Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

April/May 1994
Vol. 10, No. 4&5

SID '94 SHOW ISSUE

AT&T Picasso still-image phone
Fiber optics for displays
Making the image dance
Products on display at SID '94

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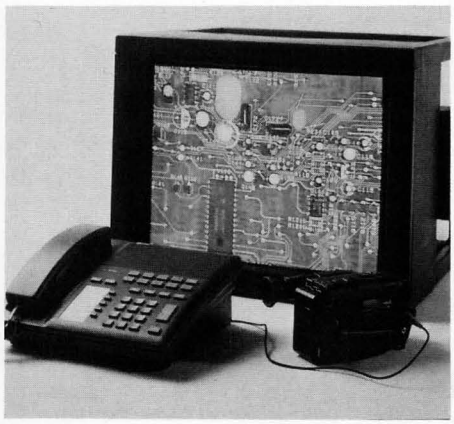
Cover: The Picasso Still-Image Telephone allows users to send full-color NTSC-quality still images and simultaneously talk over the same dial-up analog phone line.



AT&T Image Solutions

Next Month in Information Display

CRT Issue
- Matsushita's color flat panel
- Odd CRTs
- Removing moire patterns

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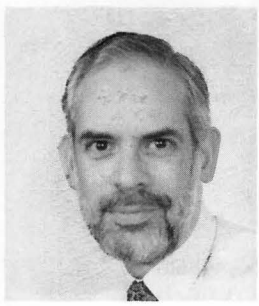
editorial



SID '94 to Open June 12 in San Jose

SID '94, this year's edition of the Society for Information Display's annual symposium, seminar, and exhibition, promises to be the biggest ever. The show – the largest event devoted to display technology, systems, products, and applications held in North America – will run June 12–17 at the San Jose Convention Center, San Jose, California; the exhibition is scheduled for June 14–16 at the Convention Center.

Riding the wave of optimism sweeping the global display industry in general and the North American industry in particular, exhibitors have booked a record number of booths. All of the display technologies competing for the lucrative high-definition television (HDTV) market that will develop beginning in 1995 will be represented. Among the representatives are the 40-in. color plasma flat-panel display from NHK (the Japanese broadcasting system), which until now has been shown only once outside of Japan, and a brand-new NHK color display. NHK will disclose the size and technical details of this new display at the show. Also on exhibit will be the high-resolution color plasma display from Photonics Imaging of Northwood, Ohio; the new high-resolution digital micromirror projection display from Texas Instruments; and HDTV CRTs from Philips, Sony, and others.

The new generation of lightweight color and monochrome flat-panel displays for laptop computers and personal digital assistants from Sharp, Toshiba, Hitachi, NEC, Kyocera, Optrex and others will be shown, along with displays that may represent the future of LCD technology, including Motif's revolutionary active-addressed LCD. Motif claims that active addressing provides active-matrix performance for only a couple of hundred dollars more than a passive-matrix price.

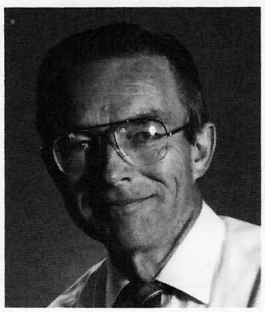
Also to be exhibited are the very-high-quality monitors from the likes of Philips and Orwin that display x-ray images well enough to replace x-ray film, and the workstation/computer monitors and CRTs from many manufacturers. Virtual-reality products/components will be shown by Celco and Crystal Vision.

The 240 technical papers to be presented include several on color facsimile and several on polysilicon LCD light valves, the approach that may finally bring LCD projection displays into direct competition with CRT projectors. The morning "How-To" seminars include one on connecting flat-panel displays to computers and another on selecting LCD backlights. The Monday and Friday seminars include surveys of LCD manufacturing and HDTV, and an encore performance of Terry Scheffer and Jurgen Nehring's sophisticated introduction to supertwist LCDs – including active-addressed types. Walt Goede will kick off the Monday morning seminars with his popular, no-holds-barred "Overview and Status of Information Displays."

If it has to do with displays and you want to select it, design it, build it, integrate it, buy it, sell it, upgrade it, ruggedize it, modify it, find components for it, see it, or learn about it, I can't imagine a better way of spending your travel dollars than using them to get yourself to San Jose in June. I look forward to seeing you there.

– Ken Werner

the display continuum



The Brainstorming Session – "Are We Having Fun Yet?"

by Aris Silzars

In the never-ending quest for the easy answer, the sure thing, the no-risk approach to picking the *Best New Technology* on which to bet our company's future, and sometimes even our own, we have discovered (drumroll please) ta-da, the **Brainstorming Session.**

I recently participated in two such events, one with a most prestigious name – The Industry Expert Panel. Both were set up as all-day sessions, administered by a "facilitator." Now as far as I can tell, The Facilitator is a person who knows nothing about the topic at hand but is there to guide the group through a process cleverly designed to arrive at THE ANSWER precisely at the scheduled ending time for the session. Organization development (OD) consultants, it seems, thrive especially well in this role.

During my twenty-plus-something-year career, I have participated in many of these brainstormers. I think by now I have seen every imaginable format and been in every conceivable location: on-site, off-site, retreats, ropes-courses, hotels, boats (yes, boats), etc. And as I look back, every one of these efforts ended up the same way.

The starting point is always the same. Facilitator-person stands at the front of the room next to a newsprint tablet with felt-tip pen at the ready. After an inspirational opening, sometimes involving a "paradigm-shifting"exercise, all participants are invited to offer any and all ideas – no matter how wild or bizarre. Bizarreness, by the way, is to be encouraged as a sign of creativity, explains the facilitator. Clarification questions can be asked, but no one is to criticize or "shoot down"anyone else's idea. After all, the wild ideas may be the most inventive and will thereby stimulate other great creative thoughts, or they could, in themselves, turn out to be pretty great.

The facilitator-person records the essence of each idea on the newsprint tablet, after which each idea-filled page is taped onto a wall until the room takes on the look of an interior-decorating experiment gone bad. For having done such an outstanding job and for covering the walls with newsprint, there is a reward – cookies and coffee and a 10-minute bathroom break.

When all ideas and ideas-upon-ideas have been exhausted, the process proceeds to – Selecting the Really Good Ones. Everyone is asked to wander about the room and put his name by the top ten or so that he thinks are the best for further consideration. This process may take some minor variants, but the expected outcome is always the same, i.e., to make a very long list into a shorter list. Everyone works hard at this and some individuals even come up with additional new ideas that also get added to the list.

Next comes the discussion about who picked what and why there is so little agreement. My goodness, is it time for lunch already? Must be another reward for doing such good work.

The first part of the afternoon follows the same methodology to arrive at what usually becomes – The Top Five. Since the selection process started with such a large number, these should be getting pretty great, right? Well, maybe not exactly. However, by now it's time for the afternoon break, so we'll pause for

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Fiber Optics for Displays

Fiber optics can optimize light transfer, guide images, and shift image planes, which makes them invaluable in many display applications.

by Jake Brain

A FIBER-OPTIC FACEPLATE is a fused mosaic of clad parallel glass fibers whose axes are usually perpendicular to the image surface of a display. That image surface is usually the phosphor screen of a CRT, but Galileo Electro-Optics, for example, has demonstrated a possible application to a pen-interfaced LCD. Such faceplates usually have an actual thickness and optical path between a fraction of an inch and 1 in., but they *seem* to have an optical thickness that is virtually zero – the image plane appears to coincide with the front surface of the faceplate!

The reason fiber optics are used in the faceplates of some photorecording CRTs and of some CRTs that have direct optical coupling to other optical devices is that a phosphor's maximum light emission is perpendicular to the surface of the screen (Lambert's law). The phosphor approximates a Lambertian light source when the luminous flux it emits is proportional to the cosine of the angle from the normal. A fiber-optic faceplate, acting as a waveguide or light pipe, captures a good portion of the light that would otherwise be wasted. This can substantially enhance the speed of direct film printing applications with photorecording CRTs.

Making Fiber-Optic Faceplates

Constructing a fiber-optic faceplate depends on redrawing operations. The starting point of a fiber optic is a glass rod – the core – having a high index of refraction, which is surrounded by glass tubing having a lower index of refraction. (The index of refraction is the ratio of the speed of light through the glass to the speed of light through air.) Glass from the core is drawn into a fiber and coated – or clad – with glass from the tubing.

The glass rod starts out being approximately 1 in. in diameter. It is placed inside a piece of glass tubing approximately 1¼ in. in diameter. The two pieces of glass are then sealed at one end. This permits the tubing to be evacuated, which will help draw the outer tubing toward the inner rod. The glass rod and tubing are then either hung or pulled through an oven. As the glass softens, it stretches, and the inner glass rod is coated with the outer glass tubing.

These sheathed cores have a mirror surface at the boundary between the two glasses – a mirror produced by the total internal reflection caused by the difference in the indices of refraction of the two glasses. This mirror surface is the mechanism that makes an optical fiber work. The light enters the end of the fiber optic and is reflected off the mirrored surface and re-reflected many times before it emerges at the other end (Fig. 1). The light

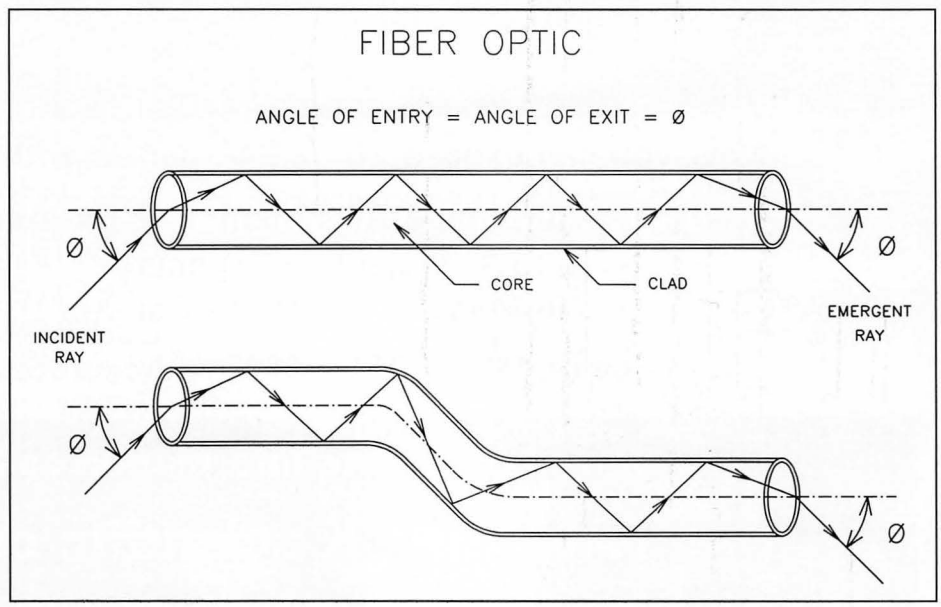

Fig. 1: *No matter how an optical fiber is bent, a light ray emerges from one end of the fiber at the same angle it entered the opposite end.*

Jake Brain *is director of corporate quality assurance for Thomas Electronics, 100 Riverview Drive, Wayne, NJ 07470. 201/696-5200, fax 201/696-8298.*

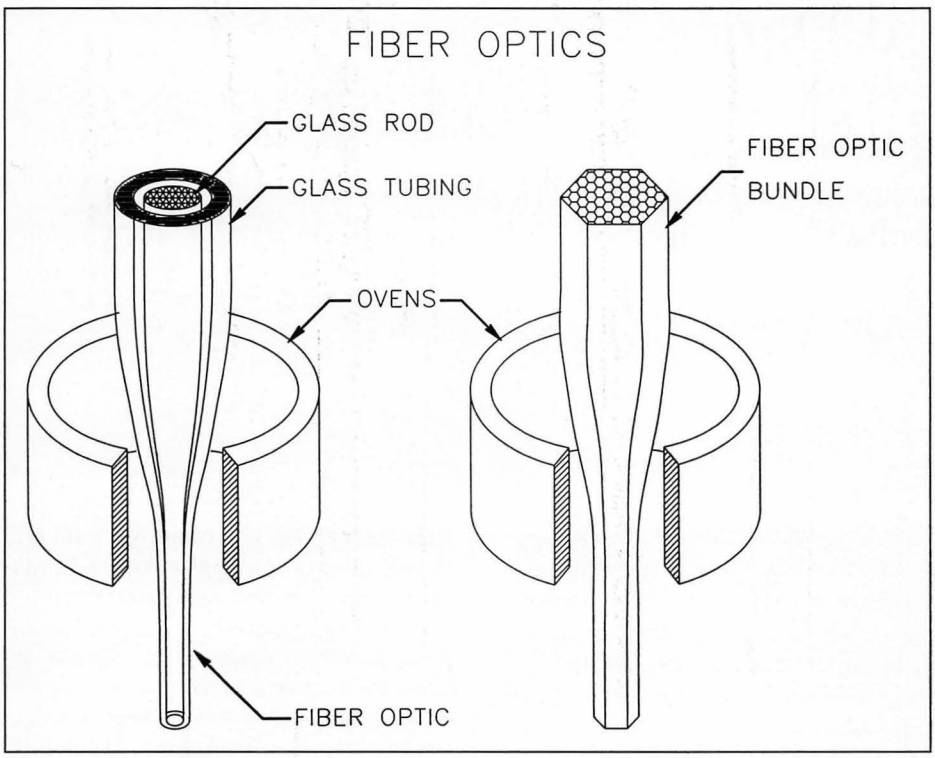

Fig. 2: An optical fiber is made by heating a glass rod surrounded by a tube made of a different glass and drawing the combination down into a thin, coated glass fiber (left). A fiber-optic bundle is made by a similar process: repeatedly drawing down a bundle of individual fibers (right).

leaves the fiber optic at the same angle it entered, no matter how the fiber is bent.

