Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

April 1988
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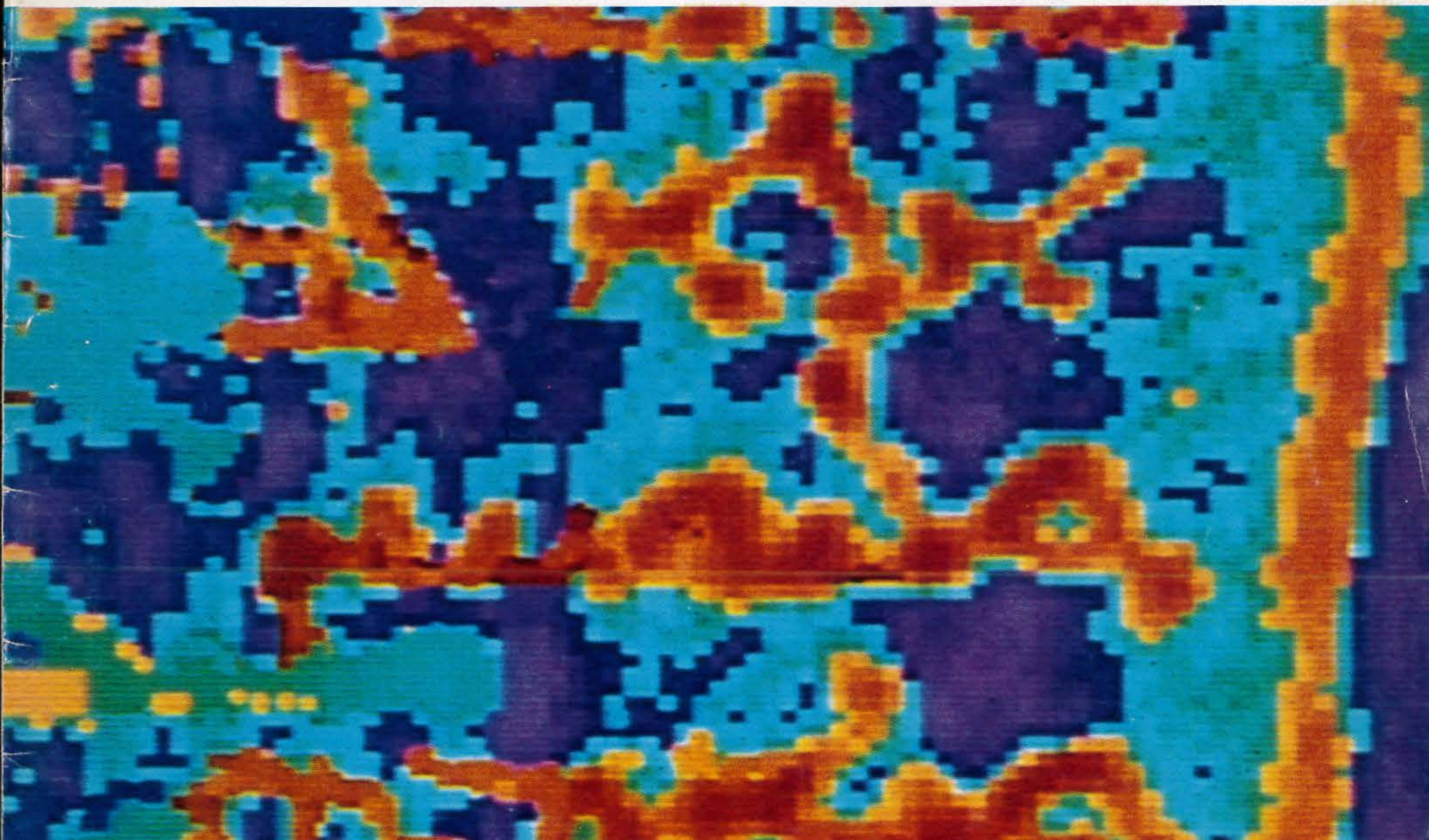

Displaying the Gospels
Portable plasma displays
Special report: DVI

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Cover: Pseudocolor reproduction of a page from a fourth-century text of the Gospels. The image has been enhanced to reveal traces of the original words, which exist beneath a later manuscript. *(page 14)*

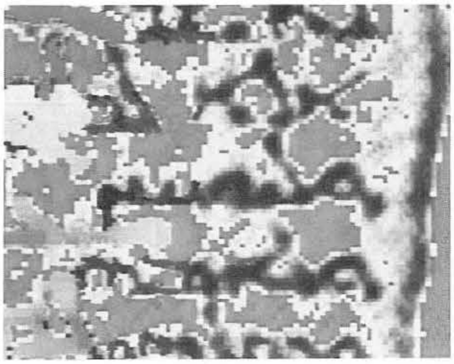

Photo: Greg Medvin, Microexpert Systems, Inc.

Next Month in Information Display

SID '88 Show Issue

- Economic display design
- Case study: using displays for market differentiation
- SID exhibit preview

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INFORMATION DISPLAY

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editorial

Though display technology continues to advance at a frenetic pace, it is a well-developed art, and displaying images is much less of a problem than storing them. The difficulty is not ignorance but the intimidating number of bits it takes to store images in digital form. When system cost is an important factor, brute force in the form of 100+ Mbyte hard discs and high-capacity data busses can not be used.

One of last year's most interesting technical developments was the David Sarnoff Research Center's announcement of Digital Video Interactive—a way of compressing images so a full 72 minutes of color motion video would fit on what is essentially an audio compact disc. But the technical prestidigitation only begins there. Bob Hurst and Arch Luther describe the system, its capabilities, and some early applications.

Storage and system costs were also critical when Microexpert, Inc., was asked to develop an imaging workstation to make visible the obliterated text of a fourth-century translation of the New Testament Gospels. Phil Borden recounts the document's history, which is as interesting as Microexpert's ultimate goal: workstations that will affordably bring to scholars in the humanities the benefits that scientists and engineers all but take for granted.

What storage is to digital video and digital imaging, drivers are to flat-panel displays—the hardware that makes an otherwise attractive technology too expensive for many applications. But Larry Weber sees reasons for optimism, particularly where plasma displays are concerned. Larry does not claim to be an objective commentator—in fact, he claims not to be—but as the developer of the independent sustain and address technique that cut the number of drivers needed for an ac plasma display in half, he is among our most knowledgeable and respected practitioners.

