applications, including machine vision, robotics, factory automation, scientific, medical, security and desktop publishing. Patrick Urbain 514/333-1301, 1-800-361-4914 fax: 514/333-1388

CORNERSTONE IMAGING, INC., 1990 Concourse Dr., San Jose, CA 95131

Designers/manufacturers of large-screen high-resolution (1600 x 1280) display controllers and subsystems for PC/AT and microchannel architecture, specifically for document image processing and publishing applications. Ken Westrick, V.P. Sls. 408/435-8900, fax: 408/435-8998

CORNING ASAHI VIDEO PRODUCTS, 2 East Denison Parkway, Corning, NY 14831

Manufacturers of a complete line of CRT panels, funnels, bulbs, and TV glass components. Alan G. Herklotz, 607/974-7791, fax: 607/974-7731

CORNING INCORPORATED,
Advanced Display Products, MP VX-1-3,
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Manufacturers of 7059F and 1737F glass
substrates for advanced technology flat-
panel displays.
Ben J. Garbowski, Mgr./N.A. Sls.
607/974-4309, 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 Halder, Sls. & Mktg. Mgr.
607/974-6023, fax: 607/974-8354

CORYPHEAUS SOFTWARE, INC.,
985 University Ave., Ste. 31, Los Gatos,
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Software developers of a comprehensive
line of real-time visual-simulation products,
including Designer's Workbench™ (DWB),
a 3D modeling and editing environment;
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408/395-4537, fax: 408/395-6351

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Manufacturers of vacuum sputter coated
films in roll form. All coatings are electrically
conductive; several are also optically
transparent. Standard products include ITO
and silver and gold based transparent
coatings on PET. In addition to standard
coatings, speciality coatings are also
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Bunny Russitti-Buckley, Sls. Mgr.
818/882-5744, fax: 818/882-6519

COVID, INC., 1725 W. 17th St., Tempe,
AZ 85281
Manufacturers of high-resolution
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distribution amplifiers, switches, and
umbilical cables. Interfaces link PCs,
terminals, and graphics workstations to
RGB data projectors and monitors for
viewing on large displays.
Suzanne Jones
602/966-2221, 1-800-638-6104
fax: 602/966-6728

CRAFT DATA, INC., 27022 Cordero La.,
Mission Viejo, CA 92691
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.
F. G. Tagg, Dir. Sls./Mktg.
+44-1-494-778-235, fax: +44-1-494-773-645

CREW SYSTEM ERGONOMICS
INFORMATION ANALYSIS CENTER,
AL/CFH/CSERIAC, 2255 H Street,
Bldg. 248, Wright-Patterson AFB,
OH 45433-7022
Information and technology distributor of
a variety of products and services to help
incorporate ergonomic principles in the
design and development of visual display
systems. Provides technical summary and
analysis support for human-factors-related
inquiries.
Kathy Reineke, Sls. Mgr.
513/255-4842

CRL, Dawley Road, Hayes, Middlesex, 483
1HH
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.
Don Miller, Dir. Sls.
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.
Ken Keller, Pres.
818/989-4610, fax: 818/989-4617

CRYSTALOID ELECTRONICS,
5282 Hudson Dr., Hudson, OH 44236
Manufacturers of LCDs for commercial,
industrial, avionic, and military applications.
Technologies include TN, STN, RCTN, and
dichroic displays and modules.
Charles E. Holland, Sls. Mgr.
216/655-2429 x240, 1-800-888-BEST-LCD
fax: 216/655-2176

CRYSTAL VISION, INC., P.O. Box 3960,
Rolling Hills Est., CA 90274
Manufacturers of video LCD controller
board that digitizes real-time "video-in-a-
window" (NTSC, PAL, SECAM, or S-Video).
Such a 32,768 color video is overlaid with
VGA graphics and displayed on two
AMTFT color LCD panels and a VGA CRT
simultaneously.
Richard Hopkins, Engrg. Mgr.
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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Manufacturers of the CTX EzPro 550
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fax: 408/541-6068

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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,
NJ 07647
Manufacturers of a full line of computer
cable, shrink tubing, modular cords, retrac-
tile cords, and electronic hardware.
Howard Danzhgai, Dir. Mktg.
201/768-5400, fax: 201/768-9642

DAGE-MTI, INC., 701 N. Roeske Ave.,
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

DAKTRONICS, INC., 331 32nd Ave.,
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Designers and manufacturers of large-
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sports, business, and government. Display
technologies include LEDs, incandescent,
and reflective in a wide variety of character
sizes and matrix configurations.
Frank Kurtenbach, Sls. Mgr.
605/697-4300, 1-888-325-8766
fax: 605/697-4700

DALE ELECTRONICS, INC., 1122 23rd St.,
Columbus, NE 68601
Manufacturers of resistive products along
with plasma display panels and touch
screens. Products are ISO-9000 certified
for use in all display applications, including
industrial controllers, medical equipment,
aviation (including GPS), and gaming and
redemption equipment. Custom plasma or
touch-panel engineering support will adapt
technology to a wide range of applications.
Neal J. Kratochvil, Sls. Appl. Engr.
402/563-6308, fax: 402/563-6418

DALIM COMPUTER GRAPHIC SYSTEME
GmbH, Daimler - Str. 2, 7640 Kehl-
Sundheim, Germany
Manufacturers of the Dalim Litho which
is both a graphic creation system as well
as a comprehensive retouching and image-
composing system. Dalim Litho is targeted
specifically at repro houses, photolabora-
tories, and the packaging industry (i.e.,
all companies involved with the pre-press
production cycle.
Winard Sulfrin
+49-7851-4021, fax: +49-7851-7737

DA-LITE SCREEN CO. INC., 3100 State
Rd. 15 North, P.O. Box 137, Warsaw,
IN 46580
Manufacturers of a neutral polarizing
filter which is stable at 100°C for the
UV and visible spectrum.
Arvid Martin, Prod. Mgr.
219/267-8101, fax: 219/267-7804

DANA ENTERPRISES INTERNATIONAL,
INC., 1440 S. De Anza Blvd., San Jose, CA
95129
Distributors of polarizers manufactured by
Sanritz, Fujioka-City, Japan; spacers for
LCDs, manufactured by Sekisul Chemical,
Osaka, Japan; and equipment for LCD
manufacturing exported by Com-Tech Ltd.,
Tokyo, Japan. Offering precision polarizer
die-cutting services — no tooling needed.
David Nakamura, Pres.
408/257-6686, fax: 408/973-9620

DARK FIELD TECHNOLOGIES,
110 Richards Ave., Suite 100, Norwalk, CT
06854
Distributors of laser-inspection systems
for coated and uncoated glass panels and
plastic film. Extensive application
experience with on-line real-time production
processes, float glass, and photoresist
metalized film and polyester, including wet-
coating inspection.
Timothy A. Potts, Pres.
203/853-2035, fax: 203/853-2350

DATA DISPLAY PRODUCTS, 445
S. Douglas St., El Segundo, CA 90245
Manufacturers of LED indicators and
lamps to replace incandescents in PCB-
mount, panel-mount, and lamp-based
applications.
Roy Appleman, Sls. Engr.
310/640-0442, 1-800-421-6815
fax: 310/640-7639

DATA PLUS - CALIFORNIA, 2970
Bannister Ave., Gilroy, CA 95020
Distributors of a wide range of video and
imaging products from companies such as
TEAM Systems, Graseby Optronics,
Integral Technologies, Pacifitek, In-Line,
Hitachi, Multimedia, Radiographic Digital
Imaging, and Komax Technology.
Bill Nicklin, Pres.
Phone/fax 408/842-9907

DATA RAY CORP., 12300 Pecos,
Westminster, CO 80234
Designers and manufacturers of high-
performance color and monochrome CRT
displays. OEM and system-integration
applications include medical and industrial
imaging, PACS and teleradiology,
simulation, and data display. ISO 9001
certified.
Ann Woodley, Dir. Sls./Mktg.
303/451-1300, 1-800-926-5556
fax: 303/451-1143

industry directory

DATA TRANSLATION, INC., 100 Locke Dr., Marlboro, MA 01752

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 Rortveit, V.P. Mktg. +47-3281-9500, fax: +47-3281-8115

DBI, INC., 4103 S.E. International Way, Milwaukie, OR 97222

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

DCI, INC., 14812 W. 117th St., Olathe, KS 66062

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

DECISION IMAGES, INC., 196 Tamarack Circle, Skillman, NJ 08558

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

DIAGNOSTIC/RETRIEVAL SYSTEMS, INC., 16 Thornton Rd., Oakland, NJ 07436

Designers/manufacturers of high-speed processing and display systems for target detection and analysis with military and industrial applications. Color high-resolution raster-based systems are multifunctional and capable of processing and displaying sonar, radar, ECM, infrared, and strategic and tactical C³ data. P. Williamson, Asst. V.P./Corp. Comm. 201/337-3800, fax: 201/337-4775/3314

DIALIGHT CORPORATION, 1913 Atlantic Ave., Manasquan, NJ 08736

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

DIAMOND TECH ONE, INC., 12100 Technology Dr., Austin, TX 78727

Providers of engineering and fabrication services for microelectronics packaging, FPD electronics, materials deposition, and back-end semiconductor-wafer 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

DICRYSTAL IMAGES, 345 Industrial Blvd., McKinney, TX 75069

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

DIGITRAN, Division of XCEL Corp., 4290 E. Brickell St., Ontario, CA 91761

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

DIMENSION TECHNOLOGIES, INC., 315 Mt. Read Blvd., Rochester, NY 14611

Developers/manufacturers of advanced LCD performance-enhancement technologies, i.e., autostereoscopic, high-brightness, high-definition displays. The DT1 1100C Virtual Window™ is a 3D visualization display for viewing, without glasses, 3D computer-generated and video imagery. Jeffrey J. Tokarz, Mktg./Sls. Mgr. 716/436-3530, fax: 716/436-3280

DIS (DISPLAY INSPECTION SYSTEMS, INC.), 46992 Liberty Dr., Wixom, MI 48393-3693

Manufacturers of surface-analysis and in-line inspection machines combining high throughput and high sensitivity. The BB/FP 350 and BB/FP 700 offer in-line inspection of glass substrates for flat-panel manufacturers. Jim Morgenstern, V.P. Marketing 810/669-7314, fax: 810/669-7310

DISPLAY ENGINEERING, INC., 972 Hamilton Ave., Palo Alto, CA 94301

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

DISPLAY LABORATORIES, INC., 2540 Frontier Ave., Suite 109, Boulder, CO 80301-2400

Manufacturers of DLAB590A™ MIMIC@-2D and 3D: Monitor controller and dynamic convergence chips generating digitally controlled horizontal/vertical rate dynamic correction waveforms for geometry and convergence. MIMICAM@ Alignment System: Patented single-camera alignment system. Display Labs@ SoftOSD™: An on-screen display requiring no hardware. Craig T. Ridgley, Dir. Mktg. 303/938-9099, fax: 303/938-9199

DISPLAY PRODUCTS TECHNOLOGY LTD., 1 Langlands Court, Kelvin South Business Park, East Kilbride, G75 0YB

Specialists in the repair of LCDs. Providers of a high-volume quick-turnaround repair/analysis service. Sub-

assembly and test facilities available in addition to new product and technical consultancy. +44(0)-1-3552-39199, fax: +44(0)-1-355241190

DISPLAYS & TECHNOLOGIES (D&T), INC., P.O. Box 3501, Zip 98668-3501, 14511 N.E. 13th Ave., Vancouver, WA 98685

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

DISPLAYS, INC., 87 Industrial Park Rd., Lewistown, PA 17044

Manufacturers of a wide range of custom and standard displays, including digital, alphanumeric, bargraph, and dot-matrix versions, used in audio equipment, pinball games, cash registers, operator interfaces, instruments, etc. Kit C. Kennedy, Pres. 717/242-2541, fax: 717/248-8680

DISPLAY SYSTEMS, INC., 15 Barber Pond Rd., Bloomfield, CT 06002

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

DISPLAY TECH, INC., 1731 Albion Rd., Albion, MI 49224

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

DISPLAY TECHNOLOGIES, INC., 1355 Holmes Rd., Elgin, IL 60123

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

DISPLAY TECHNOLOGY LIBRARY FROM INTERLINGUA, 423 S. Pacific Coast Hwy. #208, Redondo Beach, CA 90277

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

DOLCH COMPUTER SYSTEMS, INC., 3178 Laurelview Ct., Fremont, CA 94538

Manufacturers of environmentally protected flat-panel TFT-based display systems sold as operator interfaces, complete monitors, and OEM subsystems. Touch screens and network-ready embedded Pentiums are available. Vince Tarpey, Dir. DPG 510/661-2220, 1-800-538-7506 fax: 510/490-8345

DOME IMAGING SYSTEMS, INC., 400 Fifth Ave., Waltham, MA 02154
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. 617/895-1155, fax: 617/895-1133

DONNELLY APPLIED FILMS CORP., 6797 Winchester Circle, Boulder, CO 80301
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. 303/551-5490, fax: 303/530-3214

DONTECH, INC., 700 Airport Industrial Blvd., Doylestown, PA 18901
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. 215/348-5010, fax: 215/348-9959

DOTRONIX, INC., 160 First Street S.E., New Brighton, MN 55112-7894
Manufacturers of OEM video displays in both monochrome and color, specializing in medical imaging and multimedia presentation monitors. D. Michael Hunter, Natl. Sls. Mgr. 612/633-1742, 1-800-720-7218 fax: 612/633-1065

dpix, A XEROX NEW ENTERPRISE COMPANY, 3406 Hillview Ave., Palo Alto, CA 94304-1345
Manufacturers of high-performance AMLCDs and a-Si x-ray image sensors. Eagle cockpit displays deliver high brightness, low reflectance, and support for full-motion video. Advanced fabrication facility is capable of producing flat-panel products up to 20 in. on the diagonal. David B. Rose, Mktg. Mgr. 415/842-9783, fax: 415/842-9808

DRAPER SCREEN CO., INC., 411 S. Pearl St., Spiceland, IN 47362
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. 317/987-7999, fax: 317/987-7142

DRS MILITARY SYSTEMS DIVISION, 16 Thornton Rd., Oakland, NJ 07436
Manufacturers of high-technology, militarized and ruggedized display, signal processing, and trainer products for military and industrial applications. Joe Dunn, Sr. V.P. 201/337-3800, fax: 201/337-4775

DUREL CORP., 2225 W. Chandler Blvd., Chandler, AZ 85224-6155
A joint venture between 3M and Rodgers Corp. High-volume manufacturers of DUREL@3 microencapsulated EL lamps for automotive, watch, and wireless communications applications. Lamp systems for phone and keypad applications

offering significant benefits compared to conventional backlighting technologies. Chris Shol, Mktg. Mgr. 602/917-6000, fax: 602/917-6049

DYNACOLOR, INC., 4F, No. 10, Lane 609, Sec. 5, San Chung City, Taipei County, Taiwan, R.O.C.
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. +886-2-278-1938, fax: +886-2-278-1817

DYNAIR ELECTRONICS, INC., 5275 Market St., San Diego, CA 92114
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. 619/263-7711, 1-800-854-2831 fax: 619/264-4181

DYNAMIC DISPLAYS, INC., 1625 Westgate Rd., Eau Claire, WI 54703
Manufacturers of color and monochrome CRT and flat-panel displays for the industrial, medical, and commercial/military markets. Len Stewart, V.P. Mktg./Sls. 715/835-9440, 1-800-793-6862 fax: 715/835-2436

DYNAPRO THIN FILM PRODUCTS, 7025 W. Marcia Rd., Milwaukee, WI 53223
Manufacturers of analog and matrix resistive touch screens; touch-screen controlling electronics; driver software for DOS, Windows, OS/2, and other operating systems; custom design services and off-the-shelf products for OEMs interested in incorporating touch-input devices into their products; custom thin-film coatings; vacuum sputtering chamber. Kevin Brown, Sls./Mktg. Mgr. 414/365-6210, fax: 414/365-1133

EAGLE MAGNETIC CO., INC., 7417 Crawfordville, Rd., P.O. Box 24283, Indianapolis, IN 46224
Manufacturers providing the magnetic-shielding market with high-permeability (sheet stock and foil) 0.002-0.090-in. standard or ultimate annealed fabrication (prototypes to production), annealing, finishing, and assembly. Gary H. Noble, Inside Sls. 317/297-1030, fax: 317/299-1323

EARTH COMPUTER TECHNOLOGIES, P.O. Box 7089, Laguna Niguel, CA 92607
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. 714/448-9368, fax: 714/448-9316

EASTMAN KODAK CO., 343 State St., Rochester, NY 14650
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

are examples of products using Kodak-manufactured CCDs. Helen Maiz, Sls. 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., Westerville, OH 43081-6166
Manufacturers/suppliers of a comprehensive selection of products, systems engineering, training, service, and warranty. Industrial workstations provide real-time control from control room to plant floor; Factory Mate, AMI, PanelMate. David Keifer 614/882-3282, fax: 614/875-7111

ECRM TRUST, 554 Clark Road, Tewksbury, MA 01876-1631
Designers, manufacturers, and marketers of high-resolution monochrome laser graphics systems, laser scanning systems, and raster image recorders for the graphic arts and printing industries. Products designed to permit integration with a variety of electronic publishing systems and desktop publishing. Vince Cooper, Dir. Sls. 508/851-0207, fax: 508/851-7016

EDL DISPLAYS, INC., 1300 Research Park Dr., Dayton, OH 45432
Manufacturers of a wide range of multisync color monitors, custom and specialty video monitors. Michael J. McArdle, Gen. Mgr. 513/429-7423 fax: 513/429-6965

EDWARDS HIGH VACUUM INTERNATIONAL, 301 Ballardvale St., 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 508/658-5410 x3133, 1-800-848-9800 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 +44-245-493-493, fax: +44-245-492-492

E FOR M CORP., Polarizer Film Group, 625 Alaska Ave., Torrance, CA 90503
Manufacturers of standard and custom polarizers and retarder films, contrast-enhancement filters, and custom glass and acrylic laminations. William Bandel, Sls. Mgr. 310/320-9768, 1-800-269-8801 fax: 310/320-9357

EG&G POWER SYSTEMS, INC., 1330 E. Cypress St., Covina, CA 91724
Manufacturers of custom AMLCD backlight drivers and lamp assemblies featuring digital control, wide dimming range, high reliability, and regulated luminance output; FED power supplies; and high-intensity xenon and metal-halide lamps for projection displays. Ed Motokane, Mgr. Bus. Dev. 818/967-9521, fax: 818/967-3151

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, 1330 Cypress St., Covina, CA 91724
Manufacturers of custom and off-the-shelf power supplies and inverters for AMLCD backlights, offering dimming from sunlight-readable to night-vision goggle levels. Available stand-alone or as integrated backlights for avionics, computer, and medical applications. Also, short-arc xenon and metal-halide-based light sources optimized for specific applications such as projection systems. Ed Motokane, Mgr. Bus. Devel. 818/967-9521, fax: 818/967-9862

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

EKTRON APPLIED IMAGING, INC., 23 Crosby Dr., Bedford, MA 01730
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

industry directory

IEEE-488 interface from user's host computer.