In order to make the faceplates that are used in CRTs, the single strands of optical fiber are bundled together and successively redrawn in much the same way they were originally drawn through the high-temperature oven or heater (Fig. 2). Each time this process takes place, the fiber size is reduced, and the process is repeated a number of times until each of the fiber bundles – or light guides – is reduced to approximately ⅛ in. across. At this stage, the diameter of each fiber core in the light guide is approximately 0.00027 in. – or less.

The light guides are formed into a hexagon, cut into convenient lengths, and placed in a metal mold. The guides are laid parallel to the bottom of the mold and arranged precisely. Then the mold has a weighted cover placed on it, the cover is clamped, and the mold is put into an electric furnace and heated to the point where the cladding glass starts to melt. At the same time, the mold is placed under great pressure. As the glass melts, the cladding on the outer surfaces of the light guides fuse together, thus forming a solid piece of glass with cores running through it, which is called a boule. The boule is sliced and the slices are polished (Fig. 3).

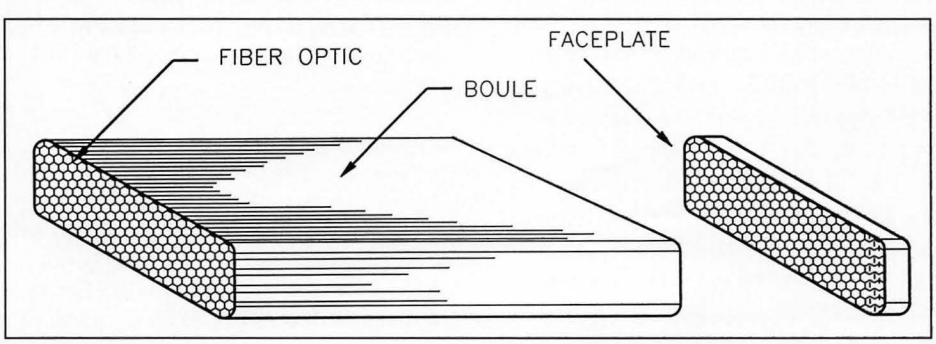

Fig. 3: A fiber-optic faceplate is made by fusing many fiber-optic bundles together into a boule, which is sliced. The slices are then polished to make the faceplates.

Not Just Faceplates

Fiber optics can also be in other forms. One – also called a light pipe, although it is very different from the device just described – consists of just a few long strands of fiber optics that are placed inside a flexible plastic jacket. These light pipes are used to direct cool light to areas that are not accessible with lens and mirrors.

Another form of fiber optics is the image guide. This is a coherent – or arranged – group of fibers that is used to transfer an image from one surface to another. The image guide can be bent as desired and still form an undistorted image on its output face.

A useful variant of the coherent image guide is the tapered fiber optic. This is a bundle of optical fibers that is drawn to form a taper. If the narrow end of the tapered bundle is placed on the image that is to be transmitted, the fiber optic will act as a magnifier because the output image is spread over a greater area than the input image. If the tapered bundle is placed with its large end on the image, it will make the image smaller.

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Making the Image Dance

Adding full-motion video to existing personal computers will sell enhanced displays and new software, but the PC/AT bus was never designed for video data rates.

by Mati Frenkel

FULL MULTIMEDIA, including full-motion video, is important for the growth of the personal-computing industry and the display industry that is so closely linked to it. Multimedia will undoubtedly be a standard feature on personal computers (PCs) developed in the next few years, but it has been difficult to develop a system that would add effective full multimedia capability to the millions of existing 386- and 486-based desktop systems that use the architecture descended from the original IBM-AT computer. (Current AT-compatible computers have evolved substantially from their IBM progenitor and much of their development has passed to non-IBM hands. As a result, it is now common industry practice to call the AT-compatible computer architecture Industry Standard Architecture – ISA.)

What's the Problem?

Four primary compatibility issues inhibit putting full-motion video on existing ISA systems:

1. The ISA bus architecture was not designed to handle real-time video data.
2. PC displays and video systems typically operate at different display refresh rates.
3. The NTSC and PAL television systems are designed for screen resolutions that are different from PC-screen resolutions.
4. Most video sources are intended for interlaced displays, while most PC displays are progressively scanned.

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In short, standard TV images can not be used for PC-based motion video, which requires digital images. The major barriers to putting full-motion digital video images on a PC display are memory and bandwidth. These barriers are being overcome with digital image compression.

Today, most developers are implementing image compression and decompression in accord with The Joint Photographic Experts Group (JPEG) standard (see *Information Display*, July/August 1991). A wide range of digital-signal-processing (DSP) chipsets are now available that support the JPEG standard and reduce the complexity of adding JPEG compression to multimedia systems.

Compression eases storage problems, but does not necessarily solve bandwidth problems – at least, not by itself. Sub-sampling a 30-frame/s (fps) 640 × 480-pixel image with 24 bits of color information per pixel at a 4:2:2 ratio (four samples of luminance for every two samples of each chrominance component) produces information at an average rate of 18 megabytes/s (MB/s). Studio-quality JPEG video can not survive a compression ratio greater than 10:1, a ratio that produces a compressed data stream with an average rate of 1.8 MB/s – well above the capability of ISA data buses, IDE hard disks, and SCSI hard disks. Low-end and intermediate-level PCs typically have hard disks limited to data rates of 500 kB/s, which becomes the limiting factor for continuous video recording and playback applications.

How Do You Do It If You Can't Do It?

The available data rate from typical hard disks prevents designers from implementing full-screen full-motion video. Two approaches to getting some sort of video on the screen are to reduce the image size to less than full screen (called "image scaling") and/or to present something less than "full" motion by reducing the frame rate (called "frame subsampling").

Scaling an image to 320 × 240 pixels – one-quarter the pixel dimensions of a VGA screen – at 30 fps requires a video-data transfer rate of approximately 5 MB/s, or 500 kB/s after a 10:1 compression. That's within the capabilities of the ISA bus and typical PC hard disks.

The alternative design approach, skipping frames, provides high image quality within the frame but compromises the quality of image motion. Reducing the NTSC standard from 30 to 10 fps and applying it to a 320 × 240-pixel image (with 16 bits of color per pixel) produces a data rate of 1.5 MB/s. A 10:1 compression reduces that to 150 kB/s – compatible with the transfer rates of "single-spin" CD-ROM drives. Such a data rate permits 30 min of video to be stored in 200 MB of disk space.

Implementing JPEG

The JPEG compression standard was designed to reduce the amount of data required to adequately represent a still image. It can be used for PC-based motion video because PC video is a sequence of still images. The JPEG compression ratio directly affects the requirements for image storage capacity and data communication speed. JPEG techniques can compress images by a ratio of 24:1 with excellent image

reproduction. *(Assessments of the degree to which compression ratios must be restricted for high-quality image reproduction vary with application. For an alternative assessment, see Mahendra Pratap's article in this issue. – Ed.)* In addition to providing for compression and decompression, JPEG provides a standard for format conversion among the various devices found in desktop multimedia systems: devices such as cameras, copiers, and scanners.

JPEG compression can be implemented with three different technologies, each with its own cost and performance tradeoffs. The least expensive (and slowest) is JPEG software running on a general-purpose computer. More performance can be had at some additional cost by using general-purpose DSP processors.

The premium solution is the use of dedicated JPEG hardware implemented in DSP technology.

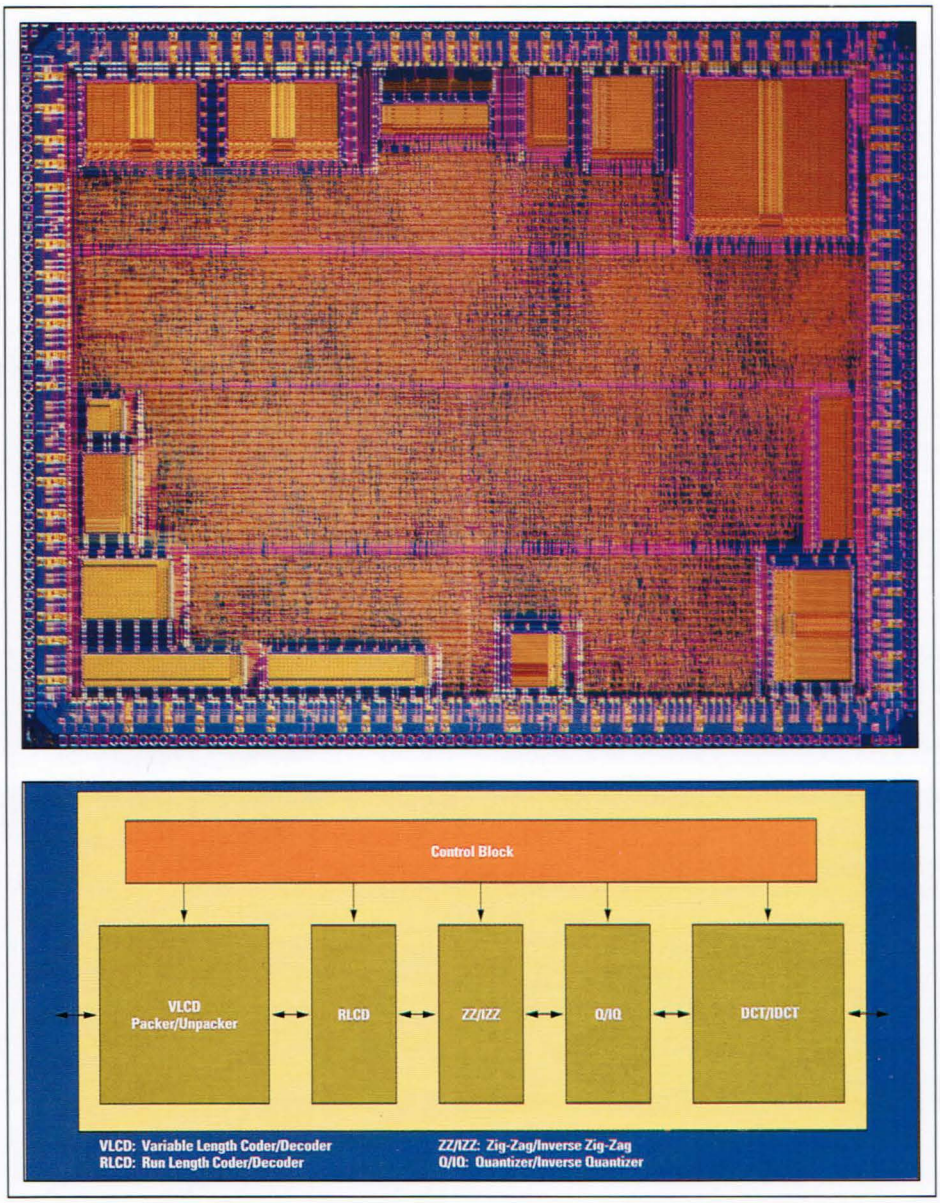


Fig. 1: *This "JPEG core" is the heart of LSI Logic's single-chip JPEG co-processor. If you wish to drop the core into your own application-specific IC (ASIC), LSI will license the core.*

The software-only solution takes about 10 s to process a 640 × 480, 24-bit/pixel image on a typical PC microprocessor. Clearly, this is much too slow for motion video. The general-purpose DSP approach combines hardware and software. The required hardware consists of several DSP chips, which are available from several vendors. Because the hardware is not optimized for JPEG processing, thousands of lines of software code are needed to implement the JPEG algorithm. As a result, compressing a 640 × 480 × 24 image takes about 1 s. This approach can be useful for still-image applications but is too slow for motion video.

Several DSP vendors now offer dedicated high-performance JPEG chipsets for a hardware solution. These first-generation chipsets provide compression and decompression rates that can support full-size high-resolution images at 30 MB/s. Systems built around such chipsets – including a chipset made by LSI Logic – tend to be too expensive for PC add-in boards. They also constitute overkill for the application because their capabilities far exceed the PC's disk speed and bus transfer rate.

At LSI Logic, we concluded that the market needed an economical – less than $50 in production quantities – single-chip JPEG solution that would handle both compression and decompression at rates compatible with those of PC hard disks and ISA buses (Fig. 1). The realization of that concept is the L64702, which processes video at up to 8.25 MB/s – a rate that can handle quarter-screen images at 30 fps [Fig. 2(a)]. The chip also has interface logic, memory control, and a dual-port architecture that gives it the flexibility to be used in printer, scanner, and video-editing applications, as well as for multimedia. In printer applications, for example, the chip's built-in memory controller outputs a JPEG-compressed file in a format which printers can use immediately. This eliminates the need to rasterize incompatible image data, which has been a bottleneck for the printing of JPEG images. As a result, the chip allows an 8½ × 11-in. image to be printed in 4 s instead of minutes.

The 33-MHz version has a 8.25-MB/s processing-rate capability that can easily compress and decompress an NTSC video of 320 × 240 at 30 fps or a PAL video of 384 × 288 at 25 fps. These video signals produce video

data rates of 4.6 and 5.5 MB/s, respectively. In fact, the 40-MHz version is capable of compressing and decompressing a complete NTSC field of 640 × 240 in real time at 30 fps. The 9.2-MB/s video rate is well below the 10-MB/s chip processing rate.

To demonstrate the capabilities of the chip and to help designers get a quick start on their own designs, we've developed a JPEG video-in-a-window (JVieW) board. A quick look at this board is interesting because it offers an example of the functional blocks a JPEG board must have [Fig. 2(b)].

The board communicates with the rest of the PC through a live video input port, a VGA input port, a display output port, and a bidirectional system port that transfers compressed data between the L64702 code FIFO and the system hard disk. The board's main sections are (1) video capture, (2) video/VGA display, (3) frame buffer, (4) L64702 JPEG co-processor, and (5) the PC interface, which connects the JVieW local data bus to the PC's ISA bus.