—Kenneth I. Werner

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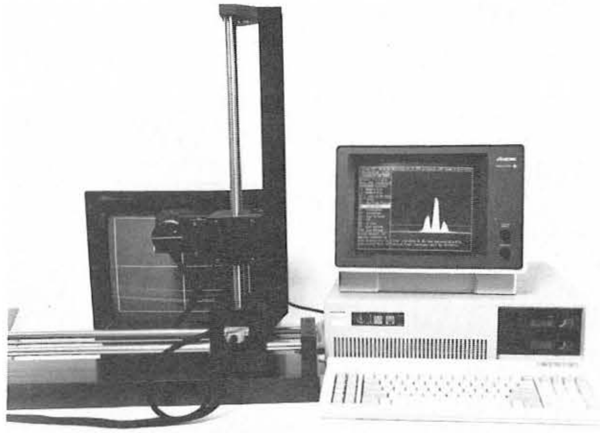

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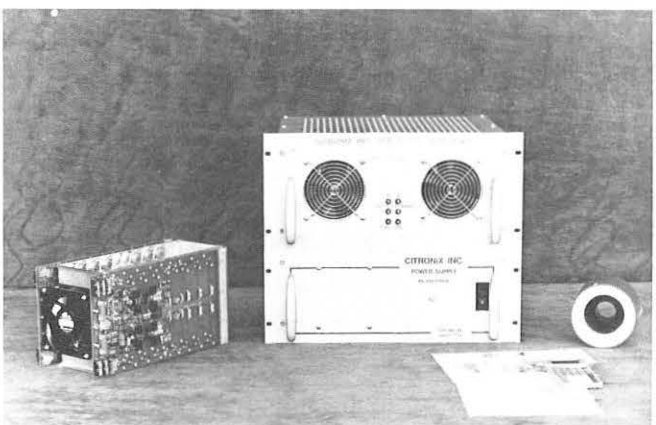

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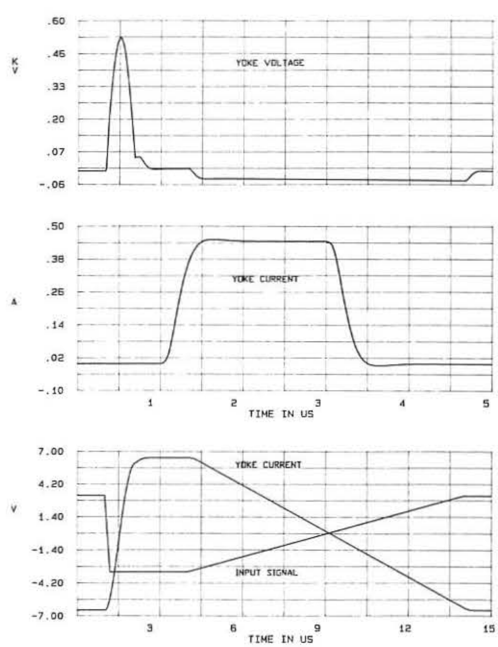

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Circle no. 6

DVI: digital video from a CD-ROM

BY ROBERT N. HURST AND ARCH C. LUTHER

EVER SINCE a Chinese sage commented on the relative worth of pictures and words, information-display specialists have been grateful for the power of the video display—and appalled at the high cost of presenting pictures to a viewer. But Digital Video Interactive (DVI) promises to reduce this cost and allow interaction between video information and its users.

In terms of modern technology, a picture is worth far more than 10,000 ASCII-coded words, which can be scrolled onto your word processor's screen using between 50 and 100 kbytes. A single frame on a TV screen needs from 300 to 600 kbytes, and adding motion to your video presentation brings you into the realm of data rates, which can run as high as 18,000 kbytes/sec. In contrast, a voice channel will talk to you quite clearly at less than 10 kbytes/sec. Between these two extremes lies the CD-ROM—a read-only memory for computers derived from the audio compact disc—which can deliver data at 150 kbytes/sec. This is a generous data rate for audio and gives us the stunning quality now available from audio CDs. But the data rate is orders of magnitude too low for putting normal motion video on an information-display screen.

*Robert N. Hurst is manager of DVI program development at GE Government Services, Cherry Hill, New Jersey. **Arch C. Luther** was formerly staff scientist at David Sarnoff Research Center, Princeton, New Jersey. He is now president of Arch Luther Associates, Merchantville, New Jersey.*

In 1984, engineers and scientists at RCA's David Sarnoff Research Center set out to show that, though it seemed impossible, full-screen full-motion video could be compressed into the limited data rate of a CD-ROM. In March 1987, at the Microsoft CD-ROM conference in Seattle, they demonstrated it is not only possible, but commercially practical. An audience of 1100 people cheered when a CD-ROM system presented several minutes of full-motion full-screen full-color video samples from the 72-min video capacity of its disc. FM-quality sound accompanied the video, and both audio and video together used only 150 kbytes/sec, or 5 kbytes per video frame. The system consisted of an IBM PC-AT personal computer fitted with a special video board, a special audio board, and an interface board for the CD-ROM drive. The CD-ROM drive itself was a standard unmodified Sony unit.

The information on the disc is stored using the same EFM digital code that is standard for both CD audio and CD-ROM. In fact, officials of 3M, the company that pressed the demonstration disc, declared they were unaware it was a video disc they had pressed until they saw the demonstration at Seattle.

The digital advantage

DVI's digital coding offers several benefits. First, one of the goals in devising DVI was to supplant the current incompatible menagerie of audio, video, and data sources with a single low-cost high-density medium. The result is a universal system that can handle not only video and audio, but also ASCII and binary codes, graphics, still pictures, audio, and sound over stills—any information now derived from tapes, discs, or diskettes in their various formats.

The second benefit is the ability to modify stored information as it is played back. Video from spatially-separated portions of the CD-ROM, for example, can be combined on screen to give a meaningful display, which would be a difficult undertaking with analog video systems.

Third, DVI can trade off among the various audio and video parameters to arrive at those that best suit the information being presented. A normal 30-frame-per-second motion video, for example, offers a 256 × 240 resolution—about the same as a VHS tape player. By cutting the frame rate in half, the user can improve the resolution to 360 × 340—about what you see on a good home TV set. By further dropping the frame rate, to 4 frames per second or below, the user can opt for 768 × 512—the resolution obtained from a broadcast-quality camera and monitor. The user selects the options.