Alan Flament, Mktg./Sls. Mgr.
617/275-0475, fax: 617/271-1977

ELASTOMERIC TECHNOLOGIES, INC.
2940 Turnpike Dr., Hatboro, PA 19040

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

ELDEC CORP., 16700 13th Ave. W.,
P.O. Box 100, M/S M1-15, Monitor &
Control Div., Lynnwood, WA 98046-0100

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.
John Ardussi, Mgr./Mktg.
206/743-8238, 206/743-8399;
fax: 206/743-8562

ELDIM S.A., Unicité, 4 rue Alfred Kastler,
Caen 14000, France

Manufacturers of spatial LCD photometers and colorimeters for testing reflective and transmissive displays under illumination. Instant evaluation of LCDs and their component versus viewing angle (up to $\pm 80^\circ$) for R&D and production (contrast, gray level, response time, uniformity).
Jean-Noel Curt, V.P.
+33-2-31-94-76-00, fax: +33-2-31-47-37-77

ELDOR CORP., 70 Walnut St., Wellesley,
MA 02181

Manufacturers of high-resolution deflection yokes with pre-set raster geometry; high-voltage power supplies; flyback and switch-mode transformers.
B. Valle
617/965-0002, fax: 617/965-0003

ELECTROGRAPHICS INTERNATIONAL
CORP., 1825 Stout Dr., Warminster, PA
18974

Manufacturers of the Polychrome LFC 7000, a large-format camera for direct imaging on chrome or iron oxide. Also, projection steppers for the generation of silicon wafers, precision photomasks, and printed-circuit boards.
Ann Grossi, V.P.
215/443-5190, fax: 215/443-9564

ELECTROHOME LTD., 809 Wellington St.
N., Kitchener, Ontario, Canada N2G 4J6

Display Systems: Manufacturers of customized CRT and LCD high-resolution color and monochrome monitors for the medical, process-control, finance, and specialty markets. Projection Systems: Manufacturers of CRT- and LCD-based video/data/graphics projectors and 3-D visualization systems.
519/744-7111, fax: 519/749-3151

ELECTRO MECHANICAL SYSTEMS INC.,
801 W. Bradley Ave., Champaign, IL 61820

Designers, manufacturers, and marketers of totally integrated touch terminals, touch monitors, and custom touch panels.
Mike Lazarevich, Pres.
217/359-7125, fax: 217/359-9839

ELECTRONIC IMAGE SYSTEMS, INC.,
A Member of the BARCO Group,
600 Bellbrook Ave., Xenia, OH 45385-4053

Designers and manufacturers of projection displays used in full flight, vehicular, and maritime simulation. Gunnery and target displays, along with stroke and vector systems for land-based entertainment, are also available. Full raster image distortion can be implemented.
Michael T. Raines, Mktg. Dev. Mgr.
937/372-7579, fax: 937/372-8645

ELECTRONIC TREND PUBLICATIONS,
1975 Hamilton Ave., Ste. 6, San Jose,
CA 95125

Market research in flat-panel displays and other electronics industry topics.
Karen Selven, V.P. Mktg.
408/369-7000, 1-800-726-6858
fax: 408/369-8021

ELECTRO-OPTICS, INC., Orlando Div.,
2160 Park Ave., Winter Park, FL 32789

Manufacturers of photometers, spectrophotometers, and spectroradiometers for testing and evaluating displays.
Dr. Robert K. McMahan, Dir.
407/645-1000, fax: 407/644-9000

ELECTRON TUBES, INC., 100 Forge Way,
Unit F, Rockaway, NJ 07866

Distributors of Brandenburg standard and custom high-voltage power supplies including multi-output reliable low-cost CRT supply modules for monochrome/color displays with UL/CSAVDE approval. Also, digital high-voltage meters/testers.
Gary Shah, Appl. Engr.
201/586-9594, 1-800-521-8382
fax: 201/586-9771

ELECTRO PLASMA, INC., 4400 Martin-
Moline Rd., Millbury, OH 43447

Manufacturers and integrators of ac plasma-based display systems with extensive experience in complex systems integration. Industrial process control.
Thomas P. Zouhary, Sls. Mgr.
419/255-5197, fax: 419/242-9713

ELFORM, INC., P.O. Box 7362, 1025
Ridgeview, Ste. 200, Reno, NV 89510

Suppliers of z-axis adhesives and flexible heat-seal connectors as well as custom EL lamps for backlight and panel applications.
Bob Short, Dir. Sls.
702/829-1905, fax: 702/829-1693

ELOGRAPHICS INC., 105 Randolph Rd.,
Oak Ridge, TN 37830

Manufacturers of touch screens, including AccuTouch® (resistive technology) and IntelliTouch® (surface-acoustic-wave technology). Line of fully integrated plug-and-play TouchMonitors in sizes ranging from 14 to 19 in.
Joseph Barresi, V.P. Sls.
510/651-2340

EL-OP ELECTROOPTICS INDUSTRIES,
LTD., P.O. Box 1165, Rehovot, Israel
76110

Manufacturers of avionics and tank-fire control systems such as head-up displays, helmet-mounted displays and sights, multi-function displays, and up-front control panels.

Ami Yachin, Dir. Corp. Intl. Mktg./Sls.
+972-8-486448, fax: +972-8-486748

ELO TOUCHSYSTEMS, INC., 41752
Christy St., Fremont, CA 94538

Manufacturers of two touch-screen technologies: IntelliTouch (surface wave) and

AccuTouch (resistive). IntelliTouch is used extensively in public-access and merchandising kiosks, training, and gaming. AccuTouch is widely used in retail POS and process-control applications. Software (mouse emulation) for all popular operating systems, including Windows (3.X, NT, 95), DOS, and OS/2.
Elo Direct Marketing Group
1-800-356-8682

ELTECH, 5524 Bee Cave Rd., Austin, TX
78746

Manufacturers of NovaLite® (screen printed) and fusion-sealed Aclar®, foil type, electroluminescent (EL) lamps; active-matrix large-pixel-size PC-board-based EL lamps; and dc-ac inverters.
Brad Lizotte, V.P. Sls.
215/441-0633, fax: 215/441-8299

ELTIVE VISION SYSTEMS, 10/14 Hall
Rd., Heybridge, Maldon, Essex, U.K.
CM9 7LA

Manufacturers of frame stores, image-processing systems, automatic visual inspection systems, and a video-fax system.
D.R. Hurst, Dir.
+44-621-859-500, fax: +44-621-855-335

EM INDUSTRIES, INC., 5 Skyline Dr.,
Hawthorne, NY 10532

Manufacturers and suppliers of display materials for liquid crystals, fiber spacers, thin-film materials, UV photoinitiators, dip coatings, and optical crystals.

Frank Allan
914/785-5840, fax: 914/592-9469

EM MICROELECTRONIC - MARIN S.A.,
Rue des Sors 3, CH 2074 Marin,
Switzerland

Manufacturers of high-precision custom LCD products. LCD technologies include TN (direct and multiplexed), first minima TN, SBE-STN, and a full range of dichroics. Capabilities include use of very thin glass substrates, shaped displays, and HSC bonding technology. Also producers of a range of LCD driver chips available in a variety of packages including TAB.
Gary Broder, LCD Mgr.
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Manufacturers of a full line of small to medium size LCDs. Product line including alphanumeric displays, passive-matrix graphics modules, polysilicon TFT displays, and ultra-MIM active-matrix modules.
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Distributors of test and measurement equipment for international non-ionizing radiation standards such as MPR2/TCO and the new IEC harmonics and flicker test requirements. Also manufacturers of accessibility and safety test probes.
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Publishers of reference books and journals in the areas of artificial intelligence, display design, CAD/CAM, ergonomics, human-factors, human-computer interaction and VDT health and safety.
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EXCEL TECHNOLOGY INTERNATIONAL CORP., 5-4 Stryker La., Belle Mead, NJ 08502

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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Manufacture, research, and development of touch-input devices for computers and electronics using guided acoustic waves (bulk, shear mode). SureTouch touch screens respond to varying pressures and can be operated with gloves or in wet or dirty surroundings. Supplier of panels, controllers, and consulting services. Terence J. Knowles, Pres. 708/866-1868, 1-800-523-5883 fax: 708/866-1808

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sunlight readability, radiance, and
irradiance.
Jack DeSoye, VP Sls./Mktg.
203/425-8900, fax: 203/425-8910

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Manufacturers of liquid mixtures for TN,
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W. Kocher
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alignment and assembly, filling, and edge
sealing. LCD optics test instrumentation
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Niclas Granér, Pres.
+46-243-390-95, fax: +46-243-390-55

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Custom-designed optical components
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John Danielson, Mktg. Mgr.
+46-241-62030, fax: +46-241-62107

HORNELL ENGINEERING, INC., 9337
Ravenna Rd., Suite B-14, Twinsburg, OH
44087
Manufacturers of the MELP (modular
equipment for LCD production) system:
modular equipment for LCD production,
covering the following process steps: bake-
curing, rubbing, dry cleaning, spacer
application, gasket seal printing/dispersing,
combined alignment-assembly, curing of
the gasket seal, and filling.
Dale B. Priem, Pres.
216/405-1419, fax: 216/405-1420

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Manufacturers of active and passive
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computer monitors, office automation,
personal communicator, and projection.
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and display industry. Products includes
thin-film deposition (ITO and AR coating).
Robert E. Gesullo
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Designers/manufacturers of a broad
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606/243-5519, fax: 606/243-5555

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92009
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Rajen Patel
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HYBRID MICROGRAPHICS, INC.,
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Manufacturers of digital film recorders,
computer-output microfilm recorders,
digital-output microfilm recorders.
Thomas A. Hoopes, Pres.
801/264-1818, fax: 801/264-10855

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Irvine, CA 92714
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vehicles and portable equipment. Distribu-
tors of standard and customized Sharp
TFEL products.
John Lewis, Sls. Mgr.
714/261-6224, fax: 714/261-9321

industry directory

HYUNDAI ELECTRONICS INDUSTRIES CO., LTD., Ichon-si, Kyoungki 467-701, Korea
Manufacturers of a line of TFT-LCDs for notebook PCs.
D. K. Kim, Sls. Dir.
+336-39-6404, fax: +336-39-6415

IBM CANADA LTD., 23 Airport Blvd., Dept. 594/MI, Bromont, Quebec, Canada J0E-1L0
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E. Pires, Mgr./Thin-Film-on-Glass Prod.
514/534-6656, fax: 514/534-6688

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914/765-1900
National organization. Please refer to your local telephone directory.

IDM (INTERNATIONAL DESIGN MODELING), 70 Horizon Dr., Bedford, NH 03110
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Phone/fax 603/472-7068

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714/543-6295, fax: 714/543-7383

IEE (INDUSTRIAL ELECTRONIC ENGINEERS, INC.), 7740 Lemona Ave., Van Nuys, CA 91409-9234
Manufacturers of standard and custom vacuum-fluorescent, liquid-crystal, LED, and dc plasma flat-panel displays. Also, keypads, keyboards, and integrated panel assemblies.
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fax: 818/901-9046

IKEGAMI ELECTRONICS (U.S.A.), INC., 37 Brook Ave., Maywood, NJ 07607
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Joe Guzman, Dir. Sls./Mktg.
201/368-9171, 1-800-368-9171
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ILC TECHNOLOGY, INC., 399 Java Dr., Sunnyvale, CA 94089
Manufacturers of Cermax® xenon arc lamps and Daymax® metal-halide lamps. Complete illumination systems for video/data projectors.
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408/745-7900, 1-800-347-2474
fax: 408/744-0829

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516/273-8900, fax: 516/273-1190

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David J. A. Morrison, VP Mktg.
416/492-4000, fax: 416/492-4001

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Manufacturers of AMLCD products for avionic, military, and other high-performance applications. Providers of both custom IQT and COTS glass, ruggedized for demanding applications. Large-area photomask with automated optical inspection to ensure high quality also available.
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510/249-0500, fax: 510/249-0550

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Manufacturers/designers of gray-scale high-brightness monitors that sync from NTSC to 2560 x 2048 in portrait or landscape mode. Sizes range from 9 to 24 in. landscape and 21 and 24 in. portrait. Compatible with multiple platforms, including PCs, Macs, and workstations such as Sun, Silicon Graphics, and H-P. Marta S. Volbrecht, V.P. Sls.
612/935-1171, fax: 612/935-1386

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Providers of worldwide service support and engineering for FPDs, including repair, remanufacturing, inventory management, and test-equipment design and engineering. In/out of warranty programs for LCD and laptop manufacturers include screening, repair, polarization, and TFT laser repair.
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INDIUM CORPORATION OF AMERICA, 1676 Lincoln Ave., Utica, NY 13502
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Manufacturers of digital-to-video converters: multiple CGA, EGA, VGA outputs, serial and parallel data inputs. Monochrome display monitors: 5-, 9-, and 23-in. models.
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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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Manufacturers of monolithic distortion correction devices that accurately correct for geometric or focus distortion in CRT displays.
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Manufacturers of full-color LCD monitors featuring very wide field of view and high brightness.
Ilana Stolov-Hecht, Dir.
+972-050-217-445

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Rikki Razdan, Pres.
617/273-4455, fax: 617/273-0076

ISE ELECTRONICS CORP., P.O. Box 46, Ise, Mie, 516-11 Japan
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

IST (IMAGING & SENSING TECHNOLOGY CORP.), 300 Westinghouse Circle, Horseheads, NY 14845-2299
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ITO AMERICA CORP., 123 NW 13th St., Suite 308, Boca Raton, FL 33432
Distributors of NGI FlexEL electroluminescent lamps for LCD backlighting. NGI touch screens for LCDs. Toshiba TAB attach and final bond equipment. Ishiyama Polarizer laminating equipment. Ohashi heatseal and TAB bonding equipment for LCDs and PWBs.
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Richard E. Walsh, Dir. FPDs
516/273-5500, fax: 516/273-5506

JKL COMPONENTS CORP., 13343 Paxton St., Paoima, CA 91331
Manufacturers of miniature lighted devices, cold cathode fluorescent lamps, LEDs, optical lamps for projectors, quartz-halogen lamps, and xenon lights.
Joe Velas, Sis. Mgr.
818/896-0019 Toll Free: 1-800/421-7244
fax: 818/897-3056

KAHN INTERNATIONAL, 782 Southampton Dr., Palo Alto, CA 94303
Publishers and consultants. Monthly multiclient report tracks and interprets

worldwide developments in flat-panel and projection display technology and markets for industry decision-makers. Quarterly data and video projector database. Technology assessment, due diligence, program review, and expert witness.
Frederic J. Kahn, Pres.
415/327-2043, fax: 415/429-2035

KAISER ELECTRONICS, 2701 Orchard Pkwy., San Jose, CA 95134
Supplier of head-up displays, multi-function displays, display processor and integrated helmet displays, and LCDs for combat aircraft.
408/432-3000 x1705

KAISER OPTICAL SYSTEMS, P.O. Box 983, 371 Parkland, Ann Arbor, MI 48108
Manufacturers of holographic head-up displays, laser eye-protection devices, LCD holographic diffusers and projection screens, holographic filters and components, imaging spectrographs, Raman fiber-optic probes and microscopes, high-resolution CCD cameras, and spectroscopy software.
James McNaughton, Dir. Bus. Dev.
313/665-8083, fax: 665-8199

KAMSTRA COMMUNICATIONS, INC.,
5914 W. Courtyard Dr., Ste. 320, Austin, TX 78730
Marketing-communications firm, coordinating planning and implementation of integrated marketing communications on behalf of clients such as Canon USA, Integrated Designs, Inc., Eagle-Picher Industries, Inc., and 3M Company.
Rick Odell, Acct. Supr.
512/343-8484, fax: 512/343-6010

K AND M ELECTRONICS, INC.,
11 Interstate Dr., W. Springfield, MA 01089
Manufacturers of high-reliability high-voltage ruggedized dc power supplies (30 W + 60 W series) for commercial, military, medical, analytical, and other high-definition high-resolution custom display applications (digital film recorders, CAD stations, etc.).
Rick Brighenti, Product Mgr.
413/781-1350 x285, 1-800-442-4334
fax: 413/737-0608

K & R ENGINEERING SALES CORP.,
227 Rt. 206, Flanders, NJ 07836
Manufacturers representative for magnetic shielding, deflection yokes, focus coils, and high-voltage power supplies.
Bob Resker, Pres.
201/584-5235, fax: 201/584-4375

KELTRON CORP., 225 Crescent St., Waltham, MA 02154
Manufacturers of high-voltage power supplies from 10 to 150 W and available as standard low-cost modules or custom units combining dynamic focus and anode modules, all with UL/CSA approvals.
Ted Chadurjian, Mktg. Mgr.
617/894-8700, fax: 617/899-9607