State of Play

The development of a one-chip JPEG co-processor has made it possible to implement economical quarter-screen full-motion video on existing 386 and 486 ISA computers. A variety of vendors are using this chip to make commercial video boards. As software developers explore the possible applications of these boards to everything from low-cost imaging to desktop video conferencing, we can expect the number of ways in which people use their PCs to grow. As that happens, the use of enhanced displays should grow as well. ■

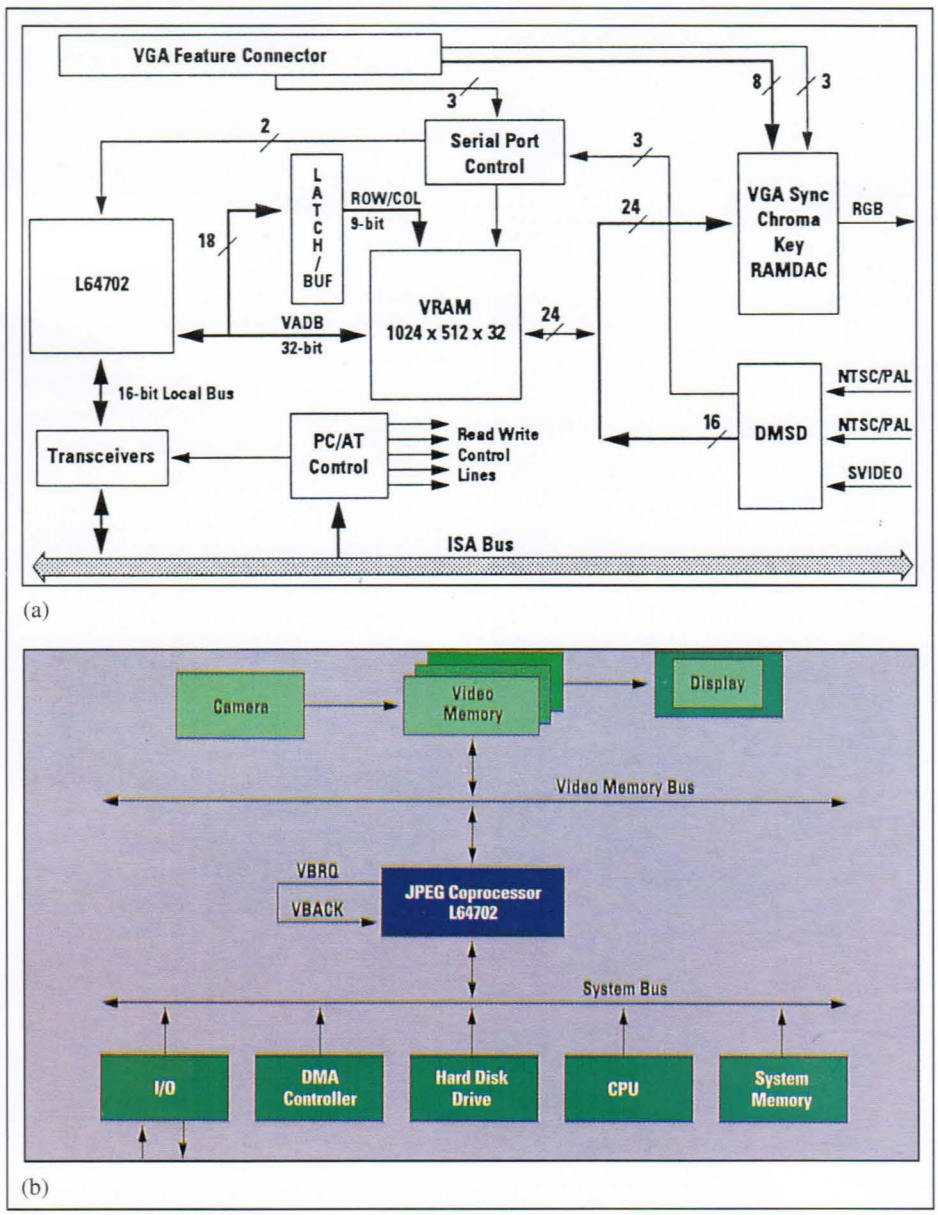


Fig. 2: A single-chip JPEG co-processor can be used in a personal computer (a) in a stand-alone configuration or (b) as part of a third-party motion-video card.

Case Study: AT&T Picasso Still-Image Phone

Modifying videophone technology for business-oriented image transmission and display required a new organization as well as skilled engineers and marketers.

by Mahendra Pratap

A UNIQUE COMBINATION of digital signal processing (DSP), transmission, and software techniques has produced a special visual telephone. The phone allows people to send and receive TV-quality color still images on the plain old telephone (POT) network while carrying on a normal telephone conversation. Both parties on the call can point and draw on the images, and the phone interfaces with a PC to display and store images on the PC. This product has been very well received; some people have even treated it as revolutionary. But, although the phone may have revolutionary effects on some business practices, the system itself is an evolutionary – if ambitious – development of largely pre-existing technology. The product was carefully developed in cooperation with some of its potential users, so suitability for market needs was built in.

From the Beginning

In January 1992, AT&T Consumer Products announced the VideoPhone 2500, a personal audio-visual terminal with built-in camera and display that provides real-time communication of color, motion video, and voice on an analog tip/ring telephone line. As I admired an early prototype of the videophone, bittersweet memories of the "Picture Phone Meeting Service" that our team had introduced nearly a decade ago filled my mind. Advances in technology were evident in the CCD color video camera and LCD display screen, in the digital compression schemes for audio and video, in the modem (the fastest available for dial-up lines), and, most of all, in the packaging of an enormous amount of computing power in such a compact electronic device. Had the time for personal visual communications finally arrived? Would the videophone forever change the way people communicate?

After euphoria, a new chain of thoughts: Is the video quality good enough for the TV generation? The screen measures only 3.3 in. and motion is rendered at only 10 frames per second (fps). Will the phone work internationally? How about the satellite circuits?

Soon I was asking some real questions: What communications standards does the videophone follow? Does it provide an alternative to ISDN? How can businesses use this device? Is the fastest dial-up modem in the world locked up in the phone or is it available for general-purpose data transfer?

Coincidentally, a marketing team at AT&T Global Business Communication Services was asking the same questions. The team had been chartered to investigate how AT&T could serve business needs in any area. Market-research and focus-group studies involving more than 500 businesses had revealed the need for a telephone that could transmit high-resolution still images.

"What differentiates the 'image phone' from a videophone is that it focuses on objects rather than people and on the needs of business customers rather than those of residential consumers," said Jerry Prestinario, marketing director and a member of the marketing team. Even at this early stage in its development, the concept of the image phone was clear – and so were some of its design challenges. The phone had to use the ubiquitous analog telephone network, but analog telephone lines have limited transmission bandwidth. A videophone uses that bandwidth for motion video; an image phone would have to trade off motion for picture clarity.

Discussions with Prestinario and Branson Hamilton, another member of the team, energized me. Could the VideoPhone 2500 be turned into an image phone? Could it be fitted with interfaces that would make it a useful business tool for conferencing, remote presentations, remote learning, and other applications?

Birth of a Venture

After studying the situation and consulting with others – including several AT&T Bell Laboratories researchers – Prestinario proposed the formation of a venture to design, produce, and market the image phone. Prestinario, who had previously helped launch Safari Systems, the successful AT&T venture for producing and marketing portable PCs, felt that combining development, marketing, operations, and product management at the same location under a venture format was necessary for a quick time-to-market and for rapid response to changing market requirements. The early members of the cross-functional team decided to name the venture "AT&T Image Solutions" and helped define its mission, vision, and values.

Mahendra Pratap *is chief architect for AT&T Image Solutions, 285 Davidson Ave., Somerset, NJ 08873. 908/764-6049, fax 908/764-6060.*

Image Phone Trial

As its first project, Image Solutions was to produce a few hundred prototypes of an image phone – code named "Picasso" – by appropriately modifying the VideoPhone 2500. The modifications were:

- Remove the built-in camera/display module of the VideoPhone 2500.
- Replace the VideoPhone's motion video board with a new image capture and compression board that accepts input from a camcorder and displays images on a television.
- Re-label the phone keys to correspond to the image-related functions such as freeze, send, store, etc.
- Change the software to accommodate basic image functionality.

The prototype units were to be given to "real" customers for 2 months of use to answer the following questions:

- Is there a real need for this product?
- If yes, what features/functions are needed for different applications?

We used the lessons learned from the prototypes to define the final product.

Doing product architecture and definition work concurrently with product design and development was a challenge, but the development and marketing teams worked together closely and decisions were made quickly. However, the project that seemed simple in theory did not turn out to be simple in implementation.

The timing of our prototype efforts was not consistent with the schedule of the VideoPhone 2500, which was not yet ready for production. Quickly, we had to develop expertise in many disciplines: analog video capture and display, speakerphone technology, image processing, low-bit-rate audio compression, transmission protocols, modem technology, and – most of all – a user interface for the prototype. Dealing with the heat generated in the telephone unit without the benefit of forced-air circulation, EMI containment, synchronization with both stable and unstable video sources, modem impairments, and network coverage challenged the engineering team led by J. Rodriquez.

The prototype taught us that an image phone is not simply a videophone that does still images on the side. In contrast to video, images stay on the screen and can be scrutinized endlessly. Furthermore, images that are worth sending and receiving are also worth storing. The final product had to have a PC interface that permits storing the images and sharing the PC screen with the remote site. We also relearned a lesson the Picture Phone Meeting Service had learned 10 years before: audio is at least as important as video for a visual communication terminal.

Users of the prototypes suggested numerous alternatives for the layout and labels of the image keypad. For effective presentations, some users needed a handheld remote control device to capture images without reaching for the image phone's keypad. Many users wanted to point and draw on the images. Our marketing director insisted that the telephone required an attractive industrial design with a modern look to be successful. A member of the advisory board wanted the product to pass a "mother test" for usability: his mother should be able to at least send and receive images without assistance and without needing a manual. Thus, the product definition evolved as development progressed and user feedback was integrated. Throughout this evolution, we were guided by our basic philosophy of keeping the product as simple to use as a standard voice telephone.

Basic Operation

The Picasso image phone is first and foremost a telephone. It looks like a telephone, behaves like a telephone, and can be used to make regular voice phone calls by following the same procedure that is used with any conventional phone. A normal voice connection is established if the called party answers the phone. If, on the other hand, the called phone is also a Picasso phone, the caller can do more than talk. While carrying on a normal telephone conversation, both parties can send and receive still color images of objects and documents. Commonly available video devices such as camcorders and television monitors can be attached to the image phone, allowing it to capture and display the desired images. The Picasso phone normally displays the local video input on a TV screen. A frame of the video can be captured by pressing the button labeled "PreView/Capture." It can then be sent to the remote party by pressing the "Send" button. Alternatively, an image stored in the internal memory of the phone can be displayed on the screen and transmitted to the remote side. The transmitted image is automatically received and displayed on the screen attached to the receiving Picasso phone. Voice-related functions of the phone – such as

AT&T Image Solutions

Fig. 1: *The Picasso Image Telephone allows users to send full-color NTSC-quality still images and simultaneously talk over the same dial-up analog phone line.*

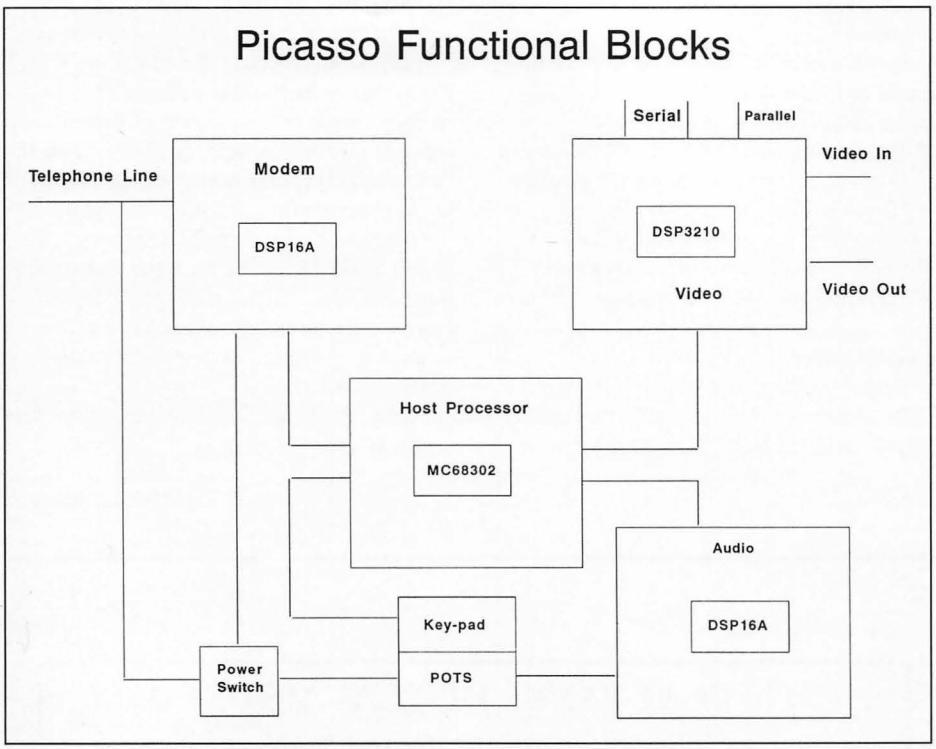


Fig. 2: *Picasso packs a lot of communications, image-processing, and graphic-controller electronics into a package not much bigger than a standard office telephone set.*

hold, mute, redial, flash, and memory dialing – work as they do in voice telephones.

The Picasso's user interface is a "see-do" interface. Before doing any image-related task, a user brings the desired image up on the monitor and then presses an appropriate button on the keypad. Each task is done by pressing a single key, which affects only the image being displayed on the screen.

Implementing User Feedback

The following enhanced functions were added to the Picasso phone as a result of user feedback.