Audio also benefits from the digital format. At 30 frames per second, about one-tenth of the bit rate is devoted to audio, and FM-quality stereo is the result. Users who choose to drop video altogether can obtain either 72 min of near-CD-quality audio or 40 hours of AM-quality audio. Another choice is eight independent audio channels, each containing up to 5 hours of program.

Putting a quart in a pint jar

The three keys to DVI are: (1) a set of video-compression algorithms that take the raw video from a camera, digitize it, and compress it to CD-ROM's capacity; (2) a pair of special VLSI chips that undo the compression in real time and display the results on a screen; and (3) the system integration, which permits flexible software control of both compression and chips.

The video compression does not run in real time. In the early days of the project, it took as much as 3 min to compress a single frame. The recent use of Meiko parallel-processing computers has brought that time down to 2 or 3 sec. Allen J. Korenjak, who heads up DVI compression research at the David Sarnoff Research Center, says that near-real-time presentation-level compression of images with today's quality is only a few years off. The algorithm set itself is a closely guarded secret.

The two VLSI chips that provide the real-time video display from the CD-ROM's data are Sarnoff-designed 2-μm CMOS chips that together contain over 265,000 transistors and operate at 12.5 MIPS—10 times the speed of a VAX minicomputer. The first of these chips is called VDP-1 (for video display processor). It receives the compressed video from the CD-ROM, decompresses it in real time (typically 30 frames per second) and passes it to the second chip, VDP-2, for display. The action of the chips is under software control, accomplished by loading microcode into VDP-1's on-chip random-access memory (RAM). VDP-1 spends the first part of a frame decompressing the video from the CD-ROM. Then, a 120-μsec infusion of microcode changes the chip's function from decompressor to graphics engine, and VDP-1 generates graphics to overlay the decompressed video. Reinstallation of the first microcode changes VDP-1 back to a decompressor, and the cycle is repeated

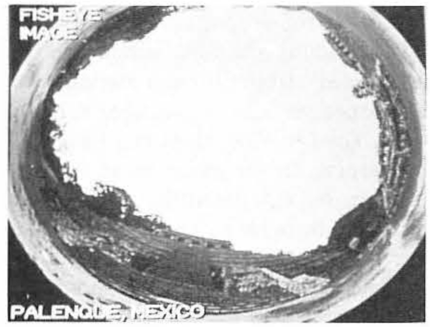


Fig. 1: Taking a photograph through a fish-eye lens pointed straight up produces a picture that is mostly sky, with the horizon wrapped around the periphery. The entire horizon, with the distortion removed, can be stored in only 12 still video frames on a DVI disc. With DVI's interactive capability, a viewer using a joystick can "roam" the horizon at will.

on the next frame. All this occurs behind the scenes, because the completed picture (video plus overlaid graphics) is handed off to VDP-2 for display.

The limits of imagination

In addition to the DVI system's obvious applications, many additional applications are, at first, not at all obvious. Collaboration with creative outside developers has shown that current limitations to developing new applications lie more in the human imagination than in the system itself.

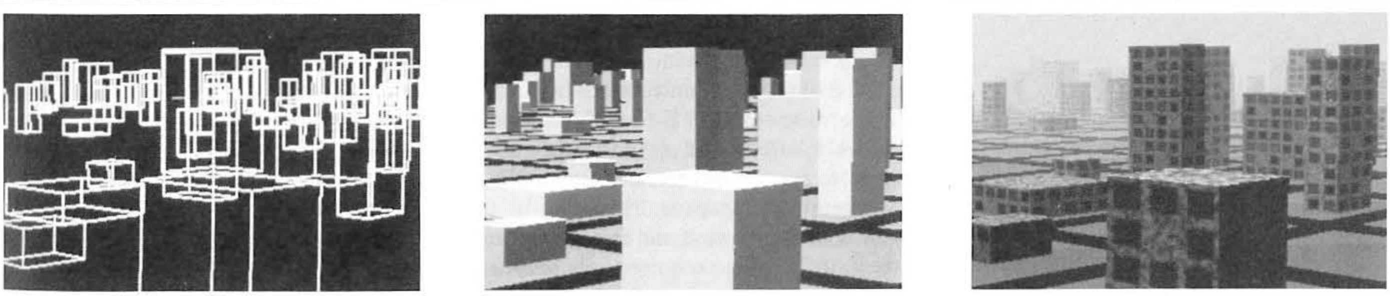
One of the more imaginative applications developed so far is the 360° user-controlled panorama. This effect is generated by fitting a fish-eye lens to a standard 35mm still camera, pointing the camera straight up, and taking a picture. The resulting view is mostly sky, with the entire horizon very distorted and wrapped around in a circle [Fig. 1]. The view is then digitized off line, the distortion is removed, and the entire horizon (with additional views above and below it) is stored in a dozen still frames on the CD-ROM. Using these images, the user can manipulate a joystick to look around, at will, anywhere on the horizon.

Because an extension of this technique was used to photograph the Mayan ruins at Palenque, on Mexico's Yucatan Peninsula, it has been dubbed Palenque by its developers, the Bank Street College of Education and the David Sarnoff Research Center. The extended technique uses not only the fish-eye lens, but also a special 16mm camera that shoots a single frame each time the cameraman takes a step. The result is a surrogate travel capability that is extraordinarily effective.

"Cartoonville" grows up

DVI can combine graphics and video in new and versatile ways. The familiar computer-graphics approach to generating a cityscape starts with wireframes and progressively adds colors and shading [Fig. 2a, b]. The result is a cartoon city that is not realistic but has the virtue of being viewable from any angle. The computer allows the viewer's apparent eye position to move simply by recalculating the vertices of the wireframes. In fact, the viewer can "walk around" the buildings in this "cartoonville."

DVI can add a new dimension to this cityscape by wrapping computer-model surfaces in actual video—a process called video texturing [Fig. 2c]. The building surfaces, the grass, and the roads can be fabricated from actual photographs of bricks, grass, and asphalt. The photographic samples are predistorted by a



(a) (b) (c)

Fig. 2: Building a computer-graphic city often starts with wireframes (a), which are then colored and shaded (b). It is not realistic, but the view from a new angle can be quickly calculated. "Video texturing" (c) wraps surface patterns around the computer-graphic model for a new level of realism without great demands on storage capabilities. The patterns are derived from photographs, stored on the DVI disc, and "wrapped" to each surface to simulate the appropriate perspective view.

