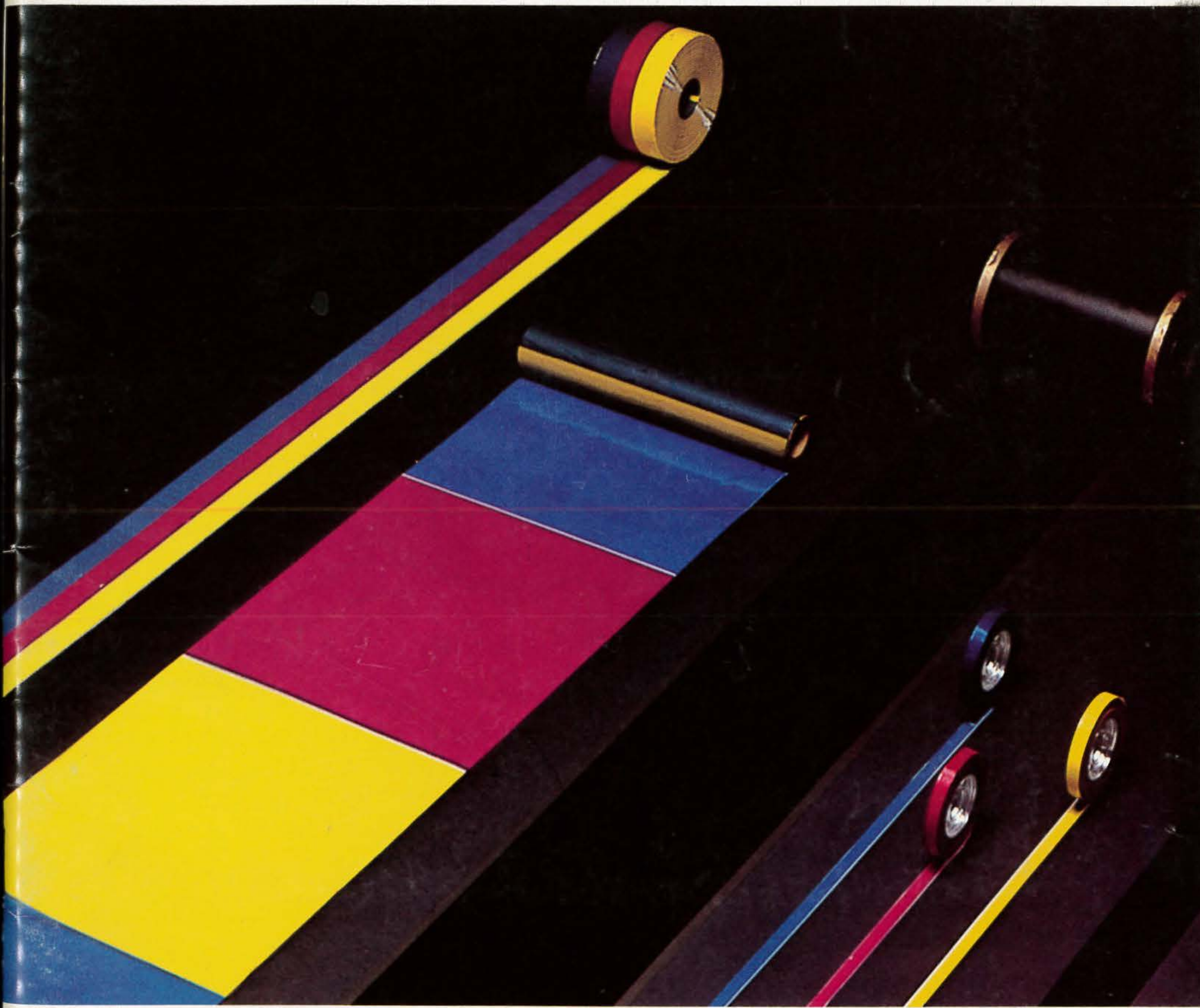
≡ Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

May 1987
Vol. 3, No. 5



New CRT phosphors
True 3D displays
Thermal-transfer printing
Interviews with industry leaders

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Circle no. 3

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INFORMATION DISPLAY

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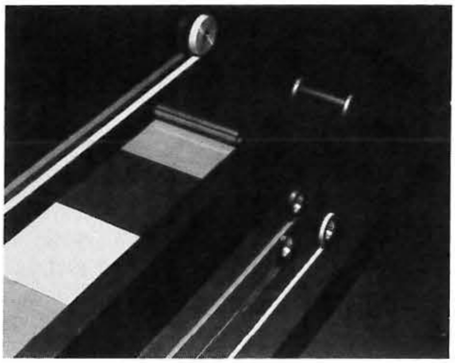
Cover: Rolls of thermal-transfer ribbon combine the three basic printing colors of cyan, yellow, and magenta. (page 23)