- ***Annotation:*** Enhances remote presentations, conferencing, and training applications by allowing the user to point to and highlight areas of interest on the image. This is done with a pointing device – such as a mouse – attached to one of the serial ports. The user may store contextual data along with the video image. Users on both sides of the telephone call can interactively point to and draw over the image being displayed on their screens.
- ***Trading Image Quality for Transmission Speed:*** All applications are not alike, and Picasso lets users choose the appropriate combination of quality and speed for each transmission. The phone uses the baseline process of the JPEG compression algorithm, which is a lossy algorithm (see *Information Display*, July/August 1991). The encoded and compressed image does not have all the information of the original, but the user can choose how much of the original picture quality to trade for a higher compression ratio. (The higher the compression ratio, the smaller the compressed file and the shorter the transmission time.)

  The right compromise depends on the application. A compression ratio between 1 and 15 produces decoded images that are nearly indistinguishable from their NTSC-quality originals. A ratio between 15 and 30 produces images with noticeable degradation, but the quality will be subjectively "good" for images that are not finely detailed. At compression ratios higher than 30, the picture quality usually degrades rapidly.

  A full NTSC TV frame is 512×512 pixels $\times$ 16 bits/pixel. With a compression ratio of 20, it takes about 20 s to transmit the picture at 9600 bits/s. Increasing the compression ratio to 40 cuts the transmission time to about 10 s. For applications that are not very sensitive to image quality, this may be a reasonable compromise.
- ***Image Enhancement:*** Digital processing has been incorporated to enhance the quality of the image being displayed on the screen. A gray-scale image that is too dark or too light can be substantially improved by histogram equalization. A binary text image, on the other hand, can be improved by detecting character edges and then smoothing and sharpening them.

  A camcorder image degraded by motion of the subject or camera can be digitally enhanced. If the subject or camera is moving when the image is captured, each half of the interlaced captured image can be slightly different because each was captured at a slightly different time. The rapid alternating of these two half images produces flicker, which can be removed by displaying only one of the fields or by composing a new frame of two identical fields. Both methods cut vertical resolution in half.
- ***Connectivity to the PC:*** Standard parallel and serial ports make practically all PC peripherals available to the Picasso phone. There is a Microsoft Windows application, for example, that allows a user to display the phone's output on a PC monitor, store images on a PC's hard and floppy disks, produce hardcopy output on PC printers, and capture PC-screen graphics for input to the Picasso phone. We are preparing a software-development kit to make it easier for customers and system integrators to write their own applications.

The one-button-per-function telephone paradigm is easy to use, but it is severely limited when the time comes for a user to access and customize enhanced functions. This dilemma was solved with on-screen menuing. Pressing the "Menu" button on the keypad puts a list of set-up options on the screen that

allows the user to configure the unit appropriately.

Inside the Picasso Phone

The Picasso looks like a simple telephone but inside it is packed with electronic boards: keypad processor, telephone processor, audio processor, video processor, host processor, modem, and I/O ports (Fig. 1). The user interacts with the phone through the keypad function keys, the remote control, and the pointing device. The MC68302 host processor, with its M68000 processor core and a flexible communications architecture, acts as a central coordinator for all subsystems.

The telephony processor (labeled POTS – for plain old telephone service – in Fig. 2) is either ac- or line-powered, so telephony features are available even when the ac power is turned off. The processor manages the telephony functions and the keypad, and forwards image-related button presses to the host processor for further action.

The Picasso Phone uses AT&T's proprietary Code Excited Linear Prediction Plus (CELP+) for audio compression. This approach is based on a GSM digital cellular submission, uses 6.8 kbit/s, and produces toll-grade quality for male, female, and children's voices. The basic audio frame compresses 20 ms of 8-kHz sampled speech into 17 filter coefficients, each 1 byte long.

The Picasso's video board – code named Eagle by its designers, Robert Farah and Robert Miller – is based on the AT&T multimedia DSP 3210, a high-performance programmable digital signal processor with 32-bit integer and floating-point computing capability.

The board color-separates the input composite video into Y, Cr, and Cb components; digitizes the components; and stores in VRAM a single video frame – 1/30 sec of video. A spatial resolution of 512 × 480 pixels with 4:2:2 sampling and 8 bits/pixel per component is used. For output, the reverse scheme encodes YCrCb to NTSC video and S-video outputs. In the preview mode, color separation, time-base correction (TBC), and re-encoding are performed in real time without storing frames in VRAM. The overlay VRAM of the video board is used for text messages and annotation display. The video board is designed to work harmoniously not only with stable video sources, but also with unstable ones such as video recorders and inexpensive still-image cameras. The DSP also handles image compression/decompression and annotation tasks. The video board interfaces to the host processor with a 200-kbit/s serial interface.

The production model of the Picasso uses a V.32*bis* modem – presently the fastest of the industry-standard dial-up data modems. The prototypes used a 19.2-kbit/s proprietary modem. Although limited to 14.4 kbit/s, V.32*bis* provides increased network coverage.

Conclusions

We announced the Picasso phone on May 11, 1993, almost exactly 1 year after the birth of AT&T Image Solutions, at a price between $3000 and $3500. It was hailed as one of the most innovative products of the year and won several industry awards. Some analysts predicted that Picasso will replace the fax machine, while others asked if a telephone is the right platform for bringing a slice of multimedia to the business world. But people are just beginning to explore Picasso's applications for businesses. For the device to realize its full market potential, open and extensible standards for visual telephony and audiographics need to be agreed upon and widely supported. AT&T is leading such standardization efforts.

Speaking personally, I think the fun has just begun. ■

Products on Display at SID '94

Some of the products on display at SID's largest exhibition ever are previewed.

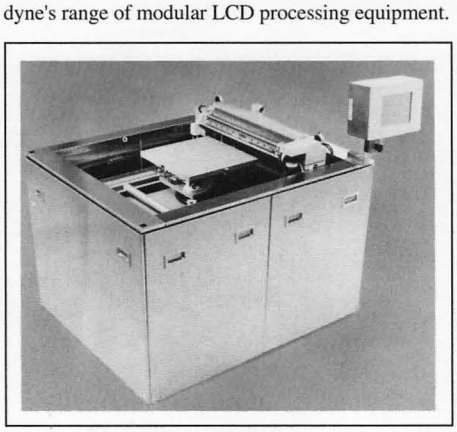
BY THE EDITORIAL STAFF

THE SID '94 INTERNATIONAL SYMPOSIUM, SEMINAR, AND EXHIBITION will be held at the San Jose Convention Center in San Jose, California, the week of June 12. For three days, June 14–16, leading manufacturers will present the latest displays, display components, and display systems. To give you a preview of the show, we invited the exhibitors to highlight their offerings. The following is based on their responses.

ACCUDYNE CORP.
Palm Bay, FL 407/724-6500
Booth 413

Rubbing machine

Accudyne will feature its rubbing machine, a state-of-the-art processing tool for LCD substrates. A small footprint combined with fully automatic features reduces cost of ownership. Ease of use is improved by touch-screen controls for operator interface, automatic roller change, automatic setup, and completely programmable parameters. The standard machine can rub substrates up to 580 mm on the diagonal (16 × 16 in. at 45°) and can process multiple sizes. Automatic substrate load and unload can be provided, allowing cassette-to-cassette processing or interfacing to other processing tools. The rubbing machine is just one component of Accudyne's range of modular LCD processing equipment.



Circle no. 1

AMERICAN HIGH VOLTAGE
El Cajon, CA 619/258-5804
Booth 809

Miniature power supply

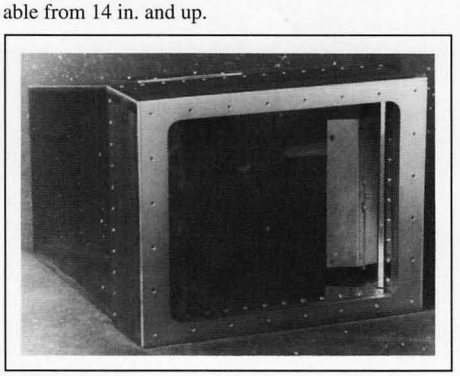
American High Voltage will display their B-1 series high-voltage power supply that provides anode, focus, G1, and G2 outputs that are adjustable and regulated. An input voltage of 15 Vdc and exceptionally small size make these power modules ideal for helmet-mounted displays and virtual-reality systems. For maximum resolution, the anode focus tracking is limited to less than 100 ppm/°C.

Circle no. 2

AD-VANCE MAGNETICS, INC.
Rochester, IN 219/223-3158
Booths 604/606

Monitor shields

Ad-Vance Magnetics will offer computer-monitor shields manufactured out of high-permeability AD-MU-80 alloys in environments from 1.2 up to 5 G dc magnetic fields. Custom monitor shields available from 14 in. and up.



Circle no. 3

ASSOCIATION EXHIBITIONS
Devon, U.K. 44-21-313-2423
Booth 427

EID '94: The U.K.'s information display event

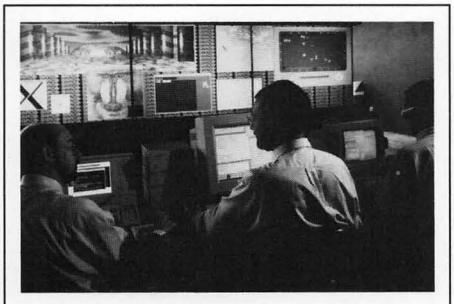
Launched last year, the Electronic Information Displays Exhibition and Conference (EID) has already made a significant impact on the U.K. market. 2480 visitors and delegates from all sectors of industry filled the '93 event. As a result, this year's show is already a near sellout; more space is being made available. The U.K. and Ireland chapter of SID will, once again, be organizing the conference. To receive conference details, contact Terry Brandon.

Circle no. 4

BARCO CHROMATICS
Tucker, GA 404/493-7000 x2108
Booths 506/508

Multiscreen windowing system

Barco Chromatics will introduce the BARCO Graph-X Wall, a new multiscreen windowing system that is an integrated hardware and software system designed for command, operations, and control-center applications. The system operates within the X-Windows environment and allows interactive display of complex, dynamic process information on a large rear-projector wall. The variable-size wall is comprised of multiple high-resolution projection systems arranged in a matrix configuration that produce an expansive display image. Each operator on the computer network can access information on the displayed image, and the layout of the windows can be dynamically configured. Using a mouse, operators can work from their local workstations or directly on the information displayed on the wall.



Circle no. 5

BRITEVIEW TECHNOLOGIES
Santa Clara, CA 408/985-8939
Booth 115

Flat collimators

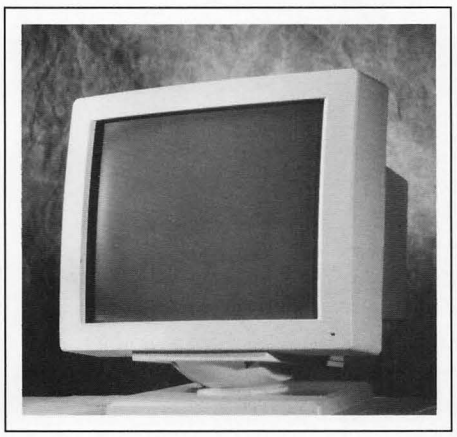
BriteView Technologies will feature the Flat Collimator™ MP-1A, a high-efficiency backlighting system for color LCDs based on an innovative approach of using a light pipe with microprism coupling to send essentially all of the light beams towards the viewer. With the output light highly collimated, LCD contrast ratio can also be improved. The prototype sample has a thickness of 5.3 mm and an illuminated area of 6 × 8 in. The MP-1T model is a transparent backlighting system that can be stacked together to give an extremely high-output brightness. Being transparent, it is also suitable for special applications such as image superposition.

Circle no. 6

CLINTON ELECTRONICS CORP.
Rockford, IL 815/633-1444
Booths 502/504

Monochrome monitors

Clinton Electronics will introduce a full line of monochrome monitors that use state-of-the-art embedded microprocessor and custom ASIC technology. Clinton's family of multifrequency monitors incorporate the design and manufacture of advanced digital technology. Digital control of previously analog circuits brings dynamic control solutions out to a keyboard – eliminating virtually every pot, trimmer, and jumper. Setup parameters are in the software, making it possible to change the characteristics of the display via the serial communication link (RS-232) to the embedded microprocessor.

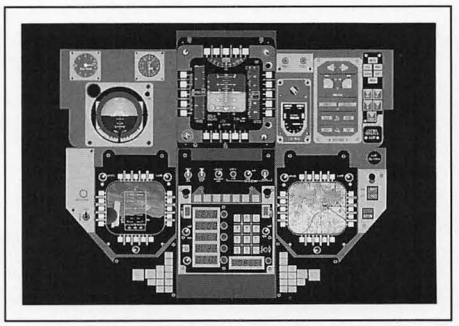


Circle no. 7

CORYPHAEUS SOFTWARE
Los Gatos, CA 408/395-4537
Booth 110

Designer's Workbench™

Coryphaeus Software will feature its Designer's Workbench (DWB) 2.1, a state-of-the-art 3D modeling environment that allows non-programmers to build and edit 3D models, out-the-window scenes, dynamic instrumentation displays, and virtual-reality databases. DWB has a modern direct-manipulation graphical interface based on industry-standard X/Motif, plus intuitive structure display for direct editing of display hierarchy. Any graphic element can be "linked" to give it dynamic behavior as a function of internal or external variables. Dynamics can be tested and optimized from within the graphics editor so that displays can be verified, debugged, and optimized interactively. Standard data interfaces include ethernet (TCP/IP and UDP/IP), shared memory, serial RS-232, and data file.