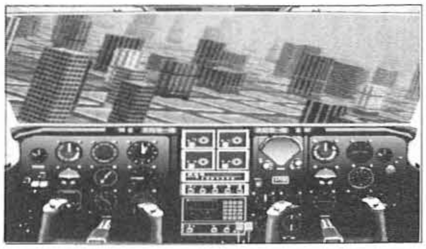
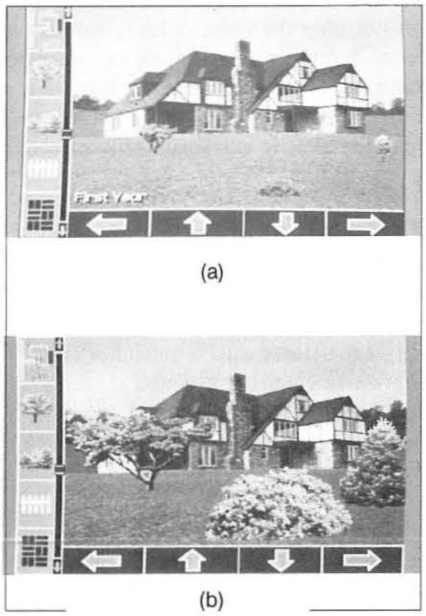


Fig. 3: DVI's fast video display processors can recalculate the warps for an entire screen several times a second, permitting highly realistic flight simulators.



(a)

(b)

Fig. 4: Plant images derived from photographs can be stored on a DVI disc and extended, repeated, and enlarged at will. With the proper programming, the future appearance of landscaping can be presented, for example, one year (a) and five years (b) after planting.

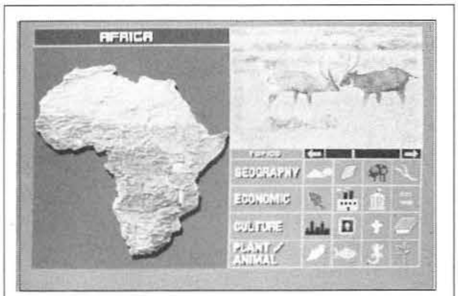


Fig. 5: DVI can serve as an interactive multimedia textbook. Here, a full-motion video shares a screen with a menu and static map of Africa—a trick that nearly quadruples the disc's capacity.

warp algorithm so they fit the wireframe surfaces at the proper angles and aspects.

The resulting video-like simulation can be "viewed" from different angles, with the warped surfaces recalculated for each angle. The fast VDP chips can recalculate the warping for the entire image several times per second, permitting the illusion of driving through a city, or even flying over it [Fig. 3]. The resulting flight simulator can be very realistic and much lower in cost than normal video-like simulations.

The digitized house

Video texturing also provides new ways of designing a house's grounds and interior. Visualizing the future appearance of plantings is a perennial problem in landscape design. With DVI, images of blossoms and foliage can be generated from photographs and repeated, extended, and sized as needed [Fig. 4].

Inside the house, a homeowner can choose furniture from a video catalog, place it in a video room, and view the room from any angle. If he or she doesn't like the fabric on the couch, another covering can be chosen from the catalog and instantly laid over the couch. This application, called Design and Decorate, was jointly developed with Videodisc Publishing, Inc.

The dynamic textbook

A mixture of media is usually the most effective way to convey information to students—an application for which DVI is ideally suited. A static map of Africa, for instance, and a menu can occupy three-quarters of a screen, while a motion video of an African scene can occupy the remaining one-quarter [Fig. 5].

If this combination of motionless and moving video were shown from a standard analog video disc, the disc would have to run at its normal 30 frames per second, even though three-quarters of the screen is stationary. With DVI, the map is recorded once, using only a half-frame's worth of disc space. It is then dumped into a RAM buffer, and played to the display screen from there, using a negligible amount of disc space. The menu is handled the same way, and the quarter-screen motion video requires only one-quarter of the disc space of a full-screen motion segment. In situations like this one, where three-quarters of the screen is static or changes only infrequently, the disc capacity is quadrupled from 72 min to 4 ¾ hours.

For vocational training, the menu can be replaced by a graphic of, for example, a fuel pump. Using soft controls alongside the graphic, the student could rotate the pump to view it from any angle or request a slow-motion demonstration of its action. Then, on command, the upper part of the screen could show a motion video of an experienced mechanic installing a fuel pump.

Less storage when frozen

Since a CD-ROM loaded with DVI video provides more than twice the running time of the older 12-in. analog disc, one might surmise that it would hold nearly 130,000 still frames. But this is not so because part of the DVI motion-video compression is based on frame-to-frame similarity of motion video. This similarity is missing in still-frame recording, so a still frame takes nearly three times the disc space of a motion frame. Also, still frames often call for higher resolution, which can take another factor of 4. Consequently, a DVI disc can store on a single side up to 40,000 still frames of VHS quality, and up to 10,000 still frames at 512 × 480.

Stills are ideal for many applications, but often require an accompanying audio commentary. In the older analog discs, this facility required a considerable added financial investment, but audio with still frames is intrinsic to DVI's digital nature. A disc that is half video (5000 high-quality stills) can hold 20 hours of AM-quality audio, for an average of 14 sec of commentary with each still frame. Two 20-hour DVI disc sides could provide the equivalent of a college course meeting 3 hours per week for 13 weeks, with an hour's space left over to administer the final exam!

Not by compact discs alone

Though CD-ROM is an attractive medium for storing DVI, any digital recording device will work. For example, one of the 800-Mbyte WORMS now available can store 1½ hours of motion video, or 13,000 high-resolution stills. A 40-Mbyte hard disc can hold 4.5 min of motion video or 700 high-resolution stills.