KENIX INDUSTRIES, INC., 2006 E. 5th St., Tempe, AZ 85281
Manufacturers of a full line of LCD-manufacturing equipment, including P1 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.
W. Joe Cho, V.P.
602/967-9461, fax: 602/921-0836

industry directory

KENT DISPLAY SYSTEMS (A Manning Ventures Business Unit), 343 Portage Blvd., Kent, OH 44240

Manufacturers of display systems modules and other products using bistable reflective cholesteric LCD technology with Image "No-Power" memory. Applications include low-power handhelds, such as data collectors, cellphones, PDAs, remote controls, signage, transportation marquees, hotel billboards, menus, and other public-information systems.
Gerald P. Willnecker, Sls./Mktg Mgr.
330/673-8784, fax: 330/673-4408

KISCO SANTA CLARA, Div. of Kishimoto Sangyo Co., Ltd., 4655 Old Ironsides Dr., Ste. 390, Santa Clara, CA 95054

Distributors of manufacturing materials and equipment for TN/STN/AMLCDs, including polarizers, spacers, ITO glass, sealants, and systems for polarizer lamination, scribe/break, PI coating, rubbing, and LC injection. Distributors of TN/STN-LCD cells from Japan/China/Taiwan on an OEM basis.
Thomas L. Climer, Mgr. LCD Group
408/748-1888, fax: 408/748-1064

KLA ACROTEC, 12-1 Fujimi 1-chome, Chiyoda-ku, Tokyo 102, Japan

Manufacturers of automated inspection systems that locate defects on flat-panel displays as they are being manufactured. Other products include review microscopes and data analysis computers that complement the inspection systems.
N. Higashi-Iraki
+81-3-3230-7011, fax: +81-3-3230-4120

KLA INSTRUMENTS, 160 Rio Robles, San Jose, CA 95134

Distributors (for all locations outside Japan) of KLA Acrotec's automated inspection equipment for flat-panel displays. See "KLA Acrotec" listing for description of this equipment.
Douglas Hendricks
408/434-4200, fax: 408/456-6864

KLEIN INSTRUMENTS, INC., 8948 S.W. Barbur Blvd., Dept. 100, Portland, OR 97219

Manufacturers of state-of-the-art video pattern generators designed for reliability, durability, and affordability from the makers of the Klein Convergence Gauge.
Molly Mossman, Sls. Mgr.
503/235-6333, fax: 503/245-8166

KOLLMORGEN CORP., Electro-Optical Div., 347 King St., Northampton, MA 01060-2390

Manufacturers of integrated optronic systems utilizing CCD and thermal imaging cameras together with image processing and control technology at an image control/graphics workstation.
Douglas R. Jones
413/586-2330, fax: 413/586-1324

KONTOY PRODUCTS CO., LTD., 166 Wai Yip St. 9/F, Kwun Tong, Hong Kong

Manufacturers of LCD production equipment and tools.
P. L. Mok, Oprns. Mgr.
+852/341-3238, fax: +852/357-4237

KONTRON IMAGE ANALYSIS, 4440 Von Karman Ave., #200, Newport Beach, CA 92660

Manufacturers of digital cameras and image processing, analysis, and archiving software with applications in material analysis, process and quality control, cell

and tissue analysis in biomedical, forensics, and microscopy, knowledge-based classification and 3-D reconstruction.

Norbert Schuster, Sls. Mgr.
714/851-1872, fax: 714/851-3180

KOPIN CORP., 695 Myles Standish Blvd., Taunton, MA 02780

Manufacturers of small-format high-resolution AMLCDs, including a 0.25-in.-diameter 320 x 240 display that requires less than 30 W to operate. Because of their low cost and high information content, these small CyberDisplays™ are the first AMLCDs that can be effectively used in personal information devices and other consumer devices.
Glen G. Kephart, V.P. Mktg. Display Prod.
508/824-6696, fax: 508/824-6958

KORRY ELECTRONICS CO., 901 Dexter Ave. N., Seattle, WA 98109

Manufacturers of night-vision-compatible backlights for AMLCDs. Designed for avionics cockpit applications, Korry's backlights offer high brightness and full sunlight readability.
Mike Phillips, Dir. Sls.
206/281-1300, 1-800-257-8921
fax: 206/281-1365

KRISTEL CORP., 555 S. Kirk Rd., St. Charles, IL 60174-3433

Manufacturers of 3-28-in. custom monochrome and color open-frame and OEM-cabinet CRT display monitors. Broad variety of horizontal frequencies and video inputs available. Touch-screen integration and color TFT-LCD monitor modules also available.
Kevin Michael, Sls. Mgr.
630/443-1290, fax: 630/443-1390

KURDEX/THINFILM EQUIPMENT DIV., 343 Gibraltar Dr., Sunnyvale, CA 94089

Manufacturers/suppliers of high-precision production equipment for large-area substrates up to 600 x 750 mm. Providers of tools for R&D/pilot and high-volume production. Equipment products include sputtering, evaporation, box coaters, PECVD, RIE etching, and PR stripping. Options: stand-alone or configured to full automatic cassette-to-cassette reactors or cassetteless substrate transfer system, cluster, or in-line systems.
William H. Kneeland, Dir. Sls./Mktg.
408/734-8181, fax: 408/734-5151

KYOCERA INDUSTRIAL CERAMICS CORP., 5713 E. Fourth Plain Blvd., Vancouver, WA 98661

Manufacturers of full line of color STN LCDs with 1/4-VGA, VGA, SVGA, and XGA resolutions. Diagonal viewing areas range from 1/4-VGA 4.7-in. panels up to the KCT1026B with its XGA (1024 x 768) resolution and 15-in. viewing diagonal.
Joseph R. Maurer, Mktg. Mgr.
360/750-6124, 1-800-826-0527
fax: 360/750-6184

LABSPHERE, INC., P.O. Box 70, Shaker St., North Sutton, NH 03260

Specialists in the design and manufacture of diffuse reflectance products: integrating spheres, integrating sphere instrumentation, diffuse reflectance coatings and materials.
Douglas S. Baxter, V.P. Sls.
603/927-4266, fax: 603/927-4694

LAMPLIGHTER INDUSTRIES, INC., 96 Lamplighter St., Oak Hill, WV 25901

Manufacturers of metal-ceramic electroluminescent panels.
M. D. Emmett, V.P.
304/469-2474, fax: 304/499-3380

LAMINATION TECHNOLOGY CORP., 12423 Gladstone Ave., Bldg. 27, Sylmar, CA 91342

Manufacturers of custom optical filters, screens, and lenses for cleanroom/optical lamination. Also, polarizers, IR filters, diffusers, anti-glare filters, flexible film to glass or plastic sheet. Contract R&D/fabrication services available.
Jack Wignot, Pres.
818/898-1989, fax: 818/365-2488

LANDMARK TECHNOLOGY, 2160 Old Oakland Rd., San Jose, CA 95131

Designers/manufacturers of custom and special-feature backlights for a wide variety of LCDs sizes (0.7-17 in.), including very-high-brightness backlights for sunlight-readable applications to low-power backlights for EL replacement. Color LCDs using very high brightness backlights achieve a screen brightness ranging from 500 to 1100 nits. Also, a computerized LCD optical performance tester for characterization of LCDs.
Ronald E. Copps, Mktg. Mgr.
408/434-9302, fax: 408/434-0954

LASERGRAPHICS, INC., 20 Ada, Irvine, CA 92718

Manufacturers of the LFR Plus™ and LFR™ 4000-line digital film recorders; the family of rasterizers, Rascol II, III, IV and Mac Rascol Print, which drive virtually any color printer to produce sharp text and brilliant color prints or transparencies; the RISC Rascol line of controllers, a design based on the high-speed MIPS processor offering a dramatic speed increase by a factor of as much as 15.
Mike DeLucca
714/753-8282, fax: 714/727-9282

LASERTECHNICS, 5500 Wilshire Ave., N.E., Albuquerque, NM 87113

Manufacturers of the DIR gray-scale printer, a high-resolution monochrome continuous-tone printer producing photographic-quality digital prints; StarBurst dual-mode color printer; 300-dpi thermal-wax or dye-diffusion printer.
Rich Macklin, Mktg. Mgr.
505/822-1123, fax: 505/821-2213

LASERTEC U.S.A., INC., 1778 Technology Dr., San Jose, CA 95110

Manufacturers of a new LCD-inspection machine that automatically inspects color filters for defects. Also, a Confocal Laser Scanning Microscope to profile the display surfaces.
Tom Pomposo, Dir. Sls.
408/437-1441, fax: 408/437-1430

LAVERSAB INDUSTRIAL COMPUTERS, 10503 Rockley Rd., Ste. 103, Houston, TX 77099

Manufacturers of industrial computers, terminals, and monitors. All products are NEMA-4 rated and feature TFT active-matrix b/w or color flat-panel displays. Industrial keyboards and resistive touch screens are also available.
Mike Ewell, Mktg. Mgr.
713/568-8394, 1-800-285-7337
fax: 713/568-8399

LCD LIGHTING, INC., 37 Robinson Blvd., Orange, CT 06477

Manufacturers of custom-designed miniature fluorescent lamps for LCD backlighting; direct- and edge-lighting schemes. Available in 2.6-20-mm diameters, hot and cold cathode, straight or

bent configurations, tri-phosphor coatings, aperture and reflector styles.
Alton G. Hudson, Sls./Mktg. Mgr.
203/795-1520, fax: 203/795-2874

LEADER INSTRUMENTS CORP., 360 Oser Ave., Hauppauge, NY 11788

Manufacturers of a wide range of test equipment, including programmable RGB generators capable of driving advanced displays. Featured are dot-clock rates to 300 MHz, on-screen techniques for raster and test-pattern design, and memory control.
Robert Sparks, Dir. Sls.
516/231-6900, 1-800-645-5104
fax: 516/231-5295

BERNARD J. LECHNER, Consultant, 98 Carson Rd., Princeton, NJ 08540-2207

Consultancy in display devices and systems and all aspects of television, including HDTV systems and standards. Knowledgeable about patent matters: infringement, interference, etc. Experienced expert witness.
Bernard J. Lechner, Consultant
609/924-7545, fax: 609/924-7547

LEICA, INC., 323D Vintage Park Dr., Foster City, CA 94404

Manufacturers of fully automatic optical-inspection and metrology systems for LCD panels up to 550 x 650 mm. High-resolution CD measurements on low-contrast patterns, film thickness on glass, and filled and unfilled LCD gaps.
Richard D. Eandi, Product Mgr.
415/578-0488, 1-800-716-0900
fax: 415/578-8116

LEICA, INC., 111 Deer Lake Rd., Deerfield, IL 60015

Manufacturers of inspection microscopes and systems for film-thickness analysis, gap measurement, and colorimetry on FPDs up to 650 x 550 mm. Automatic plate loaders can be integrated.
847/405-0123, 1-800-248-0123
fax: 847/405-0147

KURT J. LESKER CO., 1515 Worthington Ave., Clairton, PA 15025-2700

Manufacturers of flat-panel-display PVD and CVD coating systems, production-sized Torus magnetron sputter guns, pure materials, and targets; rf/dc power supplies, guns, and target bias and quartz-crystal thin-film monitors and ellipsometers for real-time measurement of physical and optical film thicknesses.
Duane Bingaman, V.P. Sls.
412/233-4200, 1-800-245-1656
fax: 412/233-4275

LEVY HILL LABORATORIES LTD., 5 Sheffield House, Fieldings Rd., Cheshunt, Herts., U.K. EN8 9TJ

Manufacturers of scintillators, x-ray screens, and detectors for x-ray image displays. Also, x-ray image storage screens.
Guy Hill, Managing Dir.
+44-99-230-808, fax: +44-99-221-909

LEYBOLD AG, Wilhelm-Rohn-Strasse 25, Postfach 15-55, D-6450 Hanau, Germany 6450

Suppliers of vacuum coating systems and vacuum processing technology (sputtering, PE-CVD, plasma-etching) for production of active-matrix LCD and color displays.
Dr. Reinack
+33-6181-34-0, fax: +33-6181-34-1690

LEYBOLD TECHNOLOGIES, INC.,
1860 Hartog Dr., San Jose, CA 95131
Manufacturers of high-throughput in-line sputtering systems, complete with ITO, silicon dioxide, and metal processes commonly used in LCD and other FPD manufacture. Substrate areas range from 350 x 400 mm to 830 x 1500 mm. Also, the Panel 450, a large-area plasma etching system. And the LC 350, a large-area LPCVD system for the deposition of a-Si and p-Si.
Tony Sisca, Sls. Engr.
408/436-2822, fax: 408/436-2847

LIBBEY-OWENS-FORD CO., 811 Madison Ave., P.O. Box 799, Toledo, OH 43697-0799

Manufacturers of float glass, including on-line pyrolytic coatings using atmospheric CVD technology. Industrial products include TEC-glass, on-line multilayer tin-oxide-coated float glass, and UltraFloat, a super-flat high-quality clear float glass.
Peter F. Gerharding, Mgr. New Prod. Technology
419/247-3931, fax: 419/247-4517

LIBERTY MIRROR, 851 Third Ave., Brackenridge, PA 15014

Custom design and engineering of optical thin films, specialty mirrors, and optical components. Capabilities cover a broad range from coating customer's material to supplying a complete optical product. Coatings range from highly reflective front-surface mirrors to low-reflection coatings to dichroic and beamsplitter coatings. Also, conductive coatings for EMI and RFI applications.
Steve Zebert, Coatings Sls. Engr.
412/224-1800, fax: 412/224-8754

LIGATURE SOFTWARE, INC., 25 Burlington Mall Rd., Ste. 300, Burlington, MA 01803

Developers of CharacterEyes, 32-bit OCR software that scans documents, analyzes page layout, and outputs directly to a word processor. CharacterEyes supports all major scanners and image file formats. It is available for Windows and Macintosh and is priced at \$695.
Ed McGuigan, Dir. No. Amer. Oprns.
617/238-6734, 1-800-888-0060
fax: 617/272-3085

LIGHTING SCIENCES, INC., 7830 E. Evans Rd., Scottsdale, AZ 85260

Manufacturers of custom photometric test equipment, including high-speed vid-photometer systems (backlight and display technology) and automated goniometer and photometer systems. Also, developers of Raymaster® Consulting services for a wide range of illumination/optical-design applications.
Dana Hutton, Sls. Mgr.
602/998-9252, fax: 602/998-9498

LINDGREN RF ENCLOSURES, 3138 E. Senundo, Hawthorne, CA 90250

Manufacturers of rf-shielded enclosures, rf-shielded anechoic chambers, RFI/EMI power, signal, data and control line filters, rf-shielded honeycomb air vents.
Janet O'Neill, Sls. Adm.
213/870-9383, 1-800-969-9383
fax: 213/870-0828

LINFINITY MICROELECTRONICS, INC., 11861 Western Ave., Garden Grove, CA 92641

Manufacturers of linear and mixed-signal ICs and modules and the LXM1590 series of single-stage LCD backlight inverters

ideal for driving LCD backlight lamps in portable computers, including the latest 12.1-in. panels.

John Lynes, West. Reg. Sls. Mgr.
714/898-8121, 1-800-LMI-7011
fax: 714/893-2570

LITTON ELECTRON DEVICES, 1215 S. 52 St., Tempe, AZ 85281

Manufacturers of high-resolution CRTs for a wide range of recording, scanning, and viewing applications, including typesetting, color graphics, medical imaging, and flying spot scanning.
Bryan Harding, Sls. Mgr.
602/968-4471, fax: 602/966-9055

LITTON SYSTEMS CANADA LTD., 25 Cityview Dr., Etobicoke, Ontario, Canada M9W 5A7

Designers/manufacturers of LED- and AMLCD-based displays and display systems for military and avionic applications.
Van Angelo, Mgr. Displ. Bus. Dev.
416/249-1231 x3905, fax: 416/246-2955

LMT, P.O. Box 269046, MB 116, San Diego, CA 92196

Manufacturers of a complete line of photometers (both luminance and illuminance meters) and colorimeters for display measurements and high-accuracy lab use. Some are NiCd-battery operable for field use with lab accuracy.
Margaret M. Watson
619/271-7474, fax: 619/693-3670

LOCKHEED SANDERS, INC., P.O. Box 868, 95 Canal St., Nashua, NH 03061

Manufacturers of ruggedized and militarized cockpit display systems, intelligent graphic terminals, and display workstations using color liquid-crystal flat panels and CRTs for application in aircraft, ground vehicles, movable shelters, ships, submarines, and space.
Robert Perutz, Prog. Devel. Mgr.
603/885-3524, 1-800-258-1573
fax: 603/885-7284

LOCTITE LUMINESCENT SYSTEMS, INC., 101 Etna Rd., Lebanon, NH 03766-9004

Manufacturers of electroluminescent (EL) lamps and dc-ac inverters that are performance-matched to the lamps they drive. The thin, solid-state, low-power lamps are used to backlight LCDs, and come in a wide range of colors, including NVIS-compatible green.
Michael R. Hartman, V.P. Sls/Mktg.
603/448-3444, fax: 603/448-3452

LORAD POWER SYSTEMS, 36 Apple Ridge Rd., Danbury, CT 06810

Manufacturers of custom high-voltage power supplies.
Dan Lyke, V.P.
203/790-1188, fax: 203/743-3370

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.
Jim Johnson, Dir. Commer. Mktg.
1-800-325-6975, fax: 408/433-2508

LOCKHEED MARTIN DISPLAY SYSTEMS (Formerly Loral Information Display Systems), 1355 Bluegrass Lakes Parkway, Alpharetta, GA 30201

Manufacturers of ruggedized and militarized cockpit and workstation display systems using CRTs and AMLCDs for

application in aircraft, ships, submarines, and ground vehicles. Current product line offers AMLCD screen sizes up to 20.1-in. on the diagonal.