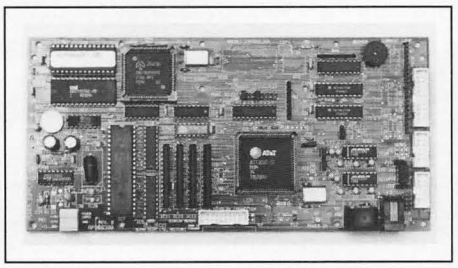


Circle no. 8

CRAFT DATA, INC.
Mission Viejo, CA 714/582-8284

Intelligent controller board

Craft Data, Inc., has introduced the AP988300, an intelligent controller board designed to drive EL, plasma, LCD, and CRT displays, both monochrome and color. The controller is capable of text, mixed mode, and full pixel graphics, has huge dual-port video-RAM capacity (2048 × 2048-pixel virtual screen area equivalent to 4 MB), VT100, VT52, and ADMA terminal emulations, graphics mode with special high-level command set, user down-loadable macros stored on the board, and multidrop capability. The FPGA chip on board allows easy configuration for most panel types. Two keyboard interfaces are available – VT220 and IBM-XT, with the unused port available to be configured for a barcode reader, track ball or equivalent, or external touch-screen controller. A printer interface is also available. The AP988300 controller can accept IR optical or membrane touch panels or membrane keyboard without an external controller. The dimensions are 228 × 110 mm; power, 7–40 Vdc, with 150 mA at 12 Vdc; and operating temperature, from 0 to +65°C.



Circle no. 9

DANA ENTERPRISES INTERNATIONAL
San Jose, CA 408/257-6686
Booths 126/128

Polarizers and micropearls

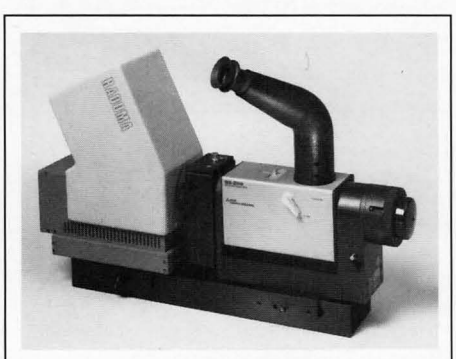
The complete line of Sanritz polarizers for the LCD industry will be featured. The line will include a high-durability polarizer which features high optical performance, a super-high-contrast polarizer, an anti-reflection polarizer, and a retardation film. Also on display will be spheres (micropearls) manufactured by Sekisui Chemical Corp. which are universally used in the production of LCDs. These uniform spheres, also available dyed black, are precise in size and have excellent heat/cold resistance, chemical resistance, and electrical insulation. When coated with gold or silver, they have excellent conductivity, and their elasticity is well suited to fine-pitch electrode coupling in products such as cog, anisotropic conductive film, and ink.

Circle no. 10

EG&G GAMMA SCIENTIFIC
San Diego, CA 619/279-8034
Booth 325

Radiometric optical multichannel analyzer

EG&G Gamma Scientific will feature the Radoma, a radiometric optical multichannel analyzer for rapid-scan spectroradiometric applications, which combines the advantages of a 1024-element optical detector array with state-of-the-art electronics to allow a spectrum to be acquired in as little as 20 ms. An exclusive automatic dynamic-range optimization feature ensures that the system electrical gains are always set for the best results. A wide variety of optical front ends, including telescopes, microscopes, and integrating spheres make Radoma suitable for nearly every radiometric application.

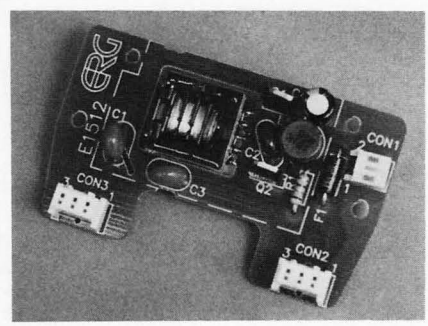


Circle no. 11

ENDICOTT RESEARCH GROUP
Endicott, NY 607/754-9187
Booth 618

Direct plug-in dc-ac inverter

Endicott Research Group, Inc. (ERG) will introduce the E1512 DC-AC inverter, which has been specifically designed to power the Sharp family of 6-in. TFT color LCD modules from a +12-V dc source, and satisfies the most common cold-cathode lighting requirements. Custom units, providing different inputs, outputs, or package refinements, are available. Moderately priced in OEM quantities, its small size makes it suitable for battery applications where high efficiency and reliability are critical.



Circle no. 12

FLAT CANDLE CO.
Colorado Springs, CO 719/573-1880
Booth 322

Fluorescent backlight lamps

Flat Candle Co. will feature small fluorescent backlight lamps developed for head-mount, helmet, and eyepiece LCD backlighting applications. Flat Candle can customize your backlight requirements.

Circle no. 13

FLOROD CORP.
Redondo Beach, CA 310/532-2700
Booth 230

Multiprobe FPD testing system

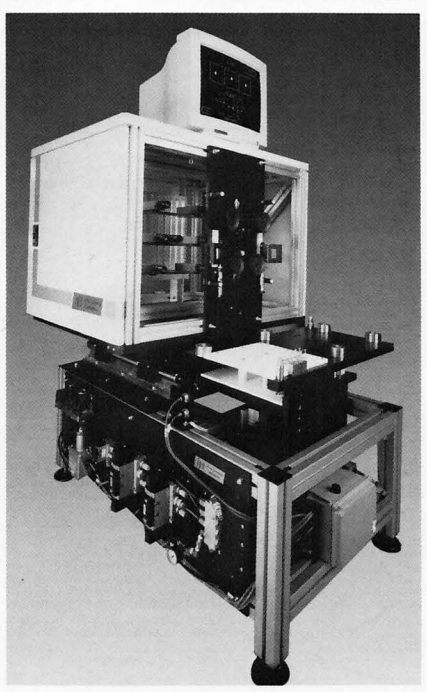
Florod Corp. will introduce the RAMP Random Access Multi-Probe Testing System for flat-panel displays. RAMP measures the pin-to-pin resistance of driver or electrode rows and columns, detects open lines and measures open impedances, and detects side-by-side line shorts, as well as crossover shorts. RAMP features four independently controlled step-and-repeat axes, each with its own probe set. Each set works together to measure the continuity and impedance of the display's rows and columns. RAMP uses Gold Bump membrane multiprobe technology to provide one standard probe setup for different pitch panels, with no customization required.

Circle no. 14

IMAGE PROCESSING SYSTEMS
Markham, Ontario, Canada 416/940-0300
Booths 215/217/219

Automated display test and alignment systems

Image Processing Systems, Inc. will feature the new computer vision-based ADIS 8200 series of automated display test and alignment systems. The 8200 systems automate a comprehensive series of test and alignment functions, including focus, convergence, and purity measurement and adjustment for on-line CRT, TV, and monitor manufacturing. System features include high-performance multiprocessor computer architecture for high-speed measurements and real-time feedback, digital color cameras with auto-focus and precision optics for high measurement accuracy despite variations in CRT curvature and glass thickness, flexible sensor array with servo-based sensor positioning for auto-changeover at the press of a button, and advanced image analysis software with auto-calibration.



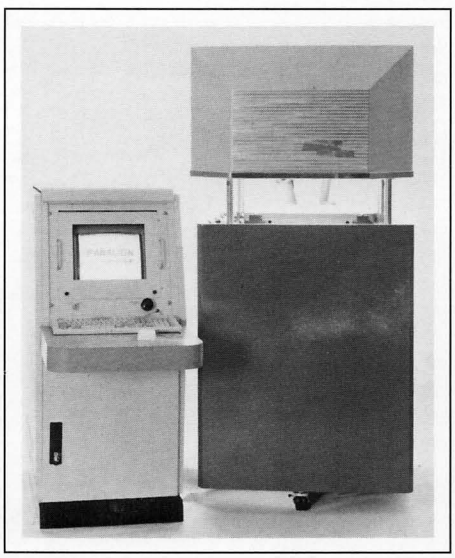
Circle no. 15

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.

INTERSERV CORP.
Bloomington, MN 612/888-9767
Booths 220/222

Alignment and assembly system

Interserv Corp. will introduce PANALIGN™, a compact automatic alignment assembly system for large-area LCD panels, capable of 1 micron precision. Precise alignment of the panels is achieved using the system's ability to align in three axes and maintain alignment during the curing process.



Circle no. 16

K AND M ELECTRONICS
West Springfield, MA 413/781-1350
Booth 203

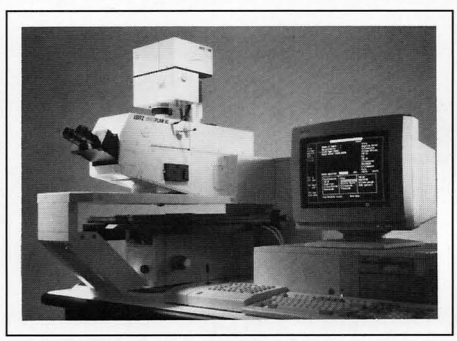
Miniature high-voltage power supplies

K and M Electronics will display miniature high-voltage power supplies for small-diameter CRT displays for stereoscopic high-resolution virtual-reality applications. This product line includes 8.6 through 12.0 kVdc anode output. The line incorporates the latest in surface-mount technology in a 5.5 (L) × 3.0 (W) × 1.0 (H) in. aluminum housing. Common features include dual independently adjustable focus and G2 outputs, with common anode and G1 outputs. Designed for a 28-Vdc input supply, the typical focus adjustment is 1800–2600 Vdc, G2 is 300–1000 Vdc, and G1 is 100-Vdc nominal. All outputs feature tight line and load regulation, with a typical temperature regulation of 100–200 ppm/°C.
Circle no. 17

LEICA, INC.
Foster City, CA 415/578-0488
Booth 629

LCD measurement system

The Leica SP400 has all the qualities essential for film and gap thickness measurement of LCDs up to 400 × 400 mm. The system has an ultrawide film-thickness measurement range from 5 nm to 150 µm, with a precision of 0.5% or 0.15 nm, whichever is greater. The thickness of filled and unfilled LCD gaps with or without color filters can also be measured with the same precision. Key features include triple-layer analysis, simultaneous measurement of double layers, simultaneous refractive-index and thickness measurements, and 2D/3D contour mapping. Optional software modules allow dispersive refractive-index measurements and quantitative colorimetric analysis. The high-performance Ergoplan XL microscope can also be used for visual inspection of LCDs.

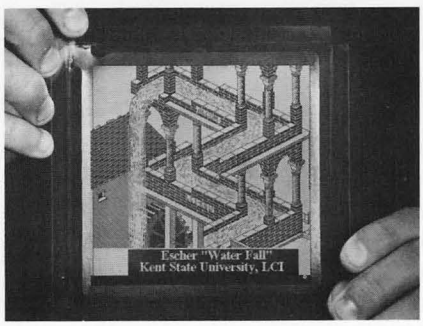


Circle no. 18

LIQUID CRYSTAL INSTITUTE
KENT STATE UNIVERSITY
Kent, OH 216/672-2511
Booth 634

New reflective display

A reflective LCD display will be shown that demonstrates recent work in applying new technology to meet emerging display requirements. This new cholesteric-nematic technology is bistable, requiring no power to maintain a static image and achieving high resolution with a passive matrix. The National Science Foundation Science and Technology Center for Advanced Liquid Crystalline Optical Materials (ALCOM) is a consortium of Kent State University, Case Western University, the University of Akron, and industrial partners. For more information, contact Dr. John West at 216/672-2581.



Circle no. 19

MICROVISION
Los Gatos, CA 408/374-3158
Booths 601/603/605

Display analysis system

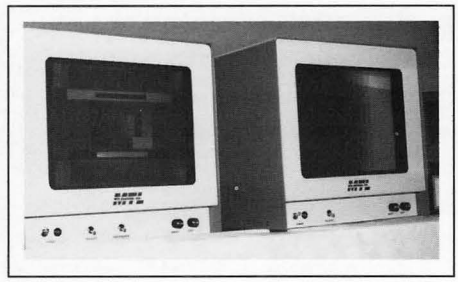
Microvision will introduce the SS200, a new-generation Display Analysis System that uses the latest X-Y CCD camera technology and powerful new video processing capability, with super VGA graphic user interface. Fast Beamview shadow-mask filtering and Beam Landing Analysis are featured, in addition to all standard display-parameter measurements.

Circle no. 20

MTL SYSTEMS
Dayton, OH 513/426-3111
Booth 622

High-resolution monitor

MTL Systems will feature the MTL 17001, a rugged high-resolution monitor which utilizes a 0.25-mm-pitch 17-in. flat-tension-mask CRT that provides unprecedented brightness, with a perfectly flat surface and resolution equal to or better than traditional 19-in. monitors. The monitor weighs less than 65 pounds, and is made in America.

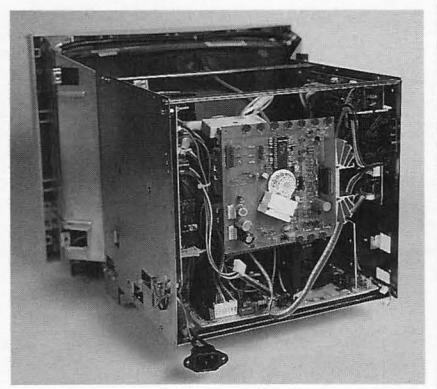


Circle no. 21

NATIONAL SEMICONDUCTOR
Santa Clara, CA 408/721-4776
Booths 408/410

Triple 80-MHz CRT driver

National Semiconductor will display the LM2427, a high-performance triple CRT driver for simplifying color-monitor designs. The device contains three large signal transimpedance amplifiers and provides direct cathode drive capability. A plastic power package and pin-to-pin compatibility make the LM2427 ideal for new designs or as a low-cost replacement for designs using the LH2426 or CR5527.