DVI's efficient compression makes it desirable to store multiple frames in RAM, with the system playing and manipulating the video from this more versatile source. The 12 frames of the Palenque (360° panorama) application can be stored in 180K of RAM; if the

continued on page 17

Plasma displays for portable computers

BY LARRY F. WEBER

NINETEEN EIGHTY-SEVEN was a very good year for plasma displays. Their widespread acceptance in top-of-the-line transportable personal computers such as the Toshiba T-3100 and Compaq Model III—which use plasma displays from Matsushita and Oki—pushed worldwide shipments of page-sized plasma displays above 500,000 per year. This success is due in large measure to the high brightness, fast response, and wide viewing angle quality of emissive plasma displays compared to the most popular alternative—liquid-crystal displays. The days are gone when customers will accept a low-quality display in a high-end portable computer. This article is a highly personal view of how plasma displays will become increasingly competitive in consumer products.

Competition in flatland

There are four major flat-panel technologies for portable computers—liquid crystal (LC), plasma, electroluminescent (EL), and vacuum fluorescent (VF)—and the competition among them is fierce. Liquid crystals lead in dollar sales, with plasma displays number two and gaining. EL and VF are a distant third and fourth, but many observers feel they have a promising future.

Larry F. Weber is a research associate professor at the Computer-based Education Research Laboratory of the University of Illinois at Urbana-Champaign, Urbana, Illinois, and senior vice president of Plasmaco in Kingston, New York, which recently acquired IBM's plasma display manufacturing plant.

Liquid crystals have recently made significant gains in image quality by using the supertwist birefringent effect (SBE) to increase multiplexability and viewing angle. A second major advance is the use of a backlight to give LCDs the appearance of an emissive display. But liquid crystal's dominant position in portable computers is vulnerable because of LC's slow response time, which prevents the high-quality display of moving graphic images. This can handicap even simple word processing, where a moving character such as a mouse cursor leaves a distracting trail across the screen.

Power to the panel—but not too much

Low power consumption by the display is critical for long battery life in portable computers. The addition of backlights to LCDs, though critical for acceptable display quality, has greatly reduced the LCD's power advantage. In fact, the luminous efficiency of an LCD with backlighting becomes comparable to that of a plasma display's gas discharge, so a properly designed plasma display should have a power consumption comparable to a backlit LCD. This is contrary to plasma's reputation for being a power hog, a reputation that has perpetuated itself by discouraging designers from optimizing plasma panel designs for battery operation.

Many images could consume less power on a plasma panel than on a backlit LCD because a plasma panel consumes power in direct proportion to how many pixels are lit. A backlit LCD, on the other hand, consumes nearly the same power for all images because most of the power is consumed by the continually operating backlight. If the two displays have equal luminous efficiency, the plasma panel will consume one-quarter the power of the LCD when displaying a typical page of text, which has only one-quarter of the pixels lit.

Any lingering deficiencies in power consumption of plasma displays are no longer sufficient to prevent their use in battery operated portable computers, as evidenced by the GRiDCase 1500 portable by GRiD Systems, which uses a plasma display manufactured by NEC. This is due, in part, to the increasing use of hard discs and large random-access memories that makes the overall power consumption larger, so the system's overall power budget is less sensitive to the consumption of the display.

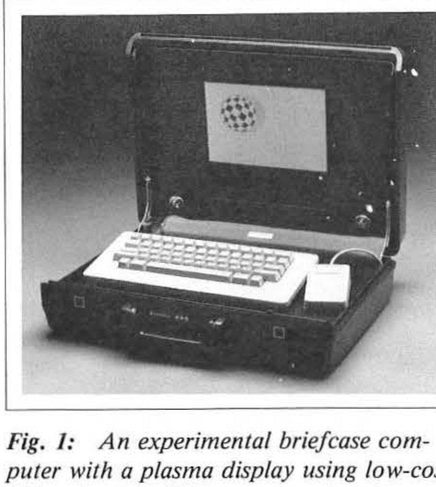


***Fig. 1:** An experimental briefcase computer with a plasma display using low-cost drive circuitry. The computer functions as an Apple Macintosh.*

Ac vs. dc plasmas

Plasma displays come in two flavors: ac and dc. Dc displays use an external resistor to limit the gas discharge current and prevent a destructive arc, and ac displays use an internal capacitor. Metal electrodes are in direct contact with the panel's internal neon gas in dc displays; a thin dielectric separates the gas and electrodes in ac versions. The dielectric layer forms the capacitor, and can be used to store charge at each pixel site, which gives ac displays inherent memory. This memory provides flicker-free displays without refreshing. Because the selected pixels in these displays are always held ON by the memory, they maintain their high brightness no matter how many display lines must be scanned. This has allowed the production of displays with 2048 × 2048 pixels that measure 1.5 m on the diagonal.

The ac plasma panel has the longest history of all flat-panel displays—the first full-page computer graphic plasma display was produced in 1971—but dc panels are responsible for today's high sales volume. This has been achieved by the consistent and aggressive marketing of manufacturers such as Matsushita and Oki, who have cut prices to build volume production, setting the plasma display industry on the road to success.

But there is no fundamental reason why ac panels must remain more expensive than their dc cousins, and ac plasma displays are generally considered to have higher brightness, a much wider viewing angle, and freedom from the flicker sometimes seen on dc displays. Most important for portable applications is that the luminous efficiency of the ac gas discharge is more than twice that of the dc discharge.

The color of money

Image quality and power consumption are important factors in determining a display's acceptability in portable computers, but the most important factor is price. All flat-panel displays suffer a large price penalty when compared to the king of displays, the CRT, and the reason is simple arithmetic. A 640 × 400 flat-panel display takes 640 plus 400, or 1040, drive circuits, compared to roughly 10 for the CRT. This huge disparity is the main reason flat panels cost 3-10 times as much as CRTs. Careful integrated circuit (IC) design can mitigate this disadvantage but is unlikely to eliminate it. Because the cost of a flat-panel device itself should be comparable to that of a CRT when they are produced in similar volumes, the strategy for low-cost flat panels must be to find more attractive electronic circuit designs.

It is here that plasma panels have an advantage over other flat displays. The gas discharge itself is rich in switching phenomena that can perform multiplexing and logic operations. The challenge to display designers is to find those phenomena that will reduce the cost of driver circuits while maintaining the performance and low manufacturing cost of the display device.