John Balderston, Dir. Mktg.
770/752-5485, fax: 770/752-5525
LSI, 101 Etna Rd., Lebanon, NH 03766

Manufacturers of new, state-of-the-art electroluminescent lamps providing thin (0.012 in.), low-current-draw, uniform illumination. Built with the latest moisture-resistant materials, the lamps are inexpensive and appropriate for high-volume applications.

Louise Stark, Regional Sls. Mgr.
603/448-3444 x3173, fax: 603/448-3452

LUCAS CONTROL SYSTEMS PRODUCTS - DEECO™ SYSTEMS, 31047 Genstar Rd., Hayward, CA 94544-7831

Manufacturers of ruggedized industrial computers, serial graphics and text terminals, VGA monitors, and embedded modules for NEMA-4/12 (IP65) applications. Systems incorporate resistive or infrared touch electroluminescent or color LCDs. Sunlight-readable models are available.
Frank Pensa, Natl. Sls. Mgr.
908/850-5889, 1-800-376-1154
fax: 908/850-6009

LUMINARY TECHNOLOGIES, 6640 Lusk Blvd., Ste. A-200, San Diego, CA 92121

Manufacturers of custom flat-panel-display controller cards and module electronics for graphics and video systems. Products include controllers for PMLCDs, AMLCDs, EL, and FEDs. Enhancement technologies include Adaptive Scanning™, Adaptive Addressing™, and WFRFC.
Robert Hott, Chief Tech. Off.
619/457-5151, fax: 619/457-4646

LUMITEX, INC., 8443 Dow Circle, Strongsville, OH 44136

Manufacturers of woven fiber-optic backlighting for LCDs, membrane switches, control panels, and automotive applications. Specialized light sources for inspection and vision systems. New products include molded light panels, super-bright LED sources, and new low-cost high-volume product designs.

David A. DeAgazio, Sls. Mgr.
216/243-8401, 1-800-969-5483
fax: 216/243-8402

LUXELL TECHNOLOGIES, INC., 5170A Timberlea Blvd., Mississauga, Ontario, Canada L4W 2S5

Engaged in the research, development, and manufacturing of the first high-performance sunlight-legible TFEL display. Features include long life, high brightness, wide viewing angle, fast response time, extended operating range, ruggedness, high contrast, and crisp clear images. The displays are suitable for portable instruments, vehicle displays, ground positioning systems, and computer displays. Available in standard and custom display formats.
Fred Prins, Intl. Mktg. Mgr.
905/206-1708, fax: 905/206-9174

LXD, INC., 7650 First Place, Oakwood, OH 44146

Manufacturers of standard and custom LCDs. Specializing in long-life high-reliability products featuring wide temperature ranges, fast response times, and wide viewing angles. Innovators in large-area and sign displays. Colored polarizers also available.
Chuck Oravec, Sls. Mgr.
216/786-8700, fax: 216/786-8711

MACHINE VISION AND CONTROL INTERNATIONAL, INC., 1804 Johni Dr., Glenview, IL 60025

System design, integration, and installation in the application of infrared- and visible-image capture and analysis for measurement, process control, quality control, and troubleshooting; training in the use of these techniques; system maintenance also provided.
Gary Shubinsky, Pres.
708/657-0200, fax: 708/729-9120

MACHOVER ASSOCIATES CORP., 152A Longview Ave., White Plains, NY 10605

A computer-graphics consultancy providing a broad range of management, engineering, marketing, and financial services worldwide to users, suppliers, and investors. Application areas served include animation, art, business, CAD, CAM, CAE, CIM, documentation, engineering, graphic arts, multimedia, presentations, process control, science, visualization, and virtual reality.
Carl Machover, Pres.
914/949-3777, fax: 914/949-3851

MAGNETIC RADIATION LABORATORIES INC., 690 Hilltop Dr., Itasca, IL 60143

Manufacturers of magnetic shielding components for CRT and related fields.
Alan J. Barone, V.P.
630/285-0800, fax: 630/285-0807

MAGNETIC SHIELD CORP., 740 N. Thomas Dr., Bensenville, IL 60106-1643

Manufacturers of standard and custom magnetic shields for CRT monitors as well furnishing CO-NETIC AA and NETIC 53-6 magnetic-shielding alloys in a wide selection of sheets and coils.
Brad Friestedt, Sls. Mgr.
630/766-7800, 1-800-304-5665
fax: 630/766-2813

MANAGEMENT GRAPHICS, INC., 1401 E. 79th St., Minneapolis, MN 55425

Manufacturers of Solitaire image recorders, offering up to 16K resolution on a variety of film formats from 16 mm to 8 x 10 in. and Mac, PC, and workstation compatible. Every Solitaire features patented Digital Geometry Control, an all-digital image-alignment system. All image characteristics are available from Solitaire's front panel.
Bill Hansen, Mktg. Mgr.
612/854-1220, fax: 612/851-6159

MAN AND MACHINE, INC., 3706 West St., Landover, MD 20782

Specializing in the repair of flat-panel displays, including replacement of TAB drivers, polarizers, and backlight bulbs for TFT, DSTN, and color gas-plasma displays. Also supports ruggedization of FPDs and buys and sells new and refurbished FPDs.
Clifton Broumand, Pres.
301/341-4900, fax: 301/341-4078

MANITRON DISPLAYS LTD., Millbuck Way, Sandbach, Cheshire, U.K. CW11 9HT

Manufacturers of very-high-resolution monochrome and color monitors up to 3K x 2K resolution; raster radar monitors (16- and 23-in. round, 16 x 16 and 20 x 20 in. square) with digital dynamic focus, dynamic astigmatism correction and 1.2-nsec rise-time video amplifiers.
Alan Hesketh
+44-270-764-171, fax: +44-270-763-160

industry directory

MANX RESEARCH, 2060 Ridgecrest Pl., Escondido, CA 92025

Reports covering the Japanese display industry, projector test and evaluation, manufacturing cost trends — projection systems. Also, custom design reviews, strategy sessions, and consultation. William K. Bohannon, Chief Scientist 619/735-9678, fax: 619/735-8987

MARKET INTELLIGENCE RESEARCH CORP. (MIRC), 2525 Charleston Rd., Mountain View, CA 94043

Market research/publisher of high-tech market research reports covering displays, graphics, and image processing. Mel Neri, Mktg. Mgr. 415/961-9000, fax: 415/961-5042

MARK IV INDUSTRIES, LTD., F-P Electronics Div., 5959 Ambler Dr., Mississauga, Ontario, Canada L4W 2P1

Manufacturers of electronic display products for passenger-information display systems for bus, rail, and airport terminals; highway-traffic information; bus-destination signs; scoreboards; fuel-pump displays; time/temperature; and advertising signs. Douglas Greenwood, Gen. Sls. Mgr. 905/624-3020, 1-800-265-7773 fax: 905/238-3141

MARSHALL INDUSTRIES, 9320 Telstar Ave., El Monte, CA 91731

Distributors of a complete line of flat-panel-display standard or customized solutions for a variety of major applications. Products include FPD kits utilizing single-board computers, embedded micro PC cards, PC 104 modules, touch screens, and accessories. Diana Beckman, Strategic Mktg. Mgr. 818/307-6101, 1-800-800-2970 fax: 818/307-6298

MARUBENI SPECIALTY CHEMICALS, INC., 10 Bank St., White Plains, NY 10606

Suppliers of a complete line of materials for the FPD industry, including UV-cure sealants, polarizing film, and spacers for TN-, STN-, and TFT-LCDs. Also, a line of planarization, RGB, and black-matrix resins for TFT applications; and phosphors, anisotropic conductive film, and moisture-barrier sealants for FED, EL, and plasma displays. Will Liu, Sls. Coord. 914/428-5933, fax: 914/428-7524

MATERIALS RESEARCH CORP., 560 Rte. 303, Orangeburg, NY 10962

Manufacturers of sputtering systems for pilot-line and high-volume production of ITR, silicon nitride, amorphous silicon, and metal layers. Systems are delivered complete with a guaranteed process to meet film specifications. Gil Chaput, Dir. Prod. Mktg. 914/398-8585, fax: 914/398-8415

MATRIX COMPONENTS, INC., 13581 Pond Springs Rd., Suite 315, Austin, TX 78729

Flat-panel repair center. Services include fine-pitch bonding, custom laminating polarizers, formulation to match OEM color specifications, prototype development, product consulting, processor repairs, failure analysis, in and out-of-warranty repair programs, and end-of-life product support. Len Bejtlich, V.P. Engr. 512/258-7590, 1-800-737-3955 fax: 512/219-0021

MATROX ELECTRONIC SYSTEMS LTD., 1055 St. Regis Blvd., Dorval, Quebec, Canada H9P 2T4

Designers and manufacturers of video controllers targeted to several distinct markets: graphics, imaging, interactive videodisc, videographics, and financial information. Markets encompass a large variety of applications including CAD, 3D-display, medical electronics, and robotics. Bruce Seidel, Sls. Mgr. 514/685-2630, 1-800-361-4903 fax: 514/685-2853

MATSUSHITA ELECTRONICS CORP., 1-1 Saiwai-cho, Takatsuki, Osaka 569, Japan

Manufacturers of the "Pure Flat" tube, the first high-resolution color CRT with a completely flat screen, a slot-type shadow mask, and auto-scanning, providing a "paper-like" image with excellent white quality and brightness uniformity. M. Sanogawaya, Mgr., CRT Sls. Dept. +81-0726-82-7614, fax: +81-0726-85-0345

McLAUGHLIN CONSULTING GROUP, 1150 University Dr., Ste. 113, Menlo Park, CA 94025

Providers of marketing and technical consulting, both strategic and tactical. Multi-client reports and custom studies. Areas of market specialization include flat-panel monitors, personal displays, and embedded flat panels. Technology expertise in PDLC, plastic displays, and miniature imagers. Chuck McLaughlin 415/323-7155, fax: 415/323-7744

McMAHAN ELECTRO-OPTICS, INC., P.O. Box 14026, 79 T. W. Alexander Dr., Bldg. 4201, Ste. 101, Research Triangle Park, NC 27709

Manufacturers of the Model MRL-V1701 high-performance 40-MFLOP image-oriented workstation. Standard and custom software are available. Tracy Frantz, Office Mgr. 919/549-7575, 1-800-733-7575 fax: 919/549-0421

McMAHAN RESEARCH LABORATORIES, P.O. Box 14026, 79 T. W. Alexander Ave. Research Triangle Park, NC 27709

Manufacturers of image-processing workstations, ranging from low-cost image controllers for analysis and reporting to high-speed image-oriented digital signal-processing workstations designed for various image-processing applications. Robert H. Hart, Tech. Staff 919/549-7575, 1-800-733-7575 fax: 919/549-0421

MDC VACUUM PRODUCTS CORP., 23842 Cabot Blvd., Hayward, CA 94545

Manufacturers of a complete line of UHV components including flanges and fittings, roughing components, electrical and motion feedthroughs, and valves. Also, a complete line of e-beam evaporation sources matching 6-, 10-, and 15-KW solid-state switching power supplies. 510/265-3500, 1-800-443-8817 fax: 510/887-0626

MECC, 200 E. Howard St., Suite 286, Des Plaines, IL 60018

Manufacturers of universal CRT and yoke testing systems (drivers) featuring multi-inductance and multi-frequency. Universal LCD module drivers and moisture meters. Development, quality assurance, and

production of CRTs, deflection yokes, and LCDs.

Megumi Usui, Sls. Mgr. 847/827-4874, fax: 847/827-4875

MEGAVISION, P.O. Box 60158, Santa Barbara, CA 93160

Manufacturers of image acquisition, display, processing, and analysis systems oriented toward engineering, and research and development. Ken Boydston, Pres. 805/964-1400, fax: 805/683-6690

MEKEL ENGINEERING, INC., 777 S. Penarth Ave., Walnut, CA 91789

Manufacturers of the M400 microfilm digitizer that scans 16 and 35mm roll microfilm for quick transfer to digital storage medias; featuring unattended operation, selectable resolution, built-in sensors to detect start and end of each image, and PC controlled. Maurice Amesbury, Pres. 909/594-5158, fax: 909/594-1216

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Manufacturers of liquid crystals for electro-optic displays, liquid-crystal polymers, thermochromic LCs, single crystals for UV and IR optics, scintillators, fluoride glass components for fiber optics, and precursors for high-T_c superconductors. Martin G. Pellatt, Bus. Mgr., Adv. Mater. +44-202-745-520, fax: +44-202-723-824

MERCK KGaA, Frankfurter Str., 64271 Darmstadt, Germany

Manufacturers of liquid crystals, alignment materials, and optical coatings for LCDs. Werner W. Becker, Tech. Mgr., LCs and Pls. +49-6151-72-7360, fax: +49-6151-72-3132

MEISSNER + WURST GmbH + CO., Rossbacherstr. 38, 70499 Stuttgart, Germany

Manufacturers and designers of ultra-clean production facilities worldwide. Inlab, a key subsidiary, provides automation solutions, a growing demand in the production arena. Stephan Durr, Mgr. Corp. Relations +49-711-8804-303, fax: +49-711-8804-566

MELLES GRIOT PHOTONICS COMPONENTS, 1770 Kettering St., Irvine, CA 92614

Manufacturers and distributors of optical components, coatings, optomechanics, fiber optics, and He-Ne and diode lasers. Products include lenses, mirrors, beam splitters, filters, prisms, polarizers, optical tables, and more. Routinely supply custom and OEM components for specialized needs. Jeff Silverman, Sls. Mgr. 714/261-5600, 1-800-835-2626 fax: 714/261-7790

METAVAC, INC., 4000 Point Street, Holtsville, NY 11742

Manufacturers of high-efficiency reflection-reducing coatings and transparent conductive coatings; contrast-enhancement filters for P43 CRT and color displays. Clifford E. Sisler, Sls. Mgr. 516/447-7700, fax: 516/447-7715

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Manufacturers of high-resolution graphics display controllers. The 5700 Series of graphics display controllers are a series of single-slot 6U VME boards designed for

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MEYLAN CORP., 543 Valley Rd., Upper Montclair, NJ 07043

Manufacturers and distributors of stopwatches, chart recorders, event loggers, gas detectors, tachometers, stroboscopic-tachometers, precision electric timers, elapsed time meters, lime study boards, and all related time study equipment. Alex Pirnaris, Sls. Mgr. 201/744-6400, fax: 201/744-1011

MICRION CORP., One Corporation Way, Centennial Park, Peabody, MA 01960-7990

Manufacturers of the L1 system for in-process repair of AMLCD panels. This system repairs "open" defects by a patented photolytic laser CVD metal process and short defects by laser ablation. David Casey, Prog. Mgr. 508/531-6464, fax: 508/531-9648

THE MICROMANIPULATOR CO., 1555 Forrest Way, Carson City, NV 89706

Manufacturers of analytical probing stations including the model 2250, a large-area flat-panel-type tester for diagnostic probing substrates or board-mounted delidded packaged devices. Full line of accessories including thermal chucks, measurement equipment for low-current testing, or for high-frequency testing, manipulators, and probes. Karen Schanhal, Advert./Promotion Mgr. 702/882-2400, 1-800-654-5659 fax: 702/882-7694

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Manufacturers of a complete line of large-area laser plotters producing photomasks for CRTs, active and passive displays, lead frames, plasma displays, and fine line interconnects. Sven Lofquist, V.P. Mktg./Sls. +468-792-6095, fax: +468-792-2480

MICRO-OPTICS TECHNOLOGIES, 8608 University Green #5, P.O. Box 620377, Middleton, WI 53562

Manufacturers of liquid-crystal-based spatial light modulators, shutters, polarization optics, and related light-control devices. Produces both stock items and custom devices. Larry Gunseor, Appl. Engr. 608/831-0655, fax: 608/831-5821

MICROTECH LIQUID CRYSTALS, INC., 1720 Macklind Ave., St. Louis, MO 63110

Manufacturers of cholesteric liquid crystals. Les Neudorf, Pres. 314/773-7099, fax: 314/773-7888

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Manufacturers of the SS200 Series of display analysis equipment. These complete and comprehensive systems are designed to make fully automatic measurement monitors, CRTs, projection systems, and LCD flat panels. Kraig Chellow, Appl. Engr. 408/374-3158, 1-800-931-3188 fax: 408/374-9394

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Manufacturers of a complete line of FPDs, including LCDs, active and dual scan color, ac plasma, and vacuum fluorescent; VGA, SVGA, XGA, and custom LCD monitors. Also, custom monitor enclosures for industrial/commercial specs; unique packaging, plastic/metal enclosures; small-footprint PCs. All touch technologies available. Controllers, inverters, and sunlight-readable technology also available. Tony Cannone, Dir. Mktg. 516/420-9800, fax: 516/420-9884

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Manufacturers of a complete line of convergence meters, including the CC-200 On-Line System, designed for use on TV and computer-monitor production lines, that simultaneously measure horizontal and vertical misalignment of red, green, and blue. Color-analyzer Models 100 and 110 for white-balance adjustment on CRTs and LCD panels. CS-100 hand-held colorimeter for non-contact measurements of light sources and reflective surfaces. 201/934-4642, fax: 201/825-4374

MINTRONIX, 5251 Verdugo Way, Suite J., Camarillo, CA 93012

Manufacturers of LCD digital video controller cards, LCD monitors with integrated touch screens, and custom interface solutions for LCDs. Digital video controllers cards designed for both PCI bus and ISA bus and feature 5- and 3.3-V functionality, NTSC/PAL video output, and compatibility with LVDS signal delivery system. Derek Nguyen, Sls. Mgr. 805/482-1298, fax: 805/987-8088

MITO FINE GLASS CO., LTD., 2-1-2 Marunouchi, Chiyod-ku, Tokyo 100, Japan

Manufacturers of large polished substrates for displays. Mgr. Sls. Dept. +81-3-218-5861, fax: +81-03-213-5486

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Manufacturers of a line of 14-42-in. (13-40-in.-diagonal viewable image) color monitors, including Diamond Scan® and high-performance Diamond Pro® desktop monitors, and large-screen Megaview® presentation and projector products. Lisa Headley, Product Mktg. Mgr. 714/220-2500, 1-800-843-2515

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Human factors and ergonomic consulting and support services related to display

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Manufactures and engineers large and small alphanumeric and numeric displays for plant floor communications. These displays range from 0.5 in. to as large as needed. Charlie Morrison, Pres. 614/851-1100, fax: 614/851-1121

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Manufacturers of flat-panel displays based on field-emissive technology. The new displays will offer TV-like performance in a thin and lightweight format, and will be suitable for a variety of OEM consumer applications. Tom Credelle, Dir., Prod. Mktg. 602/755-5500, fax: 602/755-5502

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Manufacturers of flat-tension-mask color monitors; 29-in. autosync color monitors; the Comprehensive Display Evaluation System (CODES); and video test-pattern generators. Ray Wabler, Dir. Products Div. 513/426-3111, fax: 513/426-8301

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Raphael Tam, Dir. Monitors Mktg.
408/721-8786, fax: 408/721-5691

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Manufacturers of impact printers, electro-photographic laser printers, and non-impact ion-deposition printers.