Circle no. 22

NEC CORP.
Tokyo, Japan 81-3-798-6124
Booths 120/222

TFT-AMLCDs

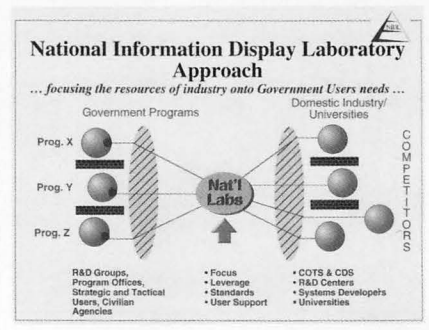
NEC will offer two 24-cm (9.4-in.) thin-film-transistor (TFT) active-matrix color LCDs. The NL6448AC30-09 color LCD features a 0.3-mm pixel pitch that allows it to display at resolutions of 640 × 480 pixels in a diagonally measured 24-cm screen. The NL6448AC30-10 color LCD displays 4096 colors with 640 × 480 pixels, consumes 5.9 W, measures 12.5 mm deep, and weighs 680 g.

Circle no. 23

NIDL
Princeton, NJ 609/951-0150
Booths 527/529

Alliance of government and commercial organizations

The National Information Display Laboratory (NIDL) is an alliance of government and commercial organizations created in 1990 to address government users and their needs in information technologies. NIDL's focus is on current and future government needs, encompassing advanced displays, information processing, softcopy tools, compression, collaboration, and communications. Leveraging the dynamic developments in the commercial marketplace, NIDL takes advantage of the commercial markets for faster acquisition, commercial compatibility, and decreased cost for the government. NIDL is a distributed lab encompassing many government, industrial, and academic partners who are leaders in their respective fields.



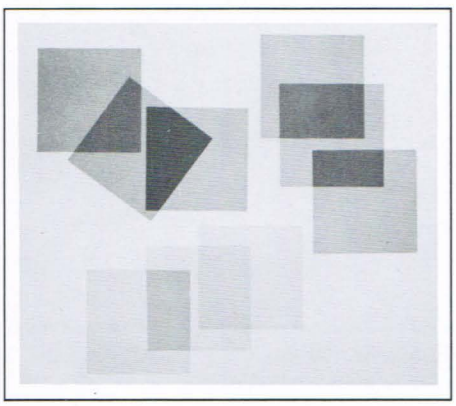
Circle no. 24

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

NITTO DENKO
New Brunswick, NJ 908/418-2775
Booths 716/718

AMLCD polarizing film

Active-matrix LCDs require a polarizing film that can provide high transmittance and a high polarizing efficiency at low input power. Nitto Denko will feature a new type of polarizing film that will satisfy both of these requirements.



Circle no. 25

Please send new contributions or noteworthy news items to Aris Silzars, Contributing Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.

OPTICAL ASSOCIATES, INC.
Milpitas, CA 408/263-4944
Booth 426

Large-panel aligner/bonder

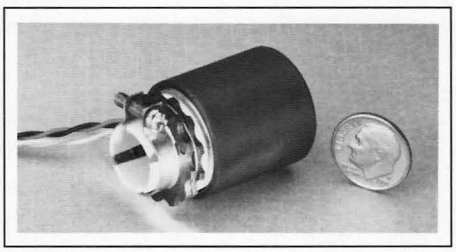
Optical Associates, Inc. (OAI) will feature the Aligner Exposure-Bonder, a system that combines alignment, exposure, and bonding capability into one system. It can precisely align large glass panels, apply pressure, and then expose the assembly to UV light to bond the substrates together. One unique feature of the new exposure-bonder is the ability to align two glass plates prior to bonding using a unique proximity alignment system. The proximity alignment system allows the operator to planarize both glass plates before initiating the substrate-to-substrate alignment process. The current system can be used to align and bond both fragile and durable substrates up to 425 mm square. It is priced well below many exposure systems available for large-panel exposure.

Circle no. 26

PENN-TRAN CORP.
Bellefonte, PA 814/355-1521
Booths 507/509

High-frequency deflection yoke

Penn-Tran will feature a new 13-mm high-frequency mini-deflection yoke used in miniature head-up and helmet-mounted displays. This component utilizes premium-grade ferrite material, in addition to special windings and highly thermal conductive materials, to minimize heat rise in high-frequency applications. The component's miniature dimensions prevent unwanted interference between the deflection yoke and the CRT electron-gun structure. This provides the best resolution and overall performance for the high-frequency display. This unit can be manufactured with a wide range of electrical parameters.



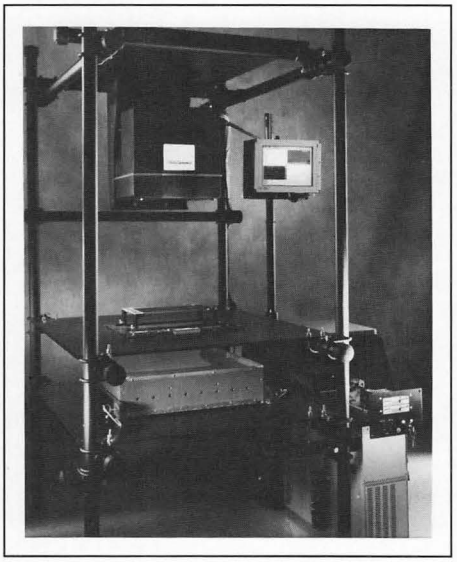
Circle no. 27

Please send new contributions or noteworthy news items to Aris Silzars, Contributing Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.

PHOTON DYNAMICS
Milpitas, CA 408/433-3922
Booths 429/431

Flat-panel inspection system

Photon Dynamics will feature a flat-panel inspection system (FIS) designed to integrate into high-volume LCD manufacturing. The FIS comes at a time when manufacturers are looking to incorporate test and inspection equipment directly into their production lines. Consisting of four modules, an optical head, a translation system, the host computer, and image processors, the system is used to test assembled panels for line and "mura" defects at an average of 5 s per test. The FIS has been production tested in automated facilities in Asia.

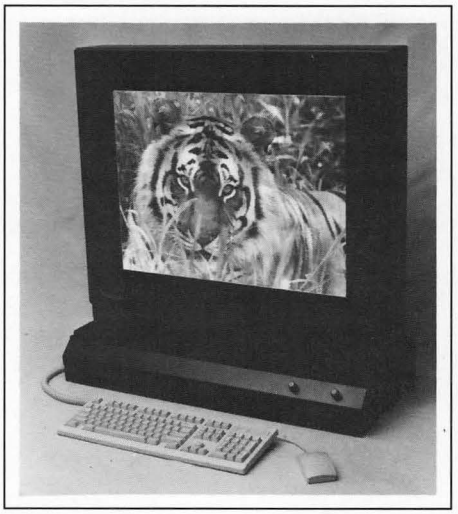


Circle no. 28

PHOTONICS IMAGING
Norwood, OH 419/666-6325
Booth 607

30-in. ac gas-discharge display

Photonics Imaging, Inc., a division and subsidiary of Photonics Systems, Inc., will feature the largest full-color flat-panel display. This ac gas-discharge display has a diagonal of 30 in. and a color resolution of 1024 × 768 (XVGA) with over 262,000 colors.



Circle no. 29

PLASMACO, INC.
Highland, NY 914/883-6800
Booth 313

ac plasma high-resolution monitor

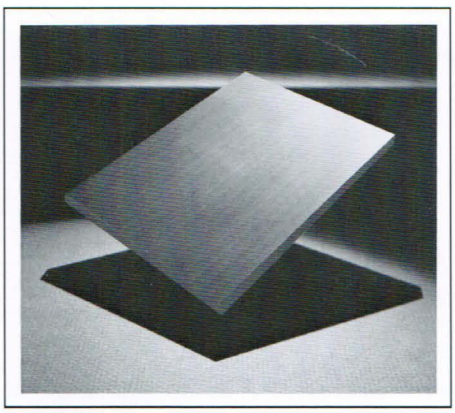
Plasmaco will feature an integrated X-terminal interface and an accelerated PC display adapter card for its 21.3-in. high-resolution monitor. Also interfacing with Sun and Macintosh computers, this monitor is ready to run most industry standard software. Featuring a 1280 × 1024 format and 0.33-mm dot pitch, this monitor is capable of displaying four full-page windows using the same character size as used on standard monitors. Incorporating ac plasma technology, the display provides high brightness, excellent contrast, and superior viewing angle. With a viewing area equivalent to that of a 23-in. CRT, multiple windows of information can be displayed in a few square inches of desk space. The lightweight monitor is also ideal for wall mounting or overhead displays.

Circle no. 30

PLASMARC™
Providence, RI 401/456-0800
Booth 117

Sputtering targets

PlasmArc™ ITO sputtering targets for all commercial and custom systems will be featured. ITO targets are highly dense and single-phase $(In_2O_3)_x$ $(SnO_2)_y$, improving both sputter rate and efficiency. The latter is due to low nodule formation and stable density throughout the target. ITO targets can be fabricated in planar (rectangular and circular) and rotating cylindrical geometries for standard and special cathode assemblies. PlasmArc™'s fully integrated manufacturing incorporates bonding to water-cooled backing plates and reclaim of spent ceramic and metal targets. PlasmArc™ also offers value-added engineering services for improved process efficiencies and custom target designs.

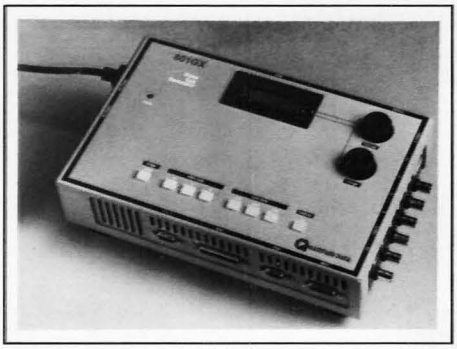


Circle no. 31

QUANTUM DATA
Elgin, IL 708/888-0450
Booths 526/528

Video test generator

Quantum Data will feature the 801GX, a new 150-MHz portable video generator for QC, production, service, and sales demos. The 801GX includes self-calibrating analog outputs, a built-in programming interface, and multimedia outputs. Most of the standard video formats and test images are included and easily accessible with the turn of a knob. You won't need to worry about adapters because the VGA, Mac, BNC, and Sun connectors are already built in. The 801GX offers you lab-generator performance at a fraction of the cost, and delivers full graphics performance for only $4995.

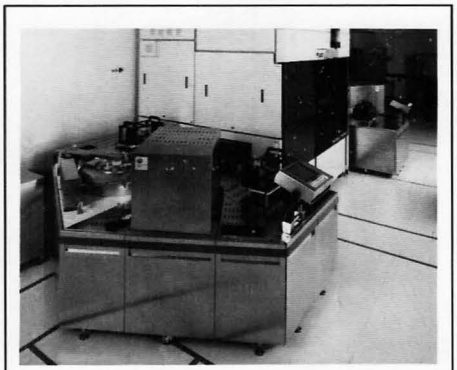


Circle no. 32

SEMICONDUCTOR SYSTEMS, INC.
Fremont, CA 510/683-8858
Booths 327/329

FPD manufacturing system

Semiconductor Systems, Inc. (SSI) has announced their entry into the rapidly growing large-area flat-panel display (FPD) manufacturing systems market. The inaugural product is the APEX FPD-500 photoprocessing system that utilizes a fully automatic robotic cluster-tool architecture engineered to coat and develop photoresist films on next-generation FPD substrates of up to 500 × 500 mm. The APEX system features simultaneous random-access processing for the ultimate in process-recipe flexibility, while maintaining a very high throughput rate. Each processing module is designed for high reliability, long duty cycles, high efficiency, and ease of maintenance. The advanced APEX system is the first FPD manufacturing system to feature a proven lithography interface. The system can be linked to a variety of advanced lithography tools for fully automatic photoprocessing in a high-throughput manufacturing environment.



Circle no. 33

SONY ELECTRONICS, INC.
San Diego, CA 619/673-2860
Booths 306/308/310

High-resolution monitors

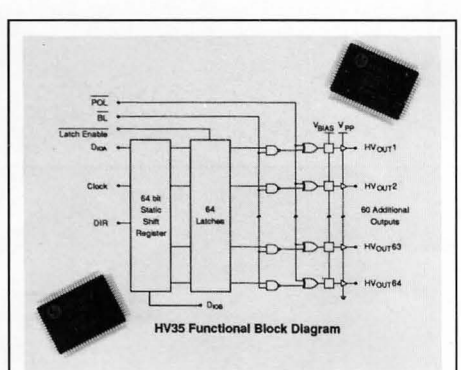
Sony will be demonstrating the first prototype of a new family of Trinitron® non-interlaced high-resolution computer display monitors. It uses the same basic technology as Sony's GDM-type monitors, but has 1920 × 1080 resolution and new 16:9 aspect ratio. The GWM can be driven directly by almost every high-performance computing platform from personal computers to supercomputers. Product availability is scheduled for Fall 1994. Target applications include but are not limited to imaging, scientific visualization, CAD/CAM, graphic design, printing/publishing, multimedia production, film and video production, animation, window and GUI-based computing environments.

Circle no. 34

SUPERTEX, INC.
Sunnyvale, CA 408/744-0100
Booth 602

64-channel driver IC

Supertex, Inc. will introduce the HV35, a monolithic 64-channel high-voltage driver IC with CMOS logic and 275-V push-pull outputs. Each of the 64 channels of the HV35 provides a push-pull output voltage of 275 V and is capable of sinking and sourcing 1.0 mA of current. The logic section, which consists of a 64-bit shift register and 64 latches, as well as direction (DIR), polarity (POL), and blanking (BL) functions, operates at V_{DD} of 5 V. The DIR feature allows for data to be clocked in either a clockwise or counterclockwise direction, depending on the high or low level applied to the DIR pin. The shift register speed is rated at 6 MHz. The HV35 is available in 80 lead plastic (PG) and ceramic (DG) gullwing packages as well as in die form (X). The price for the HV35 PG in 1000-piece quantities is $17.23 each. High-reliability processing per the test methods of MIL-STD-883 is available.