The Holy Grail

An experimental briefcase computer developed by the University of Illinois' plasma display research group is based on new low-cost drive circuitry [Fig. 1]. Functionally, the computer is an Apple Macintosh, but the conventional CRT

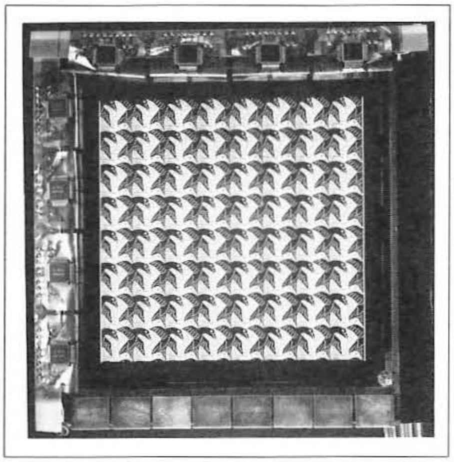


Fig. 2: The plasma panel and address drive circuits used in the briefcase computer. Only 8 Supertex HV03 high-voltage IC drivers (each of which consists of 64 n-channel open-drain high-voltage transistors and the associated shift register), are needed to address this 512×512 panel.

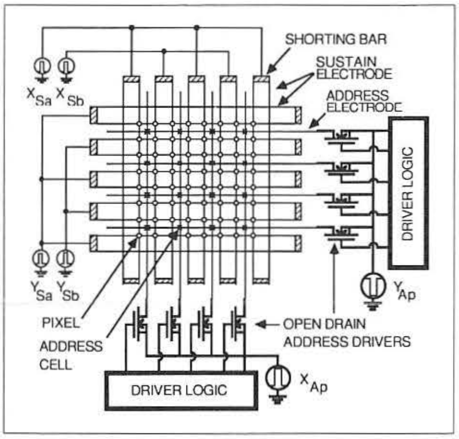


Fig. 3: The new ISA technique uses separate electrodes for addressing the pixels and sustaining them once they are on. The 64 pixels of this array (open circles) are located at the intersections of the sustain electrodes, which are bussed together and eventually connect to one of the four sustain generators (X_{Sa}, X_{Sb}, Y_{Sa}, Y_{Sb}) that supply power to the discharging pixels. The pixels are addressed through address cells at the intersections of the address electrodes (marked with small x's), which connect to the address drivers. Each address cell can control any of the four pixels that surround it depending on the phasing of the four sustain generators, thanks to a gas-discharge switching phenomenon that exploits a highly conductive plasma finger extending from the address cell to alter the wall charge of the nearby pixels. Only four sustain generators are needed for an ISA panel, regardless of size.

video interface drives a 512 × 512 plasma panel through the panel's electronics. The display requires only eight off-the-shelf IC drivers [Fig. 2].

There are 8 × 64, or 512, circuit driver connections to the panel—one-half the normal number. This reduction in drivers is achieved with a simple gas-discharge logic-multiplexing technique that uses the standard ac plasma device structure. The device can be manufactured with any existing ac plasma device manufacturing facility by simply changing the electrode mask to one with a new pattern, which incurs no change in manufacturing costs. This is the design engineer's Holy Grail: a considerable reduction in circuit cost with no increase in device manufacturing cost. We call it independent sustain and address—ISA.[1]

How ISA works

Independent sustain and address differs from the conventional ac plasma panel design in having independent electrodes for the addressing function and for the power-supplying, or sustaining, function [Fig. 3] instead of a common set of electrodes for both functions. The technique's first benefit is the reduction of address drivers by a factor of 2 because an address electrode need only be placed between every other sustain electrode. (Only four x-axis drivers and four y-axis drivers are needed to control the 8 × 8 array of pixels in Fig. 3.)

The second advantage is a significant reduction in the drive current required of the address drivers, further reducing driver costs. This occurs because the driver is now relieved of having to bear the high load of the peak sustain current when all the pixels along the electrode are on, which is the case in conventional panels. In ISA panels, the peak sustain current does not flow through the address driver, but flows instead directly to the low-impedance sustain generator. The reduced requirement for address driver current translates to a smaller silicon area for each driver's output transistors, which means lower cost.

Interestingly, the Supertex HV03 drivers used in the Illinois prototype panel were designed as row drivers for ac EL displays and can supply 10 times the current needed to drive the ISA plasma panel. Redesigning these drivers with smaller output transistors offers considerably cost savings.

The large difference in current requirements between drivers for plasma

continued on page 20

Displaying the Gospels

BY PHILIP BORDEN AND JEFFREY WIKE

TWELVE HUNDRED years ago, a monk used a knife and pumice to scrape and polish the ink from an old codex—a kind of book—so he could reuse the parchment for inscribing a copy of *The Lives of the Female Saints*. The words he erased were four centuries old at the time, and are now known to be the oldest translation of the four Gospels of the New Testament from Greek into Sinaitic Syriac, a dialect of the Aramaic spoken by Jesus.

Bruce Zuckerman of the West Semitic Research Project at the University of Southern California and his brother Ken, arguably the best manuscript photographers in the world, carefully photographed the codex at the monastery of Saint Catherine, which was built by the emperor Justinian on the slopes of Mount Sinai in the sixth century. Each page was photographed 13 times—under infrared, ultraviolet, and visible light, with different filtering and on different films. The photos made some of the erased text directly visible, but not enough to make the codex suitable for extensive study. It would take modern image processing and biblical-scholar-friendly software (at a price poorly funded researchers could afford) to revivify the syllables and cadences of Jesus' words much as he actually spoke them.

Philip Borden is vice president of Microexpert Systems, Inc., Calabasas, California. Jeffrey Wike is Microexpert's manager of intelligent imaging. Their interests in artificial intelligence include research in a computer-vision-based expert decision system for docking the space shuttle and several simulation-oriented intelligent tutoring systems.

Bits of gospel

So the West Semitic Research Project and Princeton Theological Seminary, the project's primary sponsor, asked Microexpert, Inc., to digitize and enhance the Zuckermans' photographs of what is formally known as Codex Syriacus 30, one of the three oldest existing Gospels.[1]

Making the erased and overwritten text readable required complex algorithms under the interactive control of the scholars working on the manuscript. The principal technical challenges were intensified by the document's advanced age. Much of Syriacus is crinkled, yellowed, partially destroyed, or water stained. The undertext always appears faint, broken, hidden, or blurred. Because the scholars needed a tool that would let them "play with" the images, we had to create a user interface as simple as the computational program was complex.