Richard Busbee, V.P. Sls.
813/541-2200, 1-800-327-5602
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Omid Milani, Sr. Prod. Mktg. Mgr.,
AMLCD Products
408/588-6000, fax: 408/588-6130

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Manufacturer of super-bright green/blue LEDs and phosphors for CRT, EL, and fluorescent lamps

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David E. Kettering, Sr. Sls. Mgr.
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NIMTEC, INC., 125 N. Price Rd., Chandler, AZ 85224

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602/732-9857, 1-800-NIMTEC-1
fax: 602/899-0779

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Manufacturers of glass substrate for AMLCDs and STN-LCDs. Also, image sensor cover glass and micro-rod spacers.

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Manufacturers of passive LCDs (including TN, STN, and D-STN), LCD modules (including large-area dot-matrix and multi-color), and thick-film EL and driving circuits (inverters).

Intl. Dept. +81-258-24-3311
fax: +81-258-24-6543

NIPPON SEIKO K.K., Nissei Bldg., 6-3, Ohnaki 1-chome, Shinagawa-ku, Tokyo, 141 Japan

Manufacturers of large high-precision pattern generators (mask making for FPD, exposure for shadow masks); automated test equipment; large high-precision pattern measuring machine for mask-making process. Main products relate to photo-fabrication system.

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Mike Yoshikawa, Prod. Mgr.
908/418-2775, fax: 908/418-2777

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Manufacturers of polarizing film, retardation film, and other optical plastic materials.

Masato Yoshikawa
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Kenneth I. Werner, Pres.
203/853-7069, fax: 203/855-9769

nView Corp., 860 Omni Blvd., Newport News, VA 23606

Manufacturers of LCD projection products with a worldwide network of dealers and resellers.

nView Sales Dept.
804/873-1354, fax: 804/873-2153

O&S RESEARCH, INC., 1912 Bannard St., P.O. Box 221, Riverton, NJ 08077

Manufacturers and suppliers of aircraft instrument lighting wedges, cover glasses, and CRT contrast-enhancement filler glass. Line of antireflection coatings includes MIL-C-14806A, AMS 2521A, and MIL-C-675C.

Anderson L. McCabe, Pres.
609/829-2800, fax: 609/829-0482

OCA/OPTICAL CORP. OF AMERICA, 170 Locke Dr., Marlborough, MA 01752

Manufacturers of a variety of optical components including color filters and anti-reflection coatings compatible with a variety of display systems. Included are micro-plasma products which can be deposited on glass or plastic and which demonstrate excellent hardness and humidity stability.

Walter Lekki, V.P. Mktg./Sls.
508/481-9860, fax: 508/485-0526

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Manufacturers of patented thin-film multilayer coatings and filters for all display types. Designed to improve brightness and contrast, enhance transmission, widen viewing angle, provide EMI shielding, and incorporate OCLI's high-efficiency anti-reflection (HEA) properties. These coatings can be applied by the display manufacturer, added by the OEM after the display is manufactured, or by OCLI.

Mark Parish, Display Mkt. Specialist
707/525-7038, fax: 707/525-7841

OCULAR, INC., 746 Lingco Dr., Richardson, TX 75081

Manufacturers of custom and standard LCDs and LCD modules. Engineering design and turnkey manufacturing of LCD-related products.

Ben Kwang, Mktg. Dir.
214/437-2561, fax: 214/437-2562

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Catherine Matthews, Customer Service
313/454-5560 fax: 313/207-1350

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Providers of technical market research in liquid-crystal flat-panel displays, display applications, and display markets. Analysis of technology and markets for display-manufacturing equipment and materials. Display industry surveys from Japan and other Far East locations.
William C. O'Mara, Principal
415/323-2175, fax: 415/323-0864

OMEGA ELECTRONICS, S.A., P.O. Box 6, Rue des Prés 149, Bienne 2504, Switzerland
Manufacturers of color video replay, black-and-white matrix, alphanumeric and numeric information boards with character heights from 40 to 520 mm; and timing and judging equipment for all sports.
Haldemann Heinz
+41-32-42-97-15, fax: +41-32-41-33-21

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Manufacturers and designers of graphic display controllers for a wide range of computing devices, from PCs to high-performance engineering workstations, minis, and mainframes.
H. H. Parker, Pres.
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OPTICAL ASSOCIATES, INC. (OAI), 1425 McCandless Dr., Milpitas, CA 95035
Designers/manufacturers of automated, semi-automated, and manual mask aligners and exposure systems for substrates up to 20 x 20 in. Also, edge-bead exposure systems and optical-character-recognition systems, and a full line of UV measurement instrumentation.
Mike Gillette, Dir. Sls./Mktg.
408/263-4944, 1-800-843-8259
fax: 408/263-6389

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./Sls.
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, Sls. 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./Sls.
818/969-3344 x2428, fax: 818/969-3681

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215/348-4649, fax: 215/348-9959

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Milton Lee, V.P. Oper.
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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.
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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.
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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. Transition stages and opto-mechanical assemblies. All products available with OEM discounts.
Kevin Liddane, OEM Bus. Mgr.
714/851-5881, fax: 714/851-5058

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

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310/214-1791, fax: 310/214-1721

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Distributors of a line of microscopes and LCD inspection systems manufactured by Seiya Optical Co., Ltd., Tokyo, Japan.
Sai 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 devices.
William A. Schneider, V.P. & Dir. Sls.
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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.
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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.
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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.
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fax: 818/815-3074

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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
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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

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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.
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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. Sls & 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
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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.
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fax: 201/392-4504

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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
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Manufacturers of high-resolution monochrome and color CRTs in sizes from 5 to

industry directory

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201/392-4502, fax: 201/392-4815

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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
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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
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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 Elling
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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.
Stu Taylor, V. P. Intl. Sls.
408/727-2220, fax: 408/980-5139

PEARSON & ASSOCIATES, INC., 11811 N. Tatum 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 decoders. One-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.
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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.
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PHILIPS CONSUMER ELECTRONICS CO., 1 Phillips 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.
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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.
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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.
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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
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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

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Nora McClelland, Acct. Mgr.
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fax: 408/733-2225

PHOTRONICS-COLORADO (Formerly Microphase Laboratories) 815 N. Wooten Rd., Colorado Springs, CO 80915
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508/562-4803, fax: 508/568-0514

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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.
503/244-0646, fax: 503/244-1224

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fax: 508/264-9446

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Manufacturers of a full range of high-quality high-performance displays for military, industrial, and commercial applications. Display types include electro-luminescent, miniature, active-matrix electroluminescent (AMEL), AMLCDs, and monochrome and color CRT-based systems.
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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

are high-performance monochrome, multi-color, and full-color displays. Rick Phillips, Dir. Sls., EL Displays 503/690-1100, fax: 503/690-1493

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Manufacturers and suppliers of electroluminescent flat-panel displays, providing crisp bright images of text and graphics viewable from wide angles and under most lighting conditions. Preferred for industrial applications.

Jukka Eskelinen, Sls. Mgr. +358-0-420-01, fax: +358-0-422-143

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Manufacturers of display components for medical, industrial, transportation, federal avionics, and non-military federal applications. Complete display systems for specialty information processing. Jerry Vieira, Dir. Strategic Mktg. 503/690-7383, fax: 503/690-1541

PLASMACO, INC., 180 South St., Highland, NY 12528

Manufacturers of full-color ac plasma displays featuring high brightness and contrast, and a 160° viewing angle. Jane D. Birk, Appl. Engr. 914/883-6800, fax: 914/883-6867

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Manufacturers of high-purity materials for the thin-film industry. Specializing in sputtering targets, evaporation materials, bonding service, and backing plates. Specific materials for transparent conductive coatings include fully oxidized and reduced ITO as well as ZnO. Don Sarraich, Pres. 415/277-0440, fax: 415/277-0469

PLASMA-THERM I.P., INC., 9509 Intl. Ct., St. Petersburg, FL 33716

Manufacturers of plasma process equipment (deposition and etch) for the electronics display industry. Small systems are available for R&D. Fully automated multi-chamber production systems process substrates to 22 in. sq. Complete process support is included. Scott Deferrari, Dir. Sls./Mktg. 813/577-4999

PLESSEY NAVAL SYSTEMS LTD., Command Systems Group, 241 Station Rd., Addlestone, Weybridge, Surrey, U.K. KT15 2PW

Manufacturers of naval command-and-control systems. NAUTIS (Naval Autonomous Information System) has color raster on curvilinear monochrome displays. Rugged monochrome raster monitors and 512 x 512 ac plasma terminals also available. Mike Brooks, Supp. Mgr. Sls./Mktg. +44-932-824-336, fax: +44-932-824-723

POLAROID CORP., Holographic Products Div., 2 Osborn St., 2nd Fl., Cambridge, MA 02139

Manufacturers of Imagic™ diffusers based on a proprietary process which yields high-volume cost-effective material that dramatically increases the brightness and contrast of reflective, transmissive, and transmissive LCDs. The appearance of illumination is achieved without any increase in power consumption. Glenn Barone, Sr. Mktg. Mgr. 617/386-8661, fax: 617/386-8671

POLAROID CORP., 1 Upland Road, Norwood, MA 02062

Manufacturers of polarizers for emissive electronic displays that improve contrast and reduce glare on virtually any emissive electronic display and available in plastic acrylic or glass laminations with various EM/RFI and abrasion resistant coatings in a variety of colors. Terry Holmes, Mktg. Mgr. 617/446-4505, fax: 617/446-4600

POLHEMUS, P.O. Box 560, 1 Hercules Dr., Colchester, VT 05446

Manufacturers of 3D position/orientation tracking and digitizing systems used in CAD, virtual reality, animation, and biomedical and scientific applications. Product family includes the Digitizer, Tracker, and the Isotrack. Tom Jones, Sales Rep. 802/655-3159, fax: 802/655-1439

POLYTRONIX, INC., 805 Alpha Dr., Richardson, TX 75081

Manufacturers of custom twisted-nematic displays, standard TN displays, dichroic displays, polymer-dispersed liquid-crystal film, PDLC displays, active-matrix displays, and special shutters. Gordon Laulie, Mktg./Sls. Mgr. 214/238-7045, fax: 214/644-0805

POLYVISION CORP., 50 Barnes Park North, Wallingford, CT 06492

R&D company specializing in electrochromic flat-panel displays. Thomas C. Richards, Dir. Res. 203/294-0203 x 5840, fax: 203/265-7762

POSITIVE TECHNOLOGIES, 6640 Lusk Blvd., Ste. A200, San Diego, CA 92121

Manufacturers of adaptive-scanning controllers for passive- and active-matrix displays. Adaptive scanning increases the contrast and gradations by employing selective multi-line control of both the rows and columns, depending on the image to be displayed. Robert Holto, Pres. 619/457-5151, fax: 619/457-4646

PPM PHOTOMASK, INC., 4950 Fisher St., St.-Laurent, Quebec, Canada H4T 1J6

Specializing in photomask fabrication and phototooling services for flat-panel displays including digitizing, drafting of Calma GDS II, and data conversion from various software; photomasks for optoelectronics, laser diodes, photodiodes, integrated guided-wave optics devices, surface-acoustic-wave devices, and VLSI. Tony Smith 514/737-7030, fax: 514/737-9893

PRECISION ELECTRONIC GLASS, INC., 1013 Hendee Rd., Vineland, NJ 08360

Manufacturers of hand-crafted round-glass CRT bulb blanks in diameters ranging from 0.5 to 7 in. Soft and hard glass tubes are produced to customer specifications. Manufacture prototypes and short runs. Francis M. Ciancarelli, Sls. Mgr. 609/691-2234, fax: 609/691-3090

PRECISION GLASS TECHNOLOGIES, 3110 W. Ridge Pike, Saratoga, PA 19464

Manufacturers of optical components, including glass parts, lenses, prisms, flats, mirrors, blanks, achromats, windows, and optical coatings for medical, scientific, laser, military, and harsh-environment applications. Specialties include prototypes, small lots, and custom specifications in glass of all types.

Arthur V. Mengel, Opns. Mgr. 610/323-2825, 1-800-835-8766 fax: 610/718-0755

PRECISION IMAGING, 320 Martin Ave., Santa Clara, CA 95050

Manufacturers of high-resolution monochrome and color CRT and flat-panel displays used in simulation, military, medical, archival, and stereoscopic imaging. Skip McLaughlin, Sls. Engr. 408/988-1871, fax: 408/988-1873

PRECISION LAMP, 720 Portal St., Cotati, CA 94931

Manufacturers of panels for backlighting LCD displays using incandescent, LED, or cold-cathode light sources. Also, miniature incandescent lamps that solder directly to PCBs. Precision lamp is ISO 9001 certified. Bob Carlson, Sls. Mgr. 707/792-0333, fax: 707/792-2738

PRECISION OPTICAL FILTERS, P.O. Box 507, Cedar Ridge, CA 95924

Manufacturers of contrast-enhancement filters and windows for flat-panel displays. Products available in both glass and acrylic. Circular polarizers for light-emitting displays. Complete line of services, including screen printing, machining, and laser cutting. Short lead times. Craig Edlund 916/273-5226, 1-800-522-8903 fax: 916/273-2195

PRECISION PHOTOMASK INC., 4950 Fisher St., St. Laurent, Quebec, Canada H4T 1J6

Manufacturers of large-area photomasks for LCDs and other applications. High-tolerance masks available up to 10 x 10 in. and regular tolerance up to 20 x 24 in. Materials available are emulsion, chrome, and iron oxide. M. Jain, Mktg. Mgr. 514/737-7030, fax: 514/737-9893

PRI AUTOMATION, INC., 805 Middlesex Tpk., Billerica, MA 01821

Manufacturers of FPD material transport systems, factory automation, FPD stockers, cassette loaders, and process tool loaders with mini-environment. John Davidson, Syst. Mktg. Mgr. 508/670-4270 x3378, fax: 508/663-1825

PRIMAGRAPHICS LTD., Melbourn Science Park, Melbourn, Royston, Herts., SG8 6EJ, U.K.

Manufacturers of a range of modular, VME-based hardware and software for graphics and image handling. The range includes TV, high- and ultra-high-resolution display controllers (up to 2048 x 2048), a RISC processor, and an advanced VME memory card. Kevin Jones +44-763-262-041, fax: +44-763-262-551

PROCESS TECHNOLOGIES, INC., 436 W. Rawson Ave., Oak Creek, WI 53154

Providers of hard-surface photomask services for 2 x 2 to 18 x 24-in. sizes; 1-µm lines and spaces up to 8 x 8 in.; and larger plates with a minimum of 15-µm lines and spaces; R&D quantities of InSO electrode-on-glass or plastic available. Chrome-on-glass, iron oxide, and chromium-gold images can be generated. Manfred Stelter, Pres. 414/571-9200, fax: 414/571-9202

PROGRESSIVE SYSTEM TECHNOLOGIES, INC., 11000 N. Mopac, Ste. 100, Austin, TX 78759

Manufacturers of materials-handling and isolation technology products for the semiconductor and flat-panel display manufacturing industries. Products include

wafer and substrate sorters, wafer transfer systems, lot verification systems, OEM automation, cassettes, and minienvironments.

Greg Greskovich, V.P. Sls. & Mktg. 512/342-2500 x1017, 1-800-369-3691 fax: 512/342-2010

PROLUX CORP., 32961 Calle Perfecto, San Juan Capistrano, CA 92675

Designers, manufacturers, and marketers of large-display LCD projector products. The WallZapper 1000S is a portable multimedia projector with SVGA resolution and 700 ANSI lumens. The WallZapper 1000V is VGA and 1000 ANSI lumens. The INFOWALL is a lightweight rollable 67-in. rear-projection display at SVGA resolution. Steve Lieberman, V.P. Mktg./Sls. 714/661-5400, fax: 714/661-3400

PROXIMA CORP., 9440 Carroll Park Dr., San Diego, CA 92121

Manufacturers of a complete line of LCD panels and projectors for displaying computer and video images to large or small groups. Proxima's Cyclops interactive pointer provides remote mouse control directly on the projected image. Customer Service 619/457-5500, 1-800-447-7692 fax: 619/457-9647

PRP OPTOELECTRONICS LTD., Wood Burcote Way, Towcester, Northants, U.K. NN12 6TF

Manufacturers of custom LED arrays with associated drive electronics for use in civil and military aircraft cockpits. Also, line-geometry monolithic LED arrays for thermal imaging, optical systems, and printing applications. P. B. Hart, Prod. Dir. +44-01327-359135, fax: +44-01327-359602

PSITECH, 18368 Bandilier Cir., Fountain Valley, CA 92708

Manufacturers/marketers of image frame buffers and grabbers, graphics controllers, image-compression/decompression devices, OpenGL, and X Window systems products, providing resolution-independent image display and capture hardware with host-based industry-standard application program interfaces. John Kerr, V.P. Sls. 714/964-7818, 1-800-872-7385 fax: 714/968-7884

PULNIX AMERICA, INC., 1330 Orleans Dr., Sunnyvale, CA 94089

Manufacturers of miniature CCD cameras, lenses, and accessories. Intensified low-light CCD cameras, high-speed shuttered and gated cameras, integration cameras, and custom OEM cameras. Rollande Young 408/733-1560, 1-800-445-5444 fax: 408/737-2966

PULSEVIEW, LTD., Units 1&2, Suffolk Way, Drayton Rd., Abingdon, Oxford, U.K.