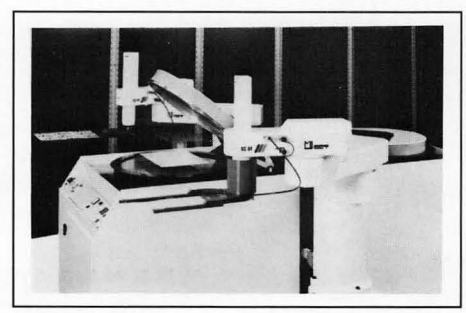
HV35 Functional Block Diagram

Circle no. 35

KARL SUSS AMERICA, INC.
Waterbury Center, VT 802/244-5181
Booth 434

Resist coater

Karl Suss America will display the Suss RC 22, a resist coater (or spinner) that can be used for any liquid film-coating requirement from positive or negative resist to spin on glass and polyimide. This tool, which offers the unique and patented GYRSET system as a standard feature, coats substrates from 6 to 16 in. square using up to four times less resist than conventional coaters.

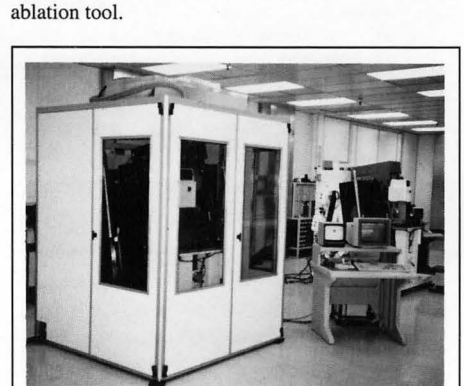


Circle no. 36

TAMARACK SCIENTIFIC CO., INC.
Anaheim, CA 714/632-5030
Booth 206

Lithography tool

Tamarack Scientific Co. will feature the 300 LGPX Large Panel Projection Exposure System, a high-precision lithography tool for flat-panel displays, multichip modules, or ultra-high-density printed-circuit boards. Panels may be as large as 500 × 600 mm. In a different version, the system may also be delivered with an excimer laser and used as a laser ablation tool.

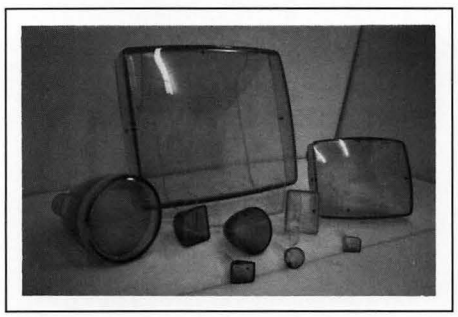


Circle no. 37

TECHNEGLAS
Columbus, OH 614/445-4800
Booths 704/706

Glass designs

Small or large, round or square, oblong or rectangular, Techneglas has the glass design for your CRT application.

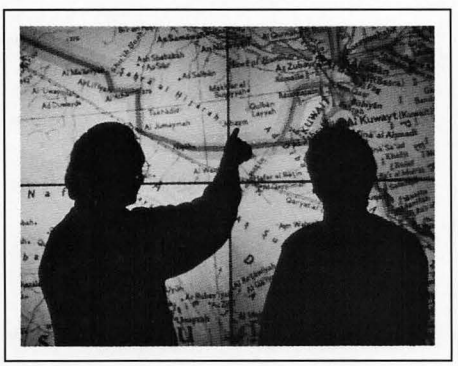


Circle no. 38

RGB SPECTRUM
Alameda, CA 510/814-7000
Booth 405

Wall-sized computer-based displays

RGB Spectrum's ComputerWall™ multiscreen display processor magnifies and splits high-resolution computer images across multiple monitors or projectors. The system is designed to create wall-sized computer-based displays with the brightness and resolution required for control rooms, simulation systems, and high-end multimedia presentations. Price: $16,995.



Circle no. 117

THOMAS ELECTRONICS
Wayne, NJ 201/696-5200
Booths 701/703

Miniature monitor

Thomas Electronics will feature a new 1.0-in.-diagonal miniature monitor that provides high-brightness high-resolution capabilities, using a P45 phosphor screen. It has a standard NTSC input signal with an optional PAL or VGA input that will be available by mid-1994. The monitor provides a resolution of 800 TV lines at a peak brightness of 1700 nits. The CRT weighs just 12.5 grams; the complete monitor assembly, only 30 grams. The monitor operates at a 6-kV anode potential, utilizing magnetic focus and has a directly heated cathode. Applications include virtual reality, HMDs, thermal viewers, hand-held viewers, simulation, and compact projectors.

Circle no. 39

TNP INSTRUMENTS
Gardena, CA 310/538-6886
Booth 102

Probe station

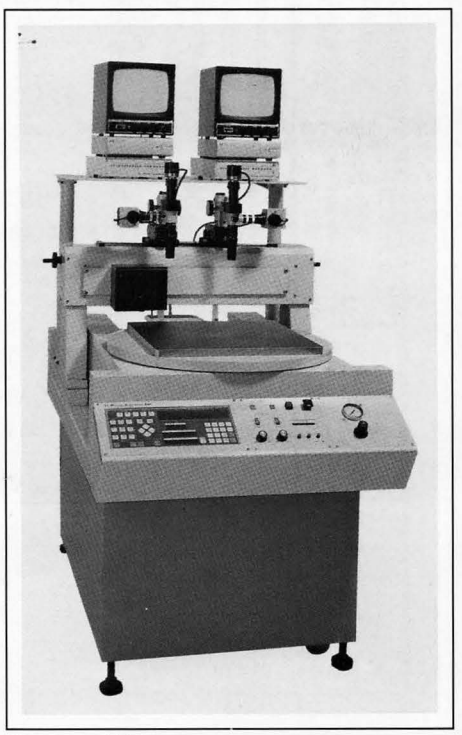
TNP Instruments, Inc. will introduce the LCD Model 2424 Probe Station, designed specifically for probing of LCDs and other large substrates, and equipped with many special features that allow a number of specific tests for LCD flat-panel manufacturers. Included among these special features are integration with machine vision (pattern recognition), interfacing to KLA/PDI inspection system (for defect and repair; review and classification), as well as the integration of Labview or Metric Software. Also included are the AF-405 Microprocessor Autofocus System and the MT-405 Objective Motorized Turret Control for a complete hands-off automated system.

Circle no. 40

UNIGLOBE KISCO
White Plains, NY 914/949-5434
Booth 621

Automatic scribing systems

Uniglobe Kisco will feature Joyo Engineering Scribing Systems designed to perform automatic scribing of LCDs up to 450 × 450 mm. They feature a heavy-duty scribe wheel held precisely in a vertical position by a steel case assembly. Also featured is WYSIWYG optics, which allows the operator to line up the scribe targets and then watch as the scribe wheel cuts through the targets. Establishing a scribe line offset is not required.



Circle no. 41 ■

continued from page 4

more refreshments, this time cookies and soft drinks. I have never been able to explain why it's coffee in the morning and pop in the afternoon (sodas to those on the East Coast). But, that's the way it always is.

The cookies and soda pop are not enough to obviate the growing uneasiness that every item on the list has some pesky problem with it. I have decided to call them, "those little tiny fatal flaws." In other words, an idea looks interesting but there is an apparent impossibility required to make it work, such as it violates the laws of physics, or no one in the group understands why the technology that is in current use works so well. Would you like a real-life example? How about wear-resistant coatings for train wheels and/or railroad tracks? That's OK, I don't know how to answer that one either. But what would the last 150 years probably tell you about the need for such a high-technology solution?

At this point, the facilitator typically brings the session to a rousing close with a talk about how well the process worked – just look at all the great ideas that were generated. Isn't it wonderful how all these ideas can now be passed on to top management for further consideration and detailed business analysis? And with the prioritization that the group has done, management will have an easy time implementing the most important ones. The future of the company is in good hands! Or, is it maybe time to look for a job with another company?

What's happening here? Why don't these sessions produce the great results expected? Why are the concepts so flawed and so little of the output useful for setting the real future direction of a company? Here's what I think is going on.

First, a group of "creatively challenged" individuals, no matter how large or how well facilitated, will not produce the quality results of a few or even one talented and genuinely creative person. This is likewise true in sports and most other pursuits. As a soccer referee, I have done games that had 11 players playing against five or six, and with just a small difference in skill level, the short side totally dominated the game. It seems that no matter how large a pool of mediocrity one assembles, it cannot overwhelm a few truly capable people. Hmmm! Perhaps that brings into question the hiring practices of certain well-known organizations?

Second, creativity does not respond to a predetermined time schedule. The brainstorming session is useful for exposing a variety of *existing* thoughts, but for them to become really interesting and/or useful, creative individuals must have time to let their talents work. For example, I find that I am most creative in the morning while getting ready for work. It is often then that solutions to problems that have been pestering me the previous day leap out from some deep mind-

recess in all of their ridiculous simplicity. Sometimes it's not the next day, but weeks or months later. I can't tell when, I just know that the creative synthesis process will work best when I am rested and when I don't try to force it to happen.

Third, I am convinced that thorough knowledge of a technology and an understanding of the marketplace are prerequisites to creating and developing truly useful new ideas. Often, the participants in these brainstorming sessions are not selected with this in mind. Thus, ideas that would be clearly flawed to those with more experience and understanding are eagerly accepted by a less knowledgeable group.

Finally, these sessions don't work for the same reason that governments are no good at selecting the future of technology and/or in deciding what's best for the rest of us. A small select group of individuals never has enough data to decide which new technology the marketplace will accept and to what degree. It is important, therefore, that many technologies and business approaches be encouraged with the expectation that a few will, through some semi-statistical process, survive because someone stumbled onto the best set of product features that customers found they really liked.

It is for this reason that I am such a strong supporter of the need to explore a large variety of display technologies and new directions. In this process there are no failures, just ever-improving insights. I believe, for example, that ARPA is taking the right approach by funding a variety of development programs. This type of "seed" financing is extremely important to encourage the development of new technologies so that they can get to the point where the marketplace can make the determination rather than a few well-meaning individuals. As Carver Mead says, "Technology is like flapjacks, you have to make a few before they get really good."

As we prepare for the upcoming SID International Symposium, I'll leave you with this parting thought. You can fool investors, industry experts, government R&D funders, early adopters, and even yourself. But YOU CAN NEVER FOOL YOUR MAINSTREAM CUSTOMERS, THE VOLUME USERS. And if you don't believe me, ask Steve Jobs of NeXT Computer, Inc., or at least read the recent book by Randall E. Stross, *Steve Jobs and the NeXT Big Thing.*

The **United States Display Consortium (USDC)** is relocating its headquarters to downtown San Jose, California. **Peter Mills** will be making the move from his previous location in Austin, Texas, and **Bob Pinnel** is giving up on East Coast winters and leaving Berkeley Heights, New Jersey. Peter tells me that a major reason for the move is that over 40% of the U.S. Flat-Panel Display (FPD) equipment supplier infrastructure is in the Bay

display continuum

Area. Their new phone number is 408/277-2400 and fax 408/277-2490.

Dr. Peter Pleshko, who established the consultancy, **PEMM Services**, a few months ago, after retiring from IBM, has provided some additional information on his areas of interest. He offers consultation on display technologies by providing assessment of characteristics, comparisons between technologies, predictions of their capabilities, recommendations on the best choice for a given application, and a strategic view of different technology choices. He also addresses such issues as manufacturability, cost, and availability. He can be reached at 914/889-4246.

The **Video Electronics Standards Association (VESA)**, mentioned in last month's column, is continuing its work on Flat-Panel Monitor Interfaces (FPMI). The March 10 regular meeting was extended to discuss this topic, with both VESA members and non-members invited to attend and present proposals for consideration. The session was moderated by **Ed Anwyl**. Additional information may be obtained from the VESA office in San Jose, California at 408/435-0333 or Ed Anwyl at 408/982-3510.

MicroTouch Systems, Inc. of Methuen, Massachusetts, has announced the appointment of **James J. Waldron** as vice president of new business development and acquisitions to lead the company's search for acquisition opportunities and product expansions in the touch, pen, and alternative input marketplaces. Mr. Waldron was most recently president and CEO of Visage, a manufacturer of a pressure-sensitive touch-input device. MicroTouch manufactures touch-screen kits and monitors used in point-of-sale terminals, information and self-service kiosks, and gaming, industrial, and other computational applications.

Rey Roque is the new vice president of the Display Products group of **Mitsubishi Electronics America, Inc.**, located in Cypress, California. In this capacity he will direct the marketing of display monitors in North America, including new product planning, supply-line management, and marketing communications. Prior to his tenure at Mitsubishi, Mr. Roque worked for Conrac Display Products in a variety of management positions. **Craig Sloss** is the product marketing manager for this group.

Fitch, Inc., an international business and design consultancy located in Worthington, Ohio, has appointed **Alex Subrizi** to direct its

efforts in the area of interface design. Mr. Subrizi, who joined Fitch in 1991, was also promoted to associate vice president. His new responsibilities will include directing all interface and multimedia design programs as well as establishing a long-term interface design strategy for the company. Fitch, Inc. has over 300 professionals, with offices in Boston, Columbus, and London.

Dave Martin has been named the general manager of **Carroll Touch** of Round Rock, Texas. Formerly development engineering manager for AMP Singapore PTE, Ltd., Mr. Martin has over 14 years experience in the electronics industry. His new responsibilities include overseeing Carroll Touch's domestic and European operations and that of its Japanese subsidiary, Carroll Touch International-Japan branch.

For contributions to and comments about this column, you may call me at 302/733-8927, or fax me at 302/733-8923. If you prefer the mail, please send your information to Jay Morreale, Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014. ■

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

update

Compiled by HOWARD L. FUNK
H. L. Funk Consulting

U.S. Patent No. 5,280,277; Issued 1/18/94
Field-Updated Deformable Mirror Device
Inventor: Hornbeck, Larry J.
Assigned to: Texas Instruments, Inc.