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Next Month in Information Display

- Single-lens TV projector system
- Why you need a 400-MHz video generator
- Choosing the printer that "fits"

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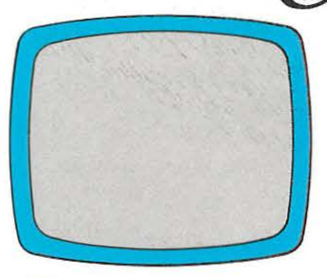
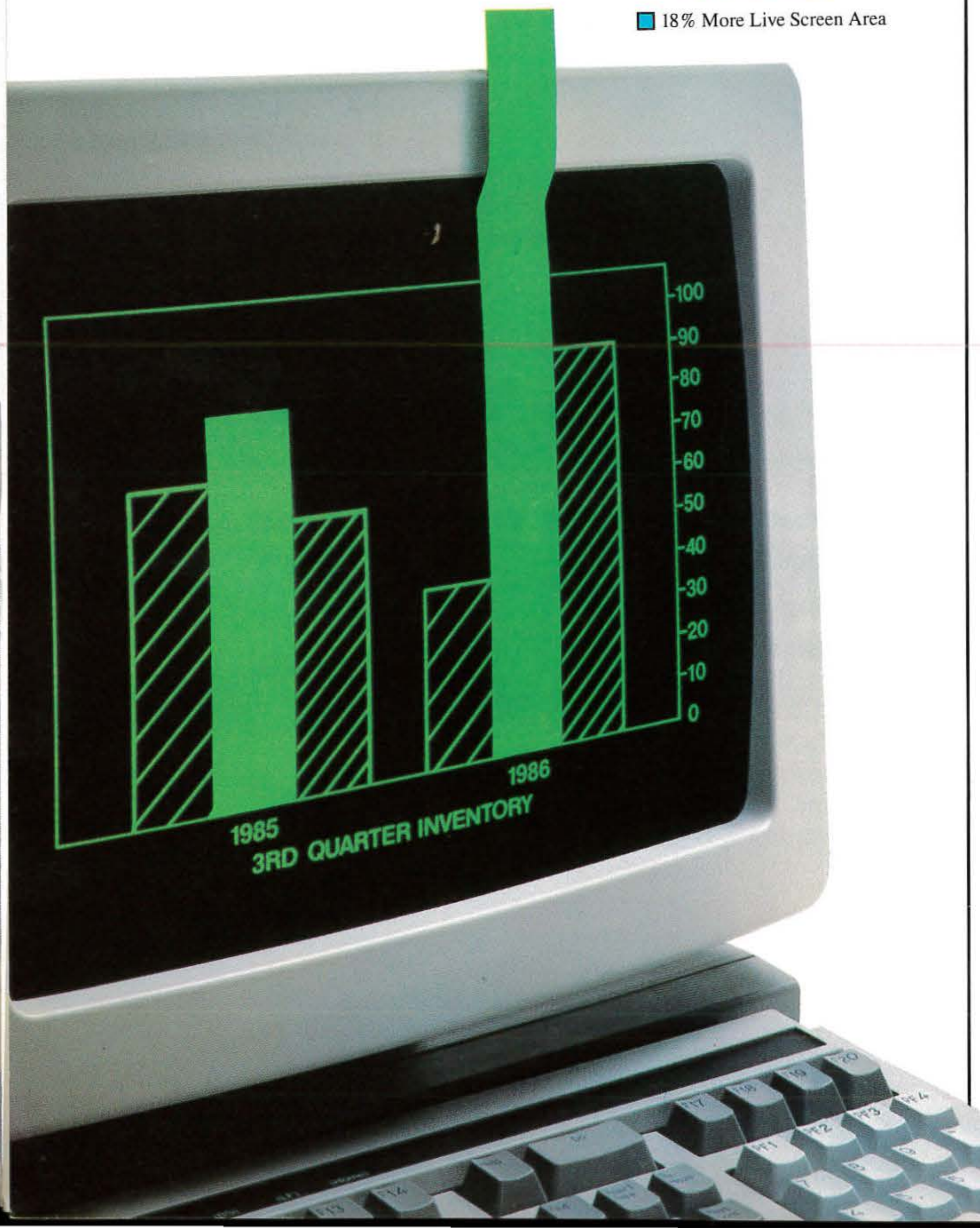
Clinton Electronics' new 15-inch, 90-degree, 20 mm cathode ray tube gives you all the advantages of the popular 14-inch CRT and more! It gives you 18% more useful screen area!