High power from cheap iron

To minimize hardware costs, we adapted the IBM PC already owned by the West Semitic Research Project by fitting it with Imaging Technology, Inc.'s powerful but inexpensive PCVision image processing add-on board for grabbing and buffering images. Keeping the cost of input and output down required a no-frills camera having sufficient quality and an appropriate RGB monitor to display the results. In each case, a stable image with 512-line resolution was considered adequate. A video surveillance camera solved the input issue, and an off-the-shelf RGB monitor satisfied the display requirements.

The most difficult hardware challenge proved to be finding a storage medium large enough both to hold interim working documents and to archive final results. This was not trivial. Each page required from ¼ Mbyte to over 5 Mbytes of storage, and the codex was nearly 400 pages long. No traditional magnetic storage device solved the problem, and the eraseable optical disc is not yet a commercial reality. We therefore developed a proprietary compression method called bit cell modulation. The approach was implemented in a PC-compatible device we named Video Slate, which stores over 1000 images on a removable Syquist 10-Mbyte hard disc.[2]

Video Slate can store images from the usual variety of input sources in less than one-half second, retrieve them randomly, and deliver them to a screen or printer in about two-tenths of a second—speeds that could make the approach useful for animated simulations, as well as for imaging and graphics. The images can be retrieved individually or in any of a variety of programmed sequences. Preliminary experiments indicate that this form of storage does not produce significant losses in image quality. Video Slate is a relatively modest capital outlay at $3000, and storage costs about seven cents per image. It integrates well with Imaging Technology's image processing hardware. The total system cost, excluding the personal computer, was less than $10,000.

Software processes the image

Syriacus 30 frequently presented an

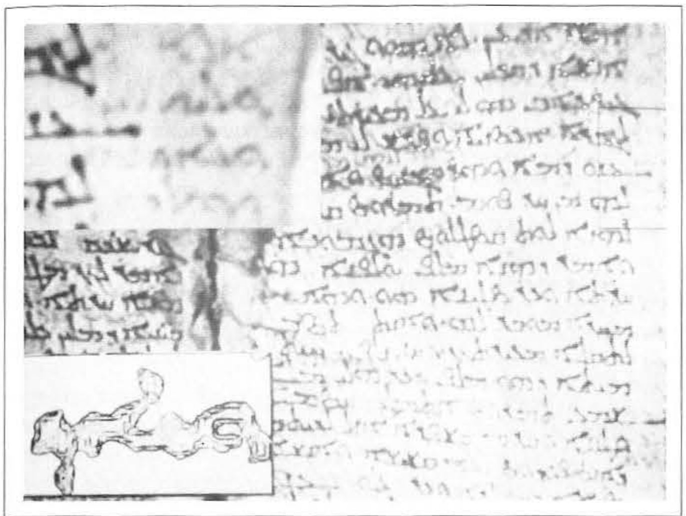


Photo: Mary Kate Denny

Fig. 1: A page of one of the oldest known versions of the Gospels of the New Testament, which was erased and overwritten about A.D. *800. The boxed word in the upper right, which was only partially overwritten, has been selected, equalized, magnified, and placed in the inset (upper left). The second inset (lower left) shows the word magnified further and enhanced by several techniques applied sequentially.*

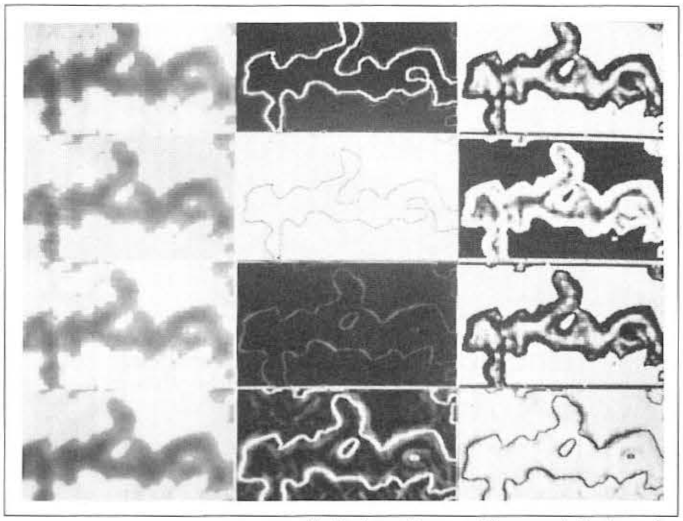


Photo: Larry Somers, Microexpert Systems, Inc.

Fig. 2: The word of Fig. 1 is here enhanced using 12 different algorithms and displayed on the monitor using 12 simultaneous windows. This reproduction lacks the pseudocolor visible on the monitor.

obscured and fuzzy undertext, which is what we were trying to make visible, so our first task was to distinguish the text as clearly as possible from its noisy background—the random crinkles and inconsistencies in the partially destroyed vellum.

Each page's photograph was digitized by taking multiple video images of it. We then averaged and intensified the brightness values for each pixel in order to remove the worst of the patterned interference. The quality of the image was then equalized over the page.

Text processing could now proceed, but two separate strategies were needed. Where the undertext was entirely overwritten and no whole undertext words existed, it was necessary to visually remove the overtext without losing information about the undertext. Along page edges, where there was no overtext and whole words could sometimes be found, the requirement was to retrieve and read faint and fractured ghost images. The successful demonstration that both strategies can actually be implemented has given us confidence that the image-understanding problem can be solved in general.

Now you see it . . .

The visual removal of overtext first requires shrinking the size of each overwritten letter as much as possible, which can be done once its edges have been accurately determined. The next step is changing the color of the overtext to the color of the background. This process makes the overtext itself invisible but leaves "halos"—dark rings surrounding the places where overprint used to be—which makes it difficult to determine where the underprint begins. Further processing "grows" the background over the halo edges and eliminates them.

The second strategy focused on individual words, which the scholars had to examine in great detail. With each manuscript page containing up to 400 words, each letter in a digitized word contained no more than 20 × 10 pixels—too few to obtain the desired effect by simply making the undertext larger and darker. The result would look like words spelled out by a Babylonian football card cheering section. We had to distort the image to make it bigger and bolder, then reconstruct its original smoothness to create a word that was visually more accurate.

But first, it was necessary to enhance the underprint. Using one of the ITEX/PC library subroutines supplied with the PCVision board, a histogram of pixel intensities was constructed that revealed different thresholds for overprint and underprint. Replacing low-valued (dark) pixels with high-valued ones, and medium-valued (light undertertext) pixels with low-valued ones brought the undertext to the surface and de-emphasized the overtext. It was then possible to enlarge the image by a factor of 3 to produce words about 2 in. high—large enough to be viewed comfortably on the monitor.