Manufacturers of display hardware and software. Optical design of display modules in all technologies, especially VFDs and LCDs. Conventional and surface-mount manufacturing. Noah Smallshaw +44-235-554-433, fax: +44-235-28971

QMS, INC., One Magnum Pass, Mobile, AL 36618

Manufacturers of intelligent graphics controllers for dot-matrix printers, and complete laser-printer systems for

industry directory

barcoding, WP/OA, electronic publishing, CAD/CAE, and other applications.
John Corbett, V.P. Sls./Svc.
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

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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.
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Leon Reznikov, Consultant
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RASTEROPS, 2500 Walsh Ave., Santa Clara, CA 95051
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+44-191-414-5511, fax: +44-191-414-0545

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Manufacturers of laminated glass, acrylic and polycarbonate optical filters for contrast enhancement, radio-frequency shielding, and privacy viewing. For CRTs, both flat and curved filters are available with etched and anti-reflection coated surface finishes. For flat-panel displays, filters incorporating polarizers and transparent coatings are available.

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fax: +44-(0)-1276-676262

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San Diego, CA 92121

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GA 30071

Manufacturers of display peripherals for IBM and Apple platforms. Also, 286 and 386 personal computers, laptops, and notebooks. Color displays in sizes ranging from 14 to 21 in.; horizontal scan from 30 to 90 kHz fixed and/or multi-frequency. Monochrome displays in sizes from 9 to 24 in.; fixed frequency with resolutions ranging from 640 x 480 up to 1600 x 1280.
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fax: 716/264-9265

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3 Odell Plaza, Yonkers, NY 10701-1405

Marketers of CRT bulbs for industrial and military displays, and thin glass substrates for LCDs and other display technologies.
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914/968-8900, fax: 914/968-8585

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01550-1960

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SCHOTT GLASS TECHNOLOGIES, INC.,
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801/972-3690, fax: 801/972-3699

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410, Scranton, PA 18503

Manufacturers of optical filters for all types of displays to control RF/EMI emissions for compliance with FCC, VDE, MIL, Tempest, BS6527, and EEC legislation.
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Technology, 300 Indian Springs Rd.,
Williamsburg, VA 23185

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Peter Seats, Consultant
804/220-3183, fax: 804/220-3263

SECURITY DEFENSE SYSTEMS CORP.,
139 Chestnut St., Nutley, NJ 07110

Manufacturers of high-resolution real-time x-ray imaging displays for security and nondestructive-testing quality-control applications.
Don Airey, Gen. Mgr.
201/235-0606, fax: 201/235-0132

SEIKO INSTRUMENTS USA, INC.,
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Manufacturers of the CH-5500 series of thermal-transfer color hard copiers and the GR-4400 series of advanced raster display systems.
Cheryl Landman, Mktg. Comm. Mgr.
408/922-5800, 1-800-255-7617
fax: 408/922-5840

SEIKO INSTRUMENTS USA, INC.,
Electronic Components Div., 2990 W.
Lomita Blvd., Torrance, CA 90505

Manufacturers of STN, FSTN, and color LCD products for telecommunications, instrumentation, medical, GPS, and hand-held applications. New standard low-cost ECB color modules. New chip-on-glass custom modules in mono and color for high-volume applications.
Don Feeney, Sls. Mgr.
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Pearl River, NY 10945-8667

Manufacturers of optics/vision alignment systems, cameras, optics, and illuminators.
Sal Cortorillo, V.P.
914/620-1999, 1-800-890-3333
fax: 914/620-1950

SEKISUI FINE CHEMICAL CO., LTD.,
1259 Izumi Minakuchi-cho, Koga-gun 528,
Japan

Manufacturers of plastic spacers for LCD in-cell use, conductive spacers for transfer material connecting ITO glass substrates, COG, and anisotropic use; photosensitive resin for LCD cell closure; and color filters.
D. Nakamura
408/257-6686, fax: 408/973-9620

SEM-COM CO., INC., 1712 N. Westwood,
Toledo, OH 43607

Manufacturers of custom glass and glass ceramics for display components, including powdered frits, seal cane, tubulation, spacers, and press-cast parts. Specializing in small-diameter rod and tubing, and various rectangular cross sections. Also offering compositional development services supported by comprehensive database of over 30,000 glasses.
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419/537-8813, fax: 419/537-7054

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Frankfort Pike, Lexington, KY 40510

Manufacturers of CPD and I-type dispenser cathodes for all types of monochrome and color CRT applications.
Jim Tarter, Dir. Tech. Sls./Dev.
606/255-3664, fax: 606/255-6829

industry directory

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Manufacturers of fully automatic cluster systems designed to clean, coat, cure, and develop photoresist, polyimide, and color filter films on large-area FPD substrates. The unique architecture of the APEX™ FPD microlithography cluster provides complete flexibility in a minimum footprint. William O'Connor, FPD Sls.
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SEMI-FPD, 805 E. Middlefield Rd.,
Mountain View, CA 94043

A division of an international trade association dedicated to expanding the global market for FPD equipment, material, and services suppliers. Provides tradeshow opportunities; educational publications, posters, and videos; marketing and technical programs; international standards committees; and economic information on FPD supplier markets.

Heidi Hoffman, Mgr., FPD Div.
415/940-6904, fax: 415/940-7919

SEMITOOL, INC., 655 W. Reserve Dr.,
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Manufacturers of the Centurium FPD process automation and control system that links large-substrate fabrication steps with materials handling, creating a clustered batch wet-process tool. Centurium can be configured with modules for stripping, cleaning, and etching applications, with automatic transfer between sequential processes.

Jason Manger, Prod. Mgr.
406/752-2107, 1-800-548-8495
fax: 406/752-5522

SEMI TOOL, INC., Equinox Div., 655 W.
Reserve Dr., Kalispell, MT 59901

Manufacturers of wet-processing equipment used in the manufacture of flat-panel displays. Also, etching, cleaning, stripping, developing, coating, and electroplating systems.

Peter Baxter, Equinox Sls. Mgr.
406/752-2107, fax: 406/752-5522

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Tom Hort, CMD Sls. Rep.
605/339-0100, 1-800-736-2673
fax: 605/339-0317

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Manufacturers of out-of-the-window display systems for simulation, CRT monitor-based collimated displays, wide-angle edge-matched multichannel projection displays, and unique laser-scanned imaging and display systems.

Owen J. Wynn
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includes memory (19-512 × 512 × 8), I/O, bus interface, and image-processing VLSI, John Lewis, Sls. Mgr.
714/261-6224, fax: 714/261-9321

SHARP ELECTRONICS CORP.,
Microelectronics Group, 5700 N.W. Pacific
Rim Blvd., Ste. MS-20, Camas, WA 98607

Manufacturers of color passive-matrix LCDs in a full range of sizes, with technology improvements such as Sharp addressing and memory addressing. Color TFT-LCDs ranging in size from 6.4 in. VGA to larger XGA sizes. Monochrome technologies including monochrome STN, DMTN, and EL.
Joel Pollack, Dir. Sls. Mktg.
360/834-8926, 360/834-8903

SHINTECH, INC., 90 Ogo-Oku Tabuse-
Cho, Kumage-Gun, Yamaguchi 742-15
Japan

Developers of modeling and simulation software for LCD designers and researchers.

Michiyuki Miyashita, Chief Engr.
+81-820-52-5230, fax: +81-820-52-5237

SHIP ANALYTICS, 183 Providence New
London Turnpike, North Stonington, CT
06359-1738

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Howard Schmidt, Pres.
713/529-9040, fax: 713/529-1147

S.I. DIAMOND TECHNOLOGY, INC.,
12100 Technology Blvd., Austin, TX 78727

Manufacturers of display elements for large electronic billboards, in particular for outdoor applications. As a research organization, developer of FED technology utilizing diamond films. DTO, Inc., and Plasmatron, Inc., are wholly owned subsidiaries providing service to the display and semiconductor industries.

Zvi Yaniv, Pres.
512/331-6200

SIEMENS AG, Siemensallee 84, Karlsruhe
76185, Germany

Designers/manufacturers of high-contrast high-brightness high-performance monochrome CRT displays for medical systems (including workstations), air-traffic control, and document imaging. Also, high-performance color displays for medical, industrial, and CAD applications.

Edgar Litzler, Dept. AUT 31 PM
+49-721-595-6096, fax: +49-721-595-4558

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fax: 908/603-5994

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Manufacturers of a line of analytical probe stations, including custom-made flat-panel probes in sizes ranging from 8 to 20 in. sq., and analytical lasers for repair.
Brian Dickson, V.P. Mktg.
408/848-2851, fax: 408/848-5763

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SILISCAPE, INC., 1032 Ellwell Court, Suite
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Alfred P. Hildebrand, Pres./CEO
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Robert C. Cowperthwait, Sls./Mktg. Mgr.
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SIMTECH LTD., 29 Hamerkava St., Holon
58101, Israel

Manufacturers of simulators for military applications. The display is based on high-resolution (1280 × 1024) color digitized images with an overlay of graphic elements in real time. The images are displayed on video projectors, color monitors, and LCD monitors.

Ben Z. Beiski, Chief Engr.
+972-3-5577-680, fax: +972-3-5564-471

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11th Ave. S.W., Calgary, Alberta T2R 1K9,
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403/245-0333, fax: 403/245-0366

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San Jose, CA 95131-1002

Designers/manufacturers/distributors of a full line of LCDs and flat-panel-display controllers and drivers.
Sang Hy, Product Mktg. Engr.
408/922-0200, fax: 408/922-0238

ALAN SOBEL, 633 Michigan Ave.,
Evanston, IL 60202

Consultant on display devices and systems, specializing in flat-panel technologies. Technical consultation, analysis, problem-solving, report and proposal writing and evaluation.

Alan Sobel, Principal
Phone/fax: 847/869-5607

SOCIETY FOR INFORMATION DISPLAY,
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Ana, CA 92705-5421

International society for the presentation, exchange, and preservation of information display technology. Sponsor of annual Symposium, Seminar, and Exhibition. Publishers of Information Display Magazine, Journal of the SID, as well as other publications.

Lauren Kinsey, Exec. Dir.
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Tokyo 141, Japan

Manufacturers of the super-high-resolution Trinitron™ color CRT, beam-index CRTs; high-resolution image pick-up tubes; projection CRTs; and other display devices.

S. Morikawa, Mgr.
+81-3-495-3630, fax: +81-3-495-3724

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Cypress, CA 90630

Manufacturers of sensing products that includes both advanced CCD cameras and Station tube cameras.

Lisa Tollner
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John Wyckoff, Prod. Mktg. Mgr.
619/673-2860, fax: 619/451-0412

SONY GRAPHIC DISPLAY, 3300 Zanker
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fax: 503/345-7140

SPECTRON ENGINEERING, INC., 255 Yuma Ct., Denver, CO 80223

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303/733-1060, fax: 303/733-2432

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Manufacturers of large-substrate ion implanters for processing technologies.
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408/727-1567 x24, fax: 408/727-1322

SPIE, P.O. Box 10, Bellingham, WA 98227-0010

SPIE, The International Society for Optical Engineering, is a nonprofit technical society dedicated to advancing scientific and engineering applications of optical, electro-optical, and optoelectronic technologies through its publications, symposia, and short courses.
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SPSE, THE SOCIETY FOR IMAGING SCIENCE AND TECHNOLOGY, 7003 Kilworth Lane, Springfield, VA 22161
A nonprofit technical society devoted to meeting the information needs of imaging professionals - scientists, engineers, and technicians working in the area of photographic and electronic imaging. Its purpose is to advance the understanding and application of imaging science and technology.
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Manufacturers of super-bright LEDs, LED displays, LED printheads, LCDs, ELs, CFLs, photoreceptors (OPC, a-Si), sub-miniature lamps, miniature halogen lamps, and driver and controller electronics for displays.
Takashi Kashiwagi
+81-3-3710-2222, fax: +81-3-3792-0007

STANLEY ELECTRIC CO., LTD., R&D Laboratory, 1-3-1 Eda Nishi, Midori-ku Yokohama 225 Japan

Manufacturers of super-bright LEDs, LED displays, LED printheads, LCDs (TN, STN, GH-D, TFT, CSH), ELs, CFLs, photo-receptors, subminiature lamps, miniature halogen lamps, and driver and controller electronics for displays.
Takashi Kashiwagi
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8341 E. Evans Rd., Suite 108, Scottsdale,
AZ 85260
Manufacturers of compound curved high-gain projection screens. DURAGAIN® and AquaBRIGHT® high-gain maintainable coatings. Integrator of large-screen displays.
Max Mariani, Dir. Oper.
602/998-4600, fax: 602/443-8833

TECHNEGLAS, INC., 707 E. Jenkins Ave.,
Columbus, OH 43207
Manufacturers of CRT glass bulbs and parts for industrial, avionics, military, and monitor applications.
James E. Kyle, Sls./Mktg. Mgr.
614/445-4800, fax: 614/445-4702

TECHNICAL VISIONS, INC., 14000 S.W.
Karl Braun Dr., M/S 46-944, Beaverton, OR
97077
A contract engineering company specializing in liquid crystal, plasma, and plasma-addressed liquid-crystal (PALC) flat-panel-display development. Capabilities include fabrication of display prototypes measuring 21 in. diagonally.
Thomas S. Buzak, Pres.
503/627-1411, fax: 503/627-2225

TECHNOLOGY TRANSFER INSTITUTE,
518 Fifth Ave., Suite 305, New York, NY
10036
Consulting, research, and reporting services on Japanese display technology and markets.
Ryoji Koiko, Exec. V.P.
212/719-5771, fax: 212/719-5874

TECH SPRAY, INC., P.O. Box 949,
Amarillo, TX 79105
Manufacturers of chemical products used to clean, coat, and protect components and finished products from grease, moisture, mildew, fungus, acid, and caustic contaminants. Static control products for carpets, glass, and plastics.
Don Schrowangen
806/372-8523, 1-800-858-4043
fax: 806/372-8750

TEKNEK ELECTRONICS LTD., Quarriers
Village, Bridge of Weir, Renfrewshire PA11
3SA, U.K.
Manufacturers/designers of equipment for removal of particulate contamination from sheet and web substrates, especially prior to coating, laminating, and printing.
Mark Sunderland, Commercial Mgr.
+44-0505-690-707, fax: +44-0505-614-708

TEKRA ATG, 16700 W. Lincoln Ave.,
#2800, New Berlin, WI 53151
Manufacturers of Terrapin hardcoated plastic films to meet the hardness (3H) and optical requirements for touch screens, flat-panel displays, and vacuum-deposition coatings.
Peter Moulds, Bus. Unit Mgr.
414/784-5533, 1-800-448-0291
fax: 414/797-3276

TEKTRONIX, INC., P.O. Box 500,
Beaverton, OR 97077
Manufacturers of portable handheld digital photometer/radiometer/colorimeter products capable of making a wide range of display measurements. Several pre-calibrated plug-in heads are available for high-accuracy display and ambient measurements.
Chuck Price, Mktg. Mgr.
503/627-5077, fax: 503/627-5622

TEKTRONIX, INC., Display Products
Operation, P.O. Box 500, Beaverton, OR
97077
Manufacturers of display products, providing high-resolution color and monochrome displays as well as 3-D stereoscopic display systems based on its liquid-crystal technology developments.
Richard Osborn, Prod. Mktg. Mgr.
503/627-5064, 1-800-TEK-WIDE x5000
fax: 503/627-1070

TELEDYNE ELECTRONIC TECHNOLOGIES, E-O Lighting & Display Products,
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Manufacturers of ALPHA LIGHT™ and DYNELAMP™ lighting for LCDs, spatial light modulators, projection displays, and other specialized illumination radiation applications over the visible portion or in the near-infrared regions of the spectrum. Also, TOPS™ advanced performance photonic products. Light sources include low-power LEDs, as well as fluorescent arc and other lamp types.
Bill Kennedy, Bus. Dev. Mgr.
213/777-0077, fax: 213/242-1924

TELEDYNE KINETICS, 410 S. Cedros
Ave., Solana Beach, CA 92075
Manufacturers of connectors for connecting flat-panel displays to printed-circuit boards.
Doreen Deschamps, Mktg. Commun.
619/755-1181, 1-800-344-4334
1-800-991-9988 (CA only)
fax: 619/755-6163

TELESENSORY, 455 N. Bernardo, P.O.
Box 7455, Mt. View, CA 94039-7455
Manufacturers of access devices for blind and low-vision people. Product line includes computer-screen enlargers, speech and braille output devices, OCR system, braille printers and video magnifying reading aids.
Kathy Kinkaid
415/960-0920, 1-800-227-8418
fax: 415/969-9064

TELETRAC CORP., 137 Aero Camino,
Santa Barbara, CA 93117
Manufacturers of large-scale inspection, electrical test, and repair systems for flat-panel displays. Produces turnkey systems with closed-loop laser interferometer servo motion control, computer vision systems, and robotic load/unload.
Barton F. Norton, V.P. Mktg./Sls.
805/968-4333, fax: 805/968-5653