The new 15-inch CRT utilizes the same mechanical mounting and faceplate dimensions as a standard 15-inch CRT.



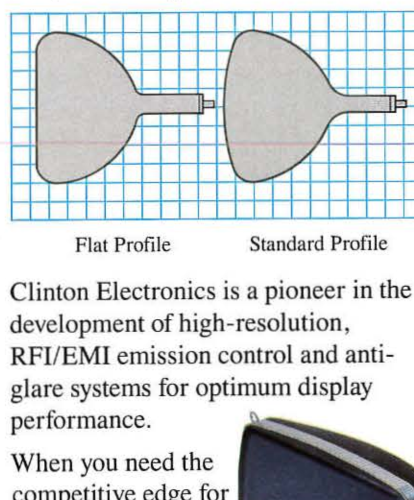
18% More Live Screen Area



It offers the additional cost savings of a 20 mm neck and a 90-degree deflection angle.

You gain the flexibility of using Clinton's new 15-inch CRT for low-cost data display, and a standard 15-inch CRT for high-resolution graphics... without retooling the terminal housing or front bezel.

Clinton's new 15-inch CRT uses 20 mm deflection components, so it uses less power and costs less than a standard 15-inch CRT. And it can be driven by the same electronics in your 14-inch display. The new 15-inch CRT is available in your choice of regular or flat profile faceplates.



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Circle no. 4

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INFORMATION DISPLAY

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editorial

Springtime, especially for those of us who live with extremes in climate, often seems like the real start of the new year. It induces us to think of where we've been and where we should be going in this fresh new world we're enjoying.

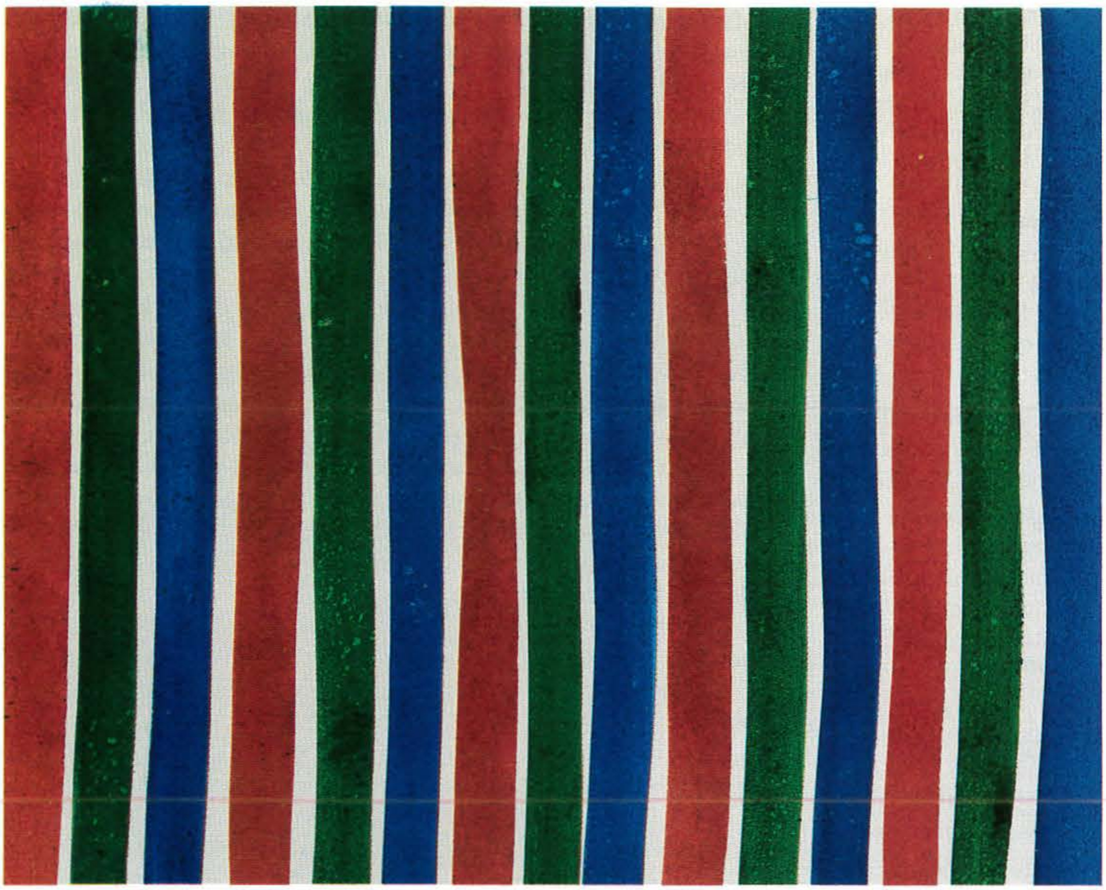
Perhaps this is as it should be, that spring *should* be a time for reflection as well as rebirth and renewal. We've certainly done our share in this spring's issues of *Information Display,* including our interviews with 25 leaders in the display industry, the final installment of which appears here. But enough of reflections; it's time we stepped back from the looking glass and into the future.