The next step was designing image processing procedures that created readable words, one at a time. Because different representation and enhancement algorithms highlight different aspects of word images, we decided to create up to 12 windows on the screen at once. Each window can hold the original word processed by a different set of algorithms (or a different ordering of the same set), allowing immediate visual comparison. Some of these images favor overall contours, others indicate area intensities with pseudocolor, yet others reverse the background and foreground or create or destroy ligatures, and so on.

An initial plan to combine expert rules from Aramaic grammars with image-understanding techniques developed elsewhere to "guess" at letters was rejected by the user-scholars, who wanted to keep complete control of the decision-making process in human hands. With the storage capacity provided by Video Slate, they can not only save their data and "final choices," but can also compare similar letters and words from various parts of the manuscript.

In search of scholar-friendly imaging

The hardware we've assembled cannot be said to be a tool for users, except in the grossest sense. The filters that have been designed, as effective as they are, will

become tools only when they are transformed from algorithms and matrices named for their inventors into natural-language instructions or icons that are easy to understand and that conform to the experience and customary methodology of the scholars using them.

In addition to tools for extracting, magnifying, clarifying, and enhancing the underprint, a full tool set would include those for zooming and panning across the page, comparing letters to other letters or graphically imposed templates, and drawing and scaling. The result will be a document-analysis workstation that scholars in ancient history should find useful across a spectrum of tasks that call for the interaction of informed sensibility and sophisticated computation at reasonable cost. Our goal is to bring to researchers in the humanities the benefits of workstation technology that are commonplace in the sciences.

Notes

[1]The data, partial funding, and some of the equipment for this work were provided by Professor Bruce Zuckerman of the West Semitic Research Project and Imaging Technology, Inc.

[2]These images contain less information than a general full-color video frame, so the frame-storage–capacity figures are not directly comparable to those for DVI in the accompanying article by Bob Hurst and Arch Luther. ■

DVI

continued from page 10

video were not compressed, it would require 7200K of RAM.

DVI for the holidays

DVI has already excited so much interest in the video and graphics community that nearly 100 companies have requested participation in the first wave of commercial applications. Military and government agencies are also interested. According to GE/RCA, DVI boards and software should be available by the third quarter of 1988, and we should be seeing applications by the end of the year. ■

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Display Standards Committee Is Formed

A committee on definitions and standards for displays is being formed. It is expected to cover the specifications and measurement methods for evaluating display performance parameters. Anyone interested in participating on the committee or having suggestions for needed standards should contact:

Peter A. Keller, Chairman
SID Definitions/Standards Committee
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The first meeting will be held during the 1988 SID Symposium.

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plasma portables

continued from page 13

and EL panels stems from a difference in capacitance—that of EL devices being 1000 times that of plasma devices. The reasons are straightforward. The gas gap of a plasma panel is typically 100 μm thick and has a dielectric constant of 1. The EL panel phosphor is typically only 1 μm thick with a dielectric constant of 10. The low current requirements of the ISA plasma panel will keep it competitive with the other flat-panel technologies.

The absent-minded professor

Following a lecture, engineering students like to embarrass their professors by asking when their wonderful theories will appear in a product. For plasma displays, the University of Illinois has established an industrial affiliates program that is supporting both the research and technology-transfer initiatives. Several industrial development efforts are now implementing these ideas in products.

I am personally participating in one of these efforts—the startup firm Plasmaco in Kingston, New York, which recently acquired the IBM ac plasma display manufacturing facility. The plant can produce 640 × 400 pixel panels at the rate of 250,000 per year. Plasmaco also acquired the exclusive license to the manufacturing know-how IBM acquired during the 20 years they conducted research and development on ac plasma displays. We will, in addition, license from the University of Illinois the circuit design for ISA (and also that for an energy-recovery sustainer) to produce what we anticipate will be a low-cost, low-power, and highly competitive flat-panel display.

Plasma's warm glow

Reduced power consumption and lower circuit costs promise to make plasma displays highly competitive in today's flat-panel market. In addition, plasma technology seems well-suited for developing trends.

The first of these is the increasing demand for higher-resolution displays with more pixels to accommodate multitasking and graphics. The day is not too far-off when one-million-pixel displays will be standard, and plasma is the only flat-panel technology that today offers products with over half a million pixels.

The second trend is the increasing demand for color—1987 was the first year in which sales of color CRT computer monitors exceeded that of monochrome monitors. Several full-color plasma displays have been developed in research laboratories, demonstrating images comparable to those on color CRTs. The most impressive is a 640 × 448 full-color 20-in.-diagonal plasma panel from NHK, which will be described in a paper to be delivered at the Society for Information Display's 1988 International Symposium, May 23–27, in Anaheim.[2]

Notes

[1] L. F. Weber and R. C. Younce, "Independent Sustain and Address Technique for the ac Plasma Display Panel," *Digest of Technical Papers, 1986 SID International Symposium* (May 1986) pp. 220–23. This presentation received the award for best paper at SID '86.

[2] H. Murakami et al., "Fabrication Techniques for a 20-in. Color Plasma Panel," *Digest of Technical Papers, 1988 SID International Symposium* (May 1988). ■

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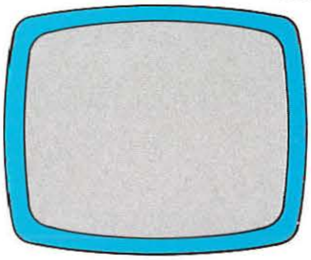

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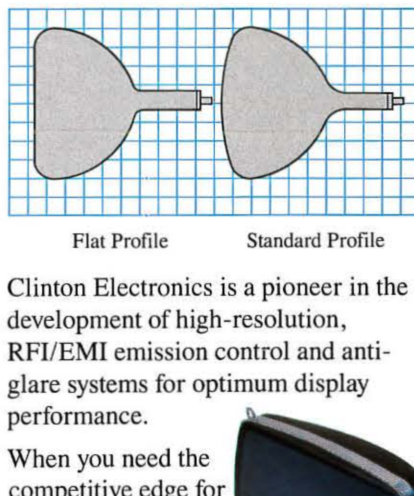

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