TELEX COMMUNICATIONS, INC.,
9600 Aldrich Ave. S., Minneapolis, MN
55420
Manufacturers of LCD desktop panels and projectors, including the 13-lb. P170 data/video projector with built-in sound, 16-million colors, backlit remote, multi-lingual on-screen menus, 140 ANSI lumens of brightness, and accepting 3 video sources and 2 computer inputs.
Todd Theilmann, Dir. Sls.
612/887-5531
1-800-828-6107 x531, fax: 612/887-5595

TELIC OPTICS, INC., 420 Maple St., Suite
25, Marlborough, MA 01752
Consultants in optical design and analysis including lens design, illumination systems analysis, and stray-light analysis. Custom optical analysis software also provided.
Jim Howard, V.P.
508/485-4088, fax: 508/485-4618

TELTRON TECHNOLOGIES, INC.,
2 Riga La., Birdsboro, PA 19508
Manufacturers of imaging devices, including various camera tubes and monochrome CRTs for high-resolution and ruggedized applications. Special-purpose tubes available.
Arthur H. Mengel, COO
610/582-9450, fax: 310/582-0851

TEMESCAL, A Division of BOC Coating
Technology, P. O. Box 2529, 2700 Maxwell
Way, Fairfield, CA 94533-0252
Developers/manufacturers of thin-film deposition systems for ICs, optics, flat-panel displays, and research; electron-

beam sources and power supplies; deposition fixturing; deposition monitors and controllers; and vacuum hardware and accessories.
Brian Kaemmer, Sls. Mgr.
707/423-2100, 1-800-522-1215
fax: 707/425-1706

TEMPEST TECHNOLOGIES, INC.,
460 Herndon Parkway, Herndon, VA 22070
Manufacturers and sellers of dot-matrix (200-400 cps), line (300-600 lpm), letter-quality (55 cps), and page (6 ppm) printers, and plotters (8 pen) for use when processing sensitive data in office and engineering activities.
James L. Leatherman
703/471-0157

**TENCOR INSTRUMENTS, One
Technology Drive, Milpitas, CA 95035**
Designers and manufacturers of innovative wafer defect inspection, software-based yield management, thin-film measurement, and metrology systems used in semiconductor manufacturing and related industries.
Tony Aniello, Worldwide Sls.
408/571-3000, fax: 408/571-3030

TENCOR INSTRUMENTS, 3231 Scott
Blvd., Santa Clara, CA 95054
Manufacturers of the FLX-2350FP, a thin-film stress-measurement system designed for flat-panel-display applications. The system monitors stress at room temperatures, and features a 500-mm scanning capability to allow local stress analysis along the scan.
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Prod.
408/654-2436, 1-800-358-6784
fax: 408/982-9654

TERRAPIXEL, Olaninluoma 9, 02200 Espoo,
Finland
Manufacturers of large-area photomasks for display manufacturing. Maximum areas, 22 x 24 in.; minimum lines, 3 µm. Applications include LCDs, FEDs, ELs, plasma, and others.
Arto Salin, Pres.
+358-9-423-537, fax: +358-9-423-813

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Manufacturers of color plasma display drivers/controllers for future A/V systems, including new chip process of high-voltage CMOS based on technology exchange agreement with Supertex. LCDs in slim TAB packages and chip-on-glass assembly covering all flat panels.
Plasma: Hiro Kawai; LCD: Toshi Ikai
+81-3-3769-8724, fax: +81-3-3457-6777

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Ave., Tustin, CA 92807
Manufacturers specializing in FPD coatings: transparent conductors (ITO), index-matched ITO (IMITO), low-glare coatings (ARs, BBARs), black chrome, display heaters, metallized electrodes, and hot or cold mirrors. Other products and services include line-line patterning, lamination, backlight heaters, touch-screen coatings, sensors, and a resistivity meter. The addition of a large-capacity low-defect ITO-coating machine will increase TFD

production an additional 1.5-2.5-million ft² a year.

Richard Tremblay, Mktg. Mgr.
714/630-7127, fax: 714/630-7119

THIN FILM TECHNOLOGY, INC., P.O. Box 1942, 153 Industrial Way, Buellton, CA 93427

Offering complete vacuum-coating and substrate patterning services for fast, flexible response to customer requirements. Both evaporation and rf/dc magnetron sputtering techniques are employed to produce conductive, resistive, dielectric, wear-resistant, or optical coatings on a variety of substrates. Coating chamber sizes range from 18 in. in diameter to 8 ft. diameter x 14 ft. deep.
Doug Cambell, Sales
805/688-4949, fax: 805/688-8487

THOMAS ELECTRONICS, INC., 100 Riverview Dr., Wayne, NJ 07470

Manufacturers of CRTs and CRT assemblies for the military, industrial, and commercial marketplace. Applications include air-traffic control, avionics, medical imaging, simulations, photo-recording, and CHI. New products include flat fluorescent lamps for use in backlighting LCDs.
Bruce Piaget, V.P. Sls.
973/696-5200, fax: 973/696-8298

THOMAS ELECTRONICS, INC., 208 Davis Parkway, Clyde, NY 14433

Manufacturers of CRTs and CRT assemblies for the military, industrial, and commercial marketplace. Applications include air-traffic control, avionics, medical imaging, simulations, photo-recording, and CHI. New products include flat fluorescent lamps for use in backlighting LCDs.
Bill Kuney, Sls. Engr.
515/923-2051, fax: 315/923-4401

THOMSON COMPONENTS & TUBES CORP., 40G Commerce Way, Totowa, NJ 07512

Manufacturers of color VGA 64-dpi flat plasma displays, monochrome high-resolution plasma panels, ruggedized color CRT monitors, 9-in. RGB projection CRTs, color beam index and monochrome avionic displays, and 26-in. diagonal plasma displays.

Jeffrey G. Ohstrom, Sls. Mgr., Optoelec. Products
201/812-9000, fax: 201/812-9050

THOMSON-CSF SERVICES INDUSTRIE, 105 Avenue de General Eisenhower #31023, Toulouse BP1009, France

Manufacturers of high-performance graphics generators and full-featured X-Window terminals that support 1280 x 1024 to 2048 x 2048 resolution and provide standard X11R6 software interface and high-speed drawing and pixel capabilities. A wide scope of interfaces are available (Ethernet, FDDI, PCI, etc.).
Alain M. Cousin, Bus. Dev. Mgr.
+33-1-4537-8937, fax: +33-1-4537-8938

THOMSON TUBES ELECTRONIQUES, 33, rue Vauthier, B.P. 305, Boulogne-Billancourt F-92102 France

Manufacturers of professional CRTs: very-high-resolution, head-up, head-down, helmet-mounted, projection, beam index, and ruggedized shadow-mask monitors; ac plasma displays (military and civil), color and monochrome with gray scale and high brightness. Models suitable for PC monitors.

P. Menes, Sls. & Mktg. Dir.
+33-1-4909-2828, fax: +33-1-4604-5209

3-D IMAGETEK CORP., 23701 Birchdr. Dr., Lake Forest, CA 92630

Manufacturers of the 3DP-2000/NVP (NTSC, VGA, PAL) for LC-based HMD or projector designs, which de-multiplexes and distributes left-eye/right-eye and stereoscopic 3-D video encoded in either field-sequential or line-segmentation (ENIGMA) formats; ASIC package in production quantities; NTSC/VGA and PAL/VGA compatibility to end-user products.
Craig M. Crawford, Pres.
714/455-1806, 1-800-355-5565
fax: 714/455-1990

3DTV CORP., P.O. Box Q, San Rafael, CA 94913-4316

Manufacturers/distributors of a wide variety of hardware and software for making and displaying stereoscopic video and computer graphics, ranging from low-cost consumer kits to professional systems.
Michael Starks, Pres.
415/479-3516, fax: 415/479-3316

THREE-FIVE SYSTEMS, INC., 1600 N. Desert Dr., Tempe, AZ 85281

Designers/manufacturers of user-interface devices for operational control and information-display functions in OEM products. Specializing in LCD and LED components and technology in providing custom design and manufacturing services for the communications, medical electronics, industrial process control, wireless data collection, and office automation marketplaces.
Bruce Sedlak, V.P. Sls.
602/389-8975, fax: 602/389-8801

3M, 3M Center, Bldg. 260-5N-10, St. Paul, MN 55144

Manufacturers of optical-enhancement films for use in transmissive, transreflective, reflective, and LCD projection displays. Films are designed to enhance brightness, increase power savings, and offer wide viewing angle.
Bill Hibbard, Sls. & Mkt. Mgr.
612/737-8686, 1-800-328-7098 x1
fax: 612/736-4503

3M ELECTRICAL SPECIALTIES DIV., Bldg. 130-3N-56, P.O. Box 2963, Austin, TX 78769-2963

Designers, manufacturers, and marketers of products for a variety of specialty electrical applications including control of static electricity, insulating tapes, resins and heat-shrink products.
Harry Borrelli, V.P.
1-800-328-1368, fax: 512/984-2211

3M ELECTRONIC PRODUCTS DIVISION, 3M Austin Center, 6801 River Place Blvd., Austin, TX 78726-9000

Manufacturers of electronic interconnects, assemblies, sockets, wire, and cable for all electronic/electrical applications.
512/984-1800, 1-800-225-5373 or 1-800-3M-HELPS, fax: 512/984-6972

3M OPTICAL SYSTEMS, 3M Center, Bldg. 225-4N-14, St. Paul, MN 55144-1000

Manufacturers of specialty optical films to control and enhance lighting for CRTs, LEDs, plasma displays, EL, and LCDs.
Mike Burns
612/733-4403, 1-800-553-9215
fax: 612/736-2298

3M PRODUCT INFORMATION CENTER, 3M Center, Bldg. 515-3N-06, St. Paul, MN 55144-1000

Manufacturers of commercial graphics, visual systems, sound products, and image-processing systems, components, and

equipment for the trade-show, display, POP, and promotional industries.
612/737-6501, 1-800-3M-HELPS
fax: 612/737-7117

TIMELINE, INC., 23605 Telo Ave., Torrance, CA 90505

Distributor of surplus inventories of LCDs, both graphic and alphanumeric; non-enclosed monitors; computer-related equipment.
Ron Klein
310/217-8912, fax: 310/532-6304

TNP INSTRUMENTS, INC., 20695 S. Western Ave., Suite #128, Gardena, CA 90249

Manufacturers of LCD probe station, laser repair systems, and thin-film, cell-gap, and CIE measuring systems for substrates up to 650 x 650 mm. Auto loader, auto focus, and motorize turret for fully automatic systems. Integrates with inspection systems and test instruments.
Vu Tran, Pres.
310/787-4620, fax: 310/787-4621

TODD CO GENERAL, INC., 7888 Silverton Ave., Ste. A, San Diego, CA 92126

Manufacturers of high-quality hot-bar bonding equipment used for production, rework, and repair or process development. Unique all-ceramic hot bars provide exceptional thermal distribution and flatness. Specializing in display attachment.
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619/549-9229, fax: 619/549-2162

TOKO AMERICA, INC., 1250 Feehanville Dr., Mt. Prospect, IL 60056

Manufacturers of miniature dc/dc converters for powering VFDs, modems, RS-232 interfaces, and other subsystems.
Tony Abarquez, Prod. Mgr.
312/297-0070, fax: 312/699-7864

TOKYO ELECTRON AMERICA, LTD., 20300 Stevens Creek Blvd., Ste. 380, Cupertino, CA 95014

Distributors of AMLCD plasma etching/ashing systems for single-substrate processing and AMLCD photoresist coater/developer systems which are capable of handling large substrates (maximum size, 550 x 650 mm).
Alex Kawano, Mktg. Mgr.
408/777-2600, fax: 408/777-2650

TOSHIBA AMERICA ELECTRONIC COMPONENTS, INC., 1060 Rincon Cir., San Jose, CA 95131

Manufacturers of color AMLCDs: medium-size 4-6-in. LCDs for navigational, visual, and entertainment; notebook-size 7.8-12.1-in. LCDs for portable computing; and large-size high-brightness 12.1-15-in. LCDs for desktop LCD monitors and industrial applications.
Cameron Zand, Sls. Engr.
408/456-8900, fax: 408/456-9002

TOSHIBA AMERICA ELECTRONIC COMPONENTS, INC., 1 Parkway North, Ste. 500, Deerfield, IL 60015-2547

Manufacturers of a wide range of passive b/w and active-matrix color LCDs; a full range of high-resolution color and monochrome CRTs; FS display tubes in 15, 17, and 21 in.
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TOSOH SMD, INC., 3600 Gantz Rd., Grove City, OH 43123-1895

Manufacturers of sputtering targets and evaporation sources in a wide variety of materials and custom materials for all sputtering and evaporation systems. Offers

research/development support, technical support, proprietary non-destructive testing data, and customer service support for all semiconductor, specialty, media, and FPD customers.

Michael W. Morris, Prod. Mgr.
614/875-7912, fax: 614/875-0031

TOTOKU ELECTRIC CO., LTD., 3-21, Okubo 1-Chome, Shinjuku-ku, Tokyo 169, Japan

Manufacturers of high-resolution monochrome and color CRT monitors and deflection yokes.

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fax: +81-3-5273-2092

TOUCH CONTROLS, INC., 4167 Auenida de la Plata, Bldg. 108, Oceanside, CA 92056

Manufacturers of 14-, 15-, 17-, and 20-in. CRTs; 9.4-, 10.4-, 12.1-, and 13.8-in. LCDs. NEMA-4X Class I, Division I and II.
David McKay, V.P. Sls./Mktg.
619/631-7911, 1-800-848-4385
fax: 619/631-7910

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fax: 408/720-9643

TRANSICOL, INC., 2650 General Armastead Dr., P.O. Box 9011, Valley Forge, PA 19485-9011

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215/539-4400, fax: 215/539-3400

TRIDENT MICROSYSTEMS, INC., 205 Ravendale Dr., Mountain View, CA 94043

Developers and marketers of high-performance graphical-user-interface accelerators, mixed-signal SVGA controller chips, LCD graphics controllers, double-byte character chipsets, and video-processing chipsets for video-windowing and desktop video production.
Mike Lollabaugh, Dir. N. Amer. Sls.
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TRONIX, INC., 31 Business Park Dr., P.O. Box 635, Branford, CT 06405

Manufacturers of high-voltage power supplies for x-ray image intensifiers.
J. Wood
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TRU-LYTE SYSTEMS, INC., 327 South Walnut Street, Beaver, PA 15009

Researchers of display and imaging technologies involving the use of fiber optics. Product lines under development include large-screen displays, high-definition television (HDTV), three-dimensional television systems (3D-TV), and head-up displays (HUDs).
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fax: 412/728-0778

TSG, 322 Lindbergh Ave., Livermore, CA 94550

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Jerry L. Martin, V.P.
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35 Orville Dr., Bohemia, NY 11716-2598
Manufacturers of high-resolution monochrome CRT display monitors.
Steven R. Sloan, Dir. Sls.
516/589-6800, fax: 516/589-6858

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Manufacturers of display windows and filters for all types of optoelectronic displays. Providing anti-glare hardcoats, contrast-enhancing lints, printed graphics, mounting adhesives, full CNC or laser fabrication, ITO or gold EMI shielding. Sheets also available.
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fax: 513/732-6988

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Klaus Ehrlich
510/734-8100, 510/734-8455

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419 Sargon Way, Horsham, PA 19044
Designers and manufacturers of hand-held terminals.
Joan Rickards, V.P. Sls.
215/441-5305

TYSON CONSULTING GROUP, 612 White Pine Rd., Buffalo Grove, IL 60089-3330
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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.
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914/892-1700, Fax: 914/892-1710

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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.
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fax: 404/664-4103

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ULVAC TECHNOLOGIES, INC.,
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Manufacturers of a line of evaporators for the FPD industry. The END Series of cluster tools and the EIH/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.
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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.
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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.
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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., Collegeville, PA 19426
Manufacturers of precision miniature metal components in 100 different alloys; specifically, oxide and dispenser cathode components.
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610/539-0700, 1-800-523-0441
fax: 610/489-2720

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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.
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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., Sloughton, 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), 4801 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, DESC, 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 color 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, Sls. 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. Sls.
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. Sls./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, autoperallactic 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, Sls./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, Sls. Engr.
203/256-4163, 1-800-962-6366
fax: 203/259-1194

VOLTRAC 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, CA 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, Sls. 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. Engr.
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 Ferrari, Bldg. A, MS 3-12, San Jose, CA 95138

Manufacturers of engineering copiers, printers, Versatec plotters, and supplies for document management.
Pamela Rivers, Mktg.
1-800-538-6477

XEROX IMAGING SYSTEMS,

535 Oakmead Parkway, Sunnyvale, CA 94086

Manufacturers and marketers of the Kurzweil intelligent scanning system for PCs, and data copy scanners and software imaging products for the Apple Mac and PCs.
408/245-7900, 1-800-248-8500
fax: 408/522-3800

XMR INC., 47281 Bayside Parkway, Fremont, CA 94538

Manufacturers of high-power industrial excimer lasers and laser-based systems for use in manufacturing high-definition display devices. Developed and proven processes for recrystallizing a-Si to poly-Si for improved AMLCD manufacturing.
Len Goldfine, Dir. Sls./Mktg.
510/668-1517, fax: 510/668-0169

XTEK ELECTRONICS, 27101 Aliso Creek Rd., Aliso Viejo, CA 92656

Distributor of LCDs specializing in VGA graphic displays. Design assistance and replacement displays available. Buyer of all types of LCDs and re-marketer at up to 50% off normal cost.
Randy Schafer, Pres.
714/448-9281

XYBION ELECTRONIC SYSTEMS, 8380 Miralani Dr., San Diego, CA 92126-4347

Manufacturers of low-light intensified gated CCD scientific imaging systems. Scientific-application video cameras and image-processing software, including

intensified, multispectral and gated video cameras. Integrated and cooled b/w and color cameras produced for the microscopy market.