The bistable deformable mirror device (DMD) used in a high-definition-television (HDTV) application must be capable of supporting at least 128 gray levels, using pulse-width modulation. If the DMD is line-updated, then the minimum field time to support 128 gray levels cannot be achieved because of the time required to perform a resonant reset once each line. This disclosure shows how the DMD can be field-updated in order to achieve the minimum required field time.

U.S. Patent No. 5,285,079; Issued 2/8/94
Electron-Emitting Device, Electron-Emitting Apparatus, and Electron-Beam Drawing Apparatus
Inventors: Okunuki, Masahiko; Tsukamoto, Takeo; Watanabe, Nobuo
Assigned to: Canon K.K. Japan

An electron-emitting device is provided for use in a flat display, an electron-beam drawing apparatus, a CRT display, etc. The electron-emitting device comprises a first layer having a first bandgap, a second layer formed on the first layer and having the first bandgap, a third layer formed on the second layer and having a second bandgap, which is narrower than the first bandgap, and a fourth layer formed on the third layer and having an electron-emitting surface. According to this structure, a high electron emission efficiency can be obtained.

U.S. Patent No. 5,286,517; Issued 2/15/94
A Process for Making an Electroluminescent Cell Using a ZnS Host Including Molecules of a Ternary Europium Tetrafluoride Compound
Inventors: Kahng, Dawon; Yoshioka, T.
Assigned to: NEC Research Institute, Inc., Japan

A flat-panel display utilizes an array of electroluminescent cells in which the active layer is of polycrystalline zinc sulfide that is the host for molecules of a ternary europium fluoride compound, advantageously lithium europium tetrafluoride. Each cell includes a pair of electrodes between which are a silicon dioxide barrier layer, sufficiently thin for electrons to tunnel therethrough, the active layer, and a capacitive dielectric layer. Other ternary europium tetrafluoride compounds are described for use as the active layer.

U.S. Patent No. 5,285,296; Issued 2/8/94
Conversion of Color Display Data to Color Print Data
Inventors: Komooka, Haruo; Matsuyama, Toshifumi; Mizuno, Masao
Assigned to: IBM Corp.

An image processor converts white areas displayable on a video display screen to white areas outlined in black and suitable for printing on white paper. In addition, black areas that are displayed on a video screen are converted to white for printing on white paper.

U.S. Patent No. 5,285,276; Issued 2/8/94
Bi-Rate High-Definition-Television Signal Transmission System
Inventor: Citta, Richard W.
Assigned to: Zenith Electronics Corp.

A frame of compressed video data is formatted for transmission into a plurality of data segments, a first group of which are encoded in the form of a plurality of four-level symbols and a second group of which are encoded in the form of a plurality of two-level symbols for providing improved noise performance. The partition between the first and second groups of data segments may be established on a fixed basis, a variable basis dependent upon the effective level of compression, or a combination of both. Preferably, the levels are selected such that the average levels of the transmitted M- and N-level symbols are substantially equal to a non-zero value to assist lock-up of the receiver PLL and reduce transmission power.

U.S. Patent No. 5,283,653; Issued 2/1/94
Dual HDTV/NTSC Receiver Using Sequentially Synthesized HDTV and NTSC Co-Channel Carrier Frequencies
Inventor: Citta, Richard W.
Assigned to: Zenith Electronics Corp.

A dual HDTV/NTSC receiver includes a microprocessor for controlling a tuner for synthesizing the carrier frequencies of HDTV and NTSC signals. The HDTV signals are inherently of much lower power than the NTSC signals. The tuner initially synthesizes the carrier frequency of a desired HDTV signal which is attempted to be detected in an narrow-band synchronous detector. Detection of the HDTV signal produces a high lock detect signal which causes the microprocessor to enable an HDTV processing channel. If no HDTV signal is detected, the lock detect signal remains low and the microprocessor controls the tuner for synthesizing the carrier frequency of the NTSC co-channel television signal. A high lock detect signal from the narrow-band synchronous detector, indicating detection of the NTSC co-channel, causes the microprocessor to enable the NTSC processing channel. A system for automatically programming the receiver and memorizing which type signal is present on each television channel is also shown.

U.S. Patent No. 5,280,397; Issued 1/18/94
Bi-Directional HDTV-Format Digital Signal Converter
Inventor: Rhodes, Charles W.
Assigned to: Advanced Television Test Center Inc.

A TV-signal-format converter is provided for converting, without loss of picture, information from any HDTV format to or from a given recorder/player format. An interface converts between RGB and luminance/chrominance inputs and between analog and digital inputs. The interface couples a HDTV format to a plurality of pairs of memories. A clock and control circuit controls addressing of the memories for reading and writing so that conversion is performed between a HDTV format and a format required for a given high-definition digital videotape recorder or any other comparable recorder.

U.S. Patent No. 5,287,105; Issued 2/15/94
Automatic Tracking and Scanning Cursor for Digitizers
Inventors: Guardado, Julio L.; Schlotterbeck, David L.
Assigned to: Calcomp Inc.

This is a hand cursor for a digitizing system allowing easier positioning of the cursor at the points to be digitized. The cursor includes a quasi-sight window having a CCD panel for viewing a two-dimensional area and an LCD panel for displaying it to the user. There is a vertical positioning line on the panel. A position signal generator is disposed in the cursor for continuously generating and outputting positional data from which a reference-point position and the orientation of the positional line on the

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tablet surface can be dynamically determined. There is also position determination logic for inputting the electrical signal output from the CCD panel and the positional data from the positional generator and for determining a point on the tablet surface where the positional line crosses a line contained in a drawing disposed on the tablet surface over which the quasi-sight window is positioned as a point to digitize.

U.S. Patent No. 5,285,361; Issued 2/8/94

Backlighting Apparatus for Flat-Panel Displays

Inventor: McKillip, Robert C.
Assigned to: Rockwell International Corp.

An apparatus for providing illumination to flat-panel displays having a multiwalled encasement device, lighting means, and a flat-panel display. The multiwalled encasement device may be of a variety of shapes and serves to support the lighting means within the cavity formed by its walls. The fluorescent bulb is fabricated into a circular design and placed within the multiwalled encasement device thereby providing uniform light intensity across the flat-panel display attached to the encasement device. The encasement device may contain convex or concave contouring to better direct or concentrate lightwave intensity to the flat-panel display.

U.S. Patent No. 5,287,131; Issued 2/15/94

Color LCD System of the Projection Type

Inventor: Lee, Jongcheon
Assigned to: Samsung Electron Devices Co. Ltd., Korea

A projection color LCD system uses a large reflecting LC panel as a screen. The system includes three unicolor light sources for emitting lights of red, green, and blue, respectively, the light sources being disposed remote from the screen; three light shutters for permitting the red, green, and blue light beams to successively and periodically pass to the screen; and three diffusing lenses for diffusing the respective beam which is passing to the screen. Each respective light shutter permits the passage of a corresponding light beam. The color driving signal corresponding to the light beam from the image controlling circuit is applied to the driver to drive the LC panel. As a result, the red, green, and blue light beams are successively reflected from the reflection-type LC panel according to the color driving signal. Since the reflecting frequency of successive three color light beams is under 1/30 sec and, a person who is looking at the front side of the screen recognizes successive three color light beams as the composite color screen.

U.S. Patent No. 5,287,180; Issued 2/15/94

Modulator/Demodulator for Compatible HDTV System

Inventor: White, Hugh E.
Assigned to: General Electric Co.

An NTSC bandwidth-compatible HDTV system employs multiple quadrature amplitude modulation (QAM). A first suppressed QAM carrier is modulated with high-priority information including predominantly low-frequency information. A second suppressed QAM carrier is modulated with low-priority information including predominantly high-frequency information. The high-priority QAM signal exhibits a larger amplitude and narrower bandwidth than the low-priority QAM signal, and is disposed in the lower portion of the multiple QAM frequency spectrum normally occupied by the vestigial sideband of a standard NTSC television signal. The frequency spectrum of the multiple QAM signal exhibits signal attenuation at frequencies associated with high-energy information in a standard NTSC signal, e.g., frequencies around the NTSC picture and sound carriers.

U.S. Patent No. 5,285,150; Issued 2/8/94

Method and Apparatus for Testing LCD Panel Array

Inventors: Henley, Francois J.; Miller, Michael J.
Assigned to: Photon Dynamics Inc.

A hierarchical testing method is implemented taking advantage of the nature of the most common defects in an LCD panel to achieve fast effective parametric testing of LCD panels and the like. At the first hierarchy of testing, the panel is logically divided into zones and each zone tested in isolation to identify zones having at least one defect. At the next hierarchy, electro-optic assisted zone inspection is performed to identify where within the zone the defects are located. Lastly, every pixel is inspected using a voltage imaging method to determine whether the switching integrity of the pixel is acceptable. The testing apparatus includes a plurality of panel interface devices coupling the panel under test's drive lines and gate lines to a precision measurement unit (PMU). A controller determines the PMU signals and configures the panel interface devices. The

PMU monitors select drive lines and gate lines to isolate zones having defects. An electro-optic voltage measurement system is used to identify the location of defects within an isolated zone.

U.S. Patent No. 5,287,038; Issued 2/15/94

High-Resolution Electron Gun

Inventors: Hagar, Robert A.; Ingle, Arthur J.
Assigned to: Litton Systems Inc.

An improved resolution electron gun for a CRT is provided having a cathode, a control grid, and an anode. A positive voltage is applied to the anode for the purpose of drawing the electron beam from the cathode, which emits the electron beam along its principal axis. The control grid between the cathode and the anode has a modulating drive voltage to modulate the emitted beam. The anode and the grid are aligned along the principal axis of the cathode and are adjacent to one another. A limiting aperture is mounted along the principal axis to clip the beam and reduce its diameter. A screen is provided along the principal axis within the CRT to receive the projected beam. To obtain increased resolution, the modulating drive voltage is increased while the aperture size is decreased. More specifically, the modulating drive voltage is increased beyond 25% of a predetermined maximum cutoff value, and the limiting aperture permits less than 50% of beam current to transmit. ■

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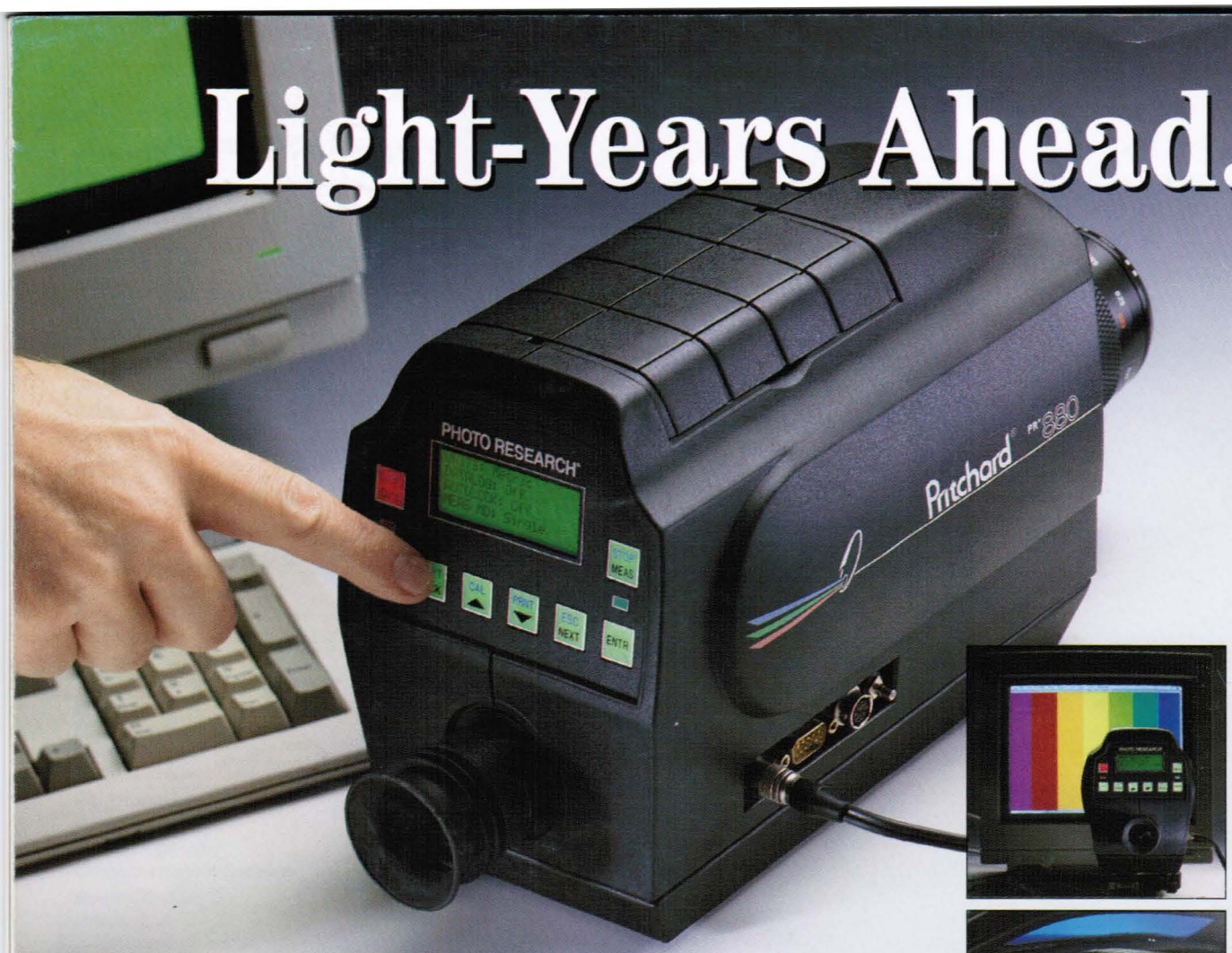

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