Richard A. Sturz, Sls. Mgr.
619/566-7850, fax: 619/566-2032

YAMAHA SYSTEMS TECHNOLOGY, 100 Century Center Court, Suite 800, San Jose, CA 95112

Manufacturers of single-chip or board-level IBM VGA, EGA, CGA, MDA, and Hercules compatible graphics controllers for driving EL, plasma, LCD (color or monochrome), or CRT displays all from a single device.
Robert Starr, Natl. Sls./Mktg. Mgr.
408/437-3133, 1-800-543-7457
fax: 408/437-8791

YOUNG TECHNOLOGY, 48012 Fremont Blvd., Fremont, CA 95051

Manufacturers of a line of thermal press equipment used for bonding of heat-seal connectors for connecting flat-panel displays to PCBs.
Dan Fritsch, Sls. Engr.
510/490-6373, 1-800-394-6373
fax: 510/490-3214

CARL ZEISS, INC., Microscope Division, One Zeiss Dr., Thornwood, NY 10594

Manufacturers of advanced microscope systems for the testing, inspection, and measurement of all microelectronic components. Microscopes available for all applications including stereo, confocal, video, and fully automated systems. Also, image analysis software to support all applications.
Microscope Div.
1-800-233-2343, fax: 914/681-7446

ZENITH COMPONENTS GROUP, 1000 Milwaukee Ave., Glenview, IL 60025

Manufacturers of 5-19 in. (monochrome) and 9-25 in. (color) displays with a wide range of phosphors, face treatments, operating frequencies, and auxiliary power.
Robert Uhrir
708/391-7733, 1-800-827-8720
fax: 708/391-7078

ZENITH ELECTRONICS CORP., Rauland Div., 2407 W. North Ave., Melrose Park, IL 60160

Manufacturers of 19V, 20V, 25V, and 27V consumer-grade CRTs, with expansion to 17-in. conventional monitor tubes in 1997. Also, manufacturers of electron guns for both consumer and display-grade applications.
Richard Steinmetz, V.P. Tech. Sls./Mktg.
708/450-8306, fax: 708/450-8393

01 PRODUCTS, INC., 3050 Hillcrest Dr., Ste. 100, Westlake Village, CA 91362

Manufacturers of head-mounted display products designed for industrial, medical, and virtual-reality OEMs, featuring the PT-01 professional-use HMD, which permits extended use without eyestrain and provides multiple adjustments for user-selectable image placement.
Garrick Matheson, V.P. Mktg.
805/446-1453, 1-800-538-3008
fax: 805/373-8966

ZYTRONICS, INC., 70 Tirrell Hill Rd., Bedford, NH 03110

Manufacturers of high-quality low-to-medium-volume custom linear and switch-mode power supplies.
Kerry D. Smith, Dir. Mktg./Sls.
603/623-8888, 1-800-770-8880
fax: 603/623-4009

Directory notes

• Listings are free and without obligation. Companies advertising in this issue are listed in boldface type in both Parts I and II.

• 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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SEPTEMBER

17th International Display Research Conference
TORONTO, CANADA
SEPTEMBER 15 - 17, 1997

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

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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NOVEMBER

Third International Conference on the Science and Technology of Display Phosphors
HUNTINGTON BEACH, CALIFORNIA
NOVEMBER 3 - 5, 1997

- An international conference on the future prospects of phosphors for:
 - ELDs - FEDs
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97

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

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NOVEMBER 3 - 5, 1997

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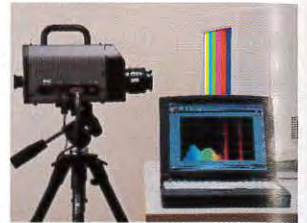
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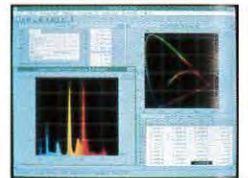
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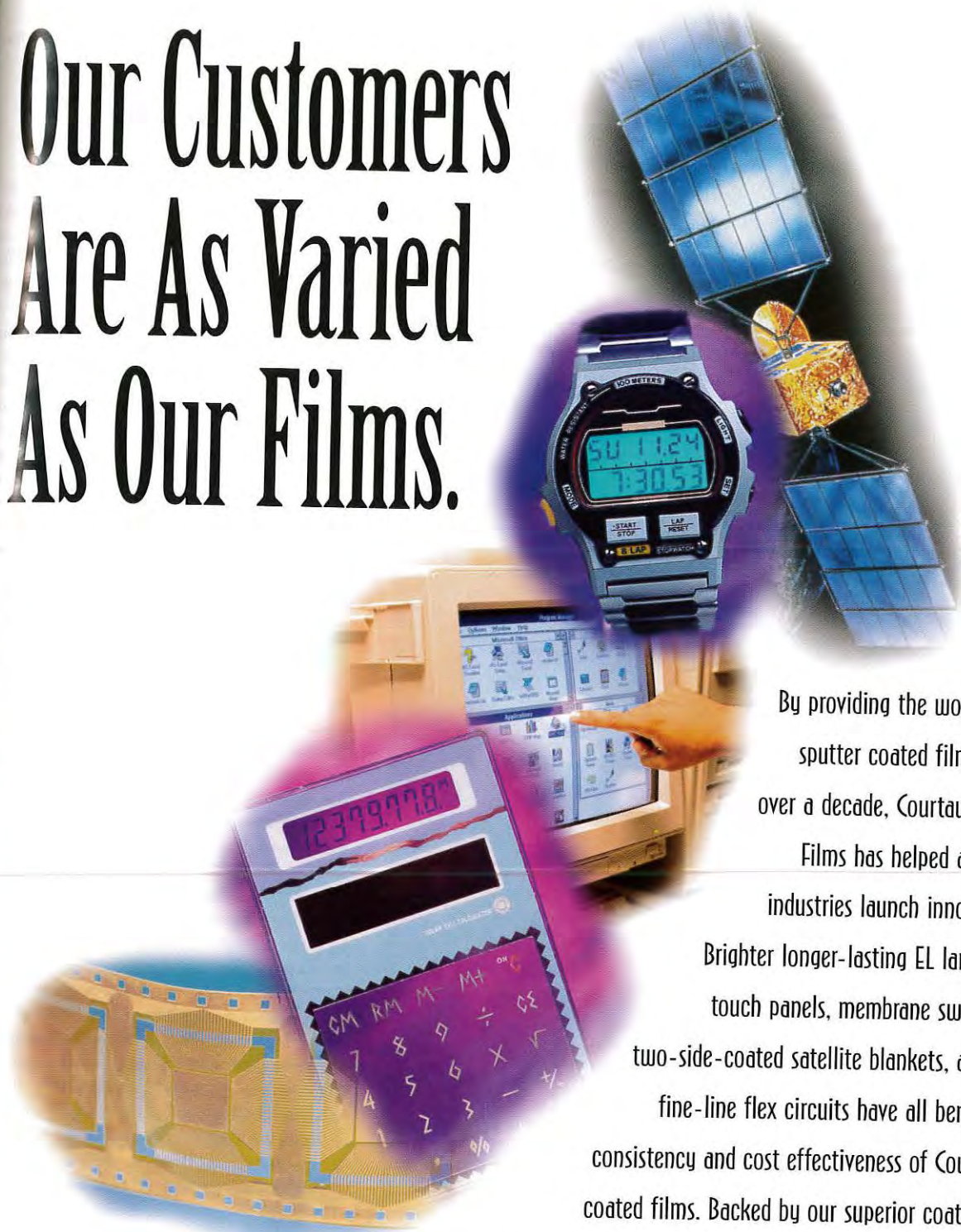


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display continuum

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



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Circle no. 37

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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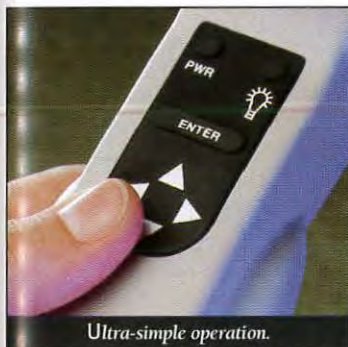
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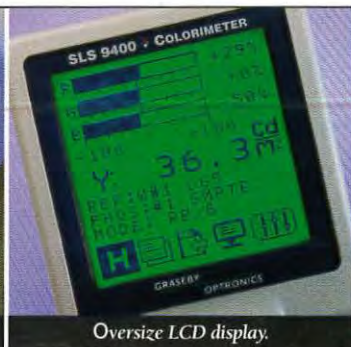
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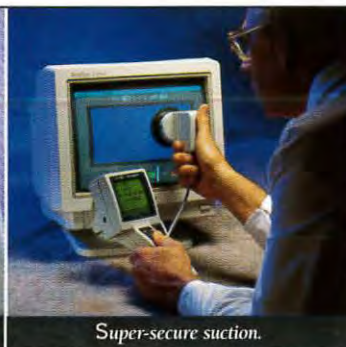
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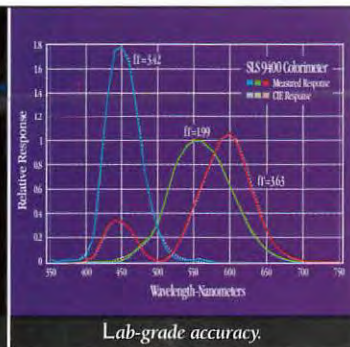
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Detroit Chapter to Sponsor FPD Strategic Forum and Technical Symposium

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

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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, somnolent 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
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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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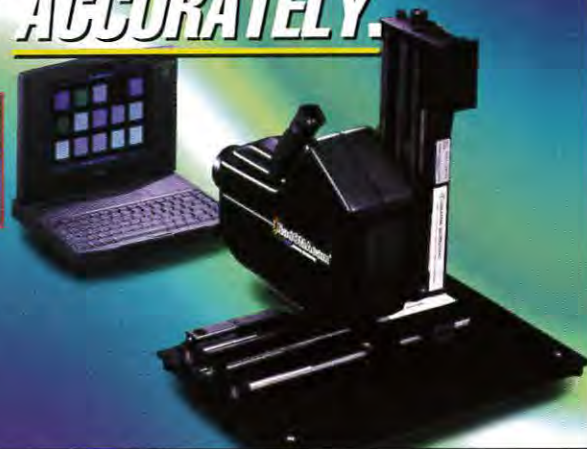
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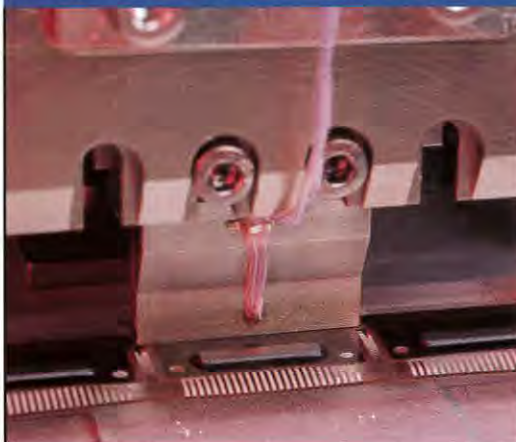
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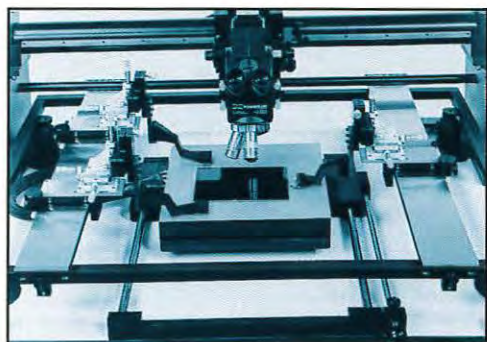
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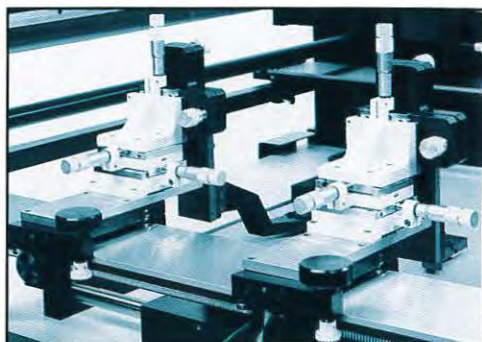
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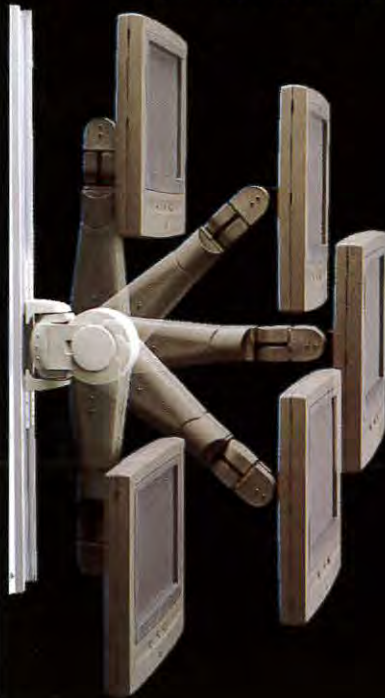
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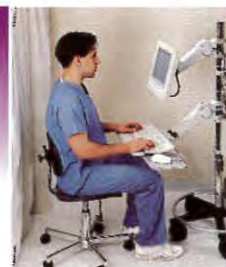
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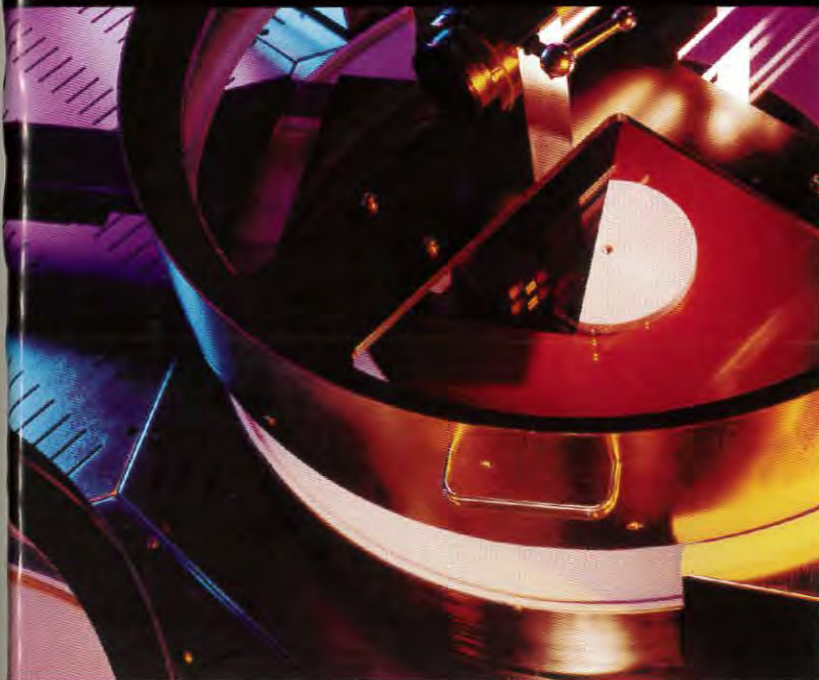
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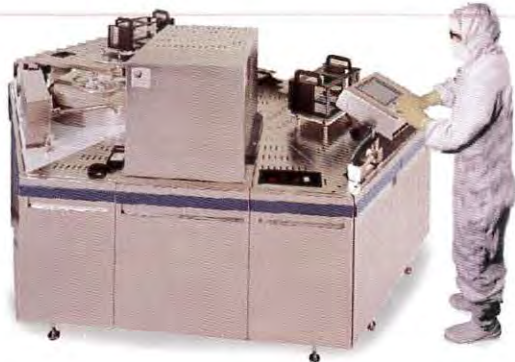
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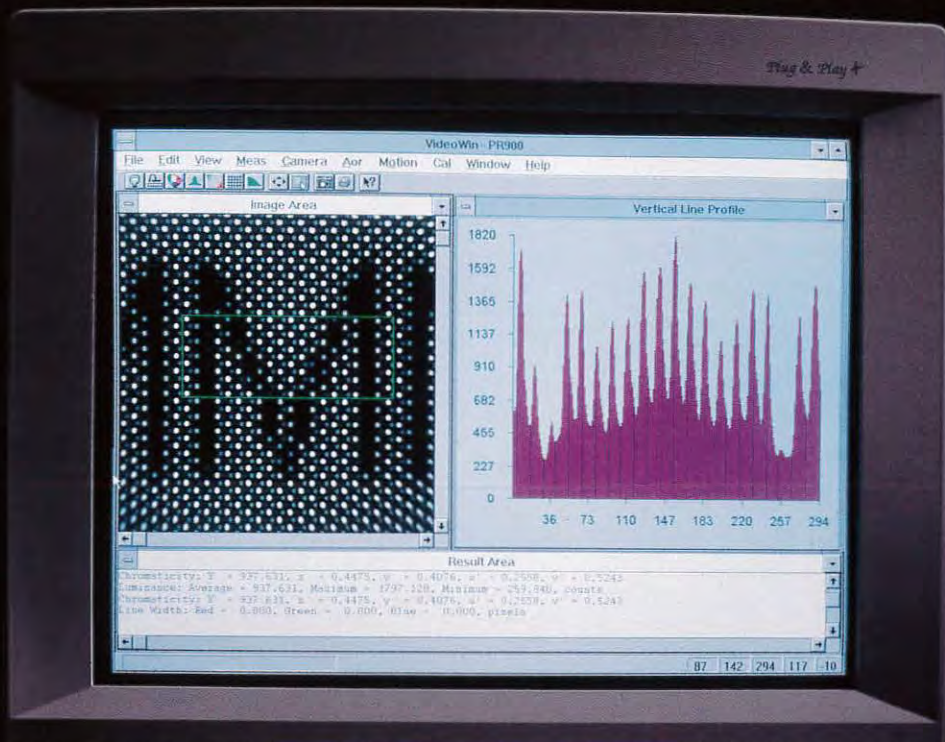
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