If there is one common theme throughout the 25 interviews, it has to be that the CRT is the dominant technology in its field, the one to beat. In our first article Al Wittenberg sets yet another challenge for the competition, in describing recent work in single-crystal CRTs, which offer distinct advantages over those using amorphous powder phosphors.

In our second article Larry Hodges and David McAllister give an overview of current three-dimensional displays. Although they outline 3D's history from the parlor stereoscopes found in antique stores everywhere to predictions on tomorrow's technology, they focus on devices based on the ubiquitous CRT.

Our third article skirts the CRT issue nicely, for it describes yet another facet of information display: thermal-transfer printing. Jack O'Leary cannot say much about its history, because it's been on the market for only 12 years. Instead, he concentrates on the widely diverse applications this technology has had and speculates on its future, especially in the realm of color displays and copiers.

Because this month's magazine is larger than usual, Howard Funk's column on "Recent Patents" will appear in the June issue. Also in that issue will be an announcement on the classified-ads section we plan to inaugurate shortly. Shortly, too, we promise to stop ending the editorial with a plea for your comments, just as public television stations promise that their pledge drives won't last forever. Compliments on past articles are much appreciated, of course, and please do keep sending them in, but we'd also like to get more cards about stories you'd like to see published. And unlike public television, your contributions won't cost you a cent—we pay the postage on the reader service cards.



Society for Information Display
8055 West Manchester Avenue, Suite 615
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president's message

In a few short weeks—and by the time this column appears in print—it will be time again to pack our suitcases to attend the SID '87 Symposium in New Orleans. Already, based on the number of papers submitted and incorporated into the technical program and the breadth of the seminar and exhibits, it will predictably be a great success.

"Success" in this instance could be measured simply by the number of papers presented or number of attendees, but I believe the importance of the SID symposia goes far beyond such numbers. In fact, a recurrent opinion expressed in the "interviews with display experts" appearing in this and the previous issue of *Information Display*, is that the International Symposia are at the core of SID's strength and uniqueness.

I personally found it interesting to try to imagine the state of the display technology in 1962 when Harold R. Luxenberg and his colleagues first laid plans for a new society "to encourage the scientific, literary, and educational advancement of information display . . . to provide forums . . . periodic publications and regular conferences for the exchange and dissemination of ideas . . . ". Color television was beginning to take off, but the color CRT was a long way from establishing its dominance in the many applications that have developed since then. The urgent need for real-time interactive computer graphics did not yet exist. Very few optimists believed that flat-panel technologies—mostly electroluminescence in those days—would ever challenge the CRT. Liquid-crystal displays, as we know them today, and digital watches, portable calculators, and other analog or digital flat display technologies and applications had not yet been invented. In retrospect, it is almost surprising that the need for a display society was sensed by our founders in 1962.

I believe it is safe to say, however, that SID has played a major role since then in *accelerating* the development of new display technologies and applications by establishing an annual forum for the dissemination of new ideas and results. The annual symposia and IDRC's (International Display Research Conferences) provide a unique opportunity for the attendees to hear what is happening elsewhere in the world and to *react* to that news. Consequently, history is shaped by these conferences, not merely retold.

Quite probably, as we look back on this year's symposium 25 years from now, we'll see more clearly how the SID '87 Symposium in New Orleans will have affected the display industry in the coming years. I sincerely hope you will enjoy this conference, both for the opportunities to learn and to exchange ideas with friends and colleagues, and that you will find it useful in shaping the future. I look forward to seeing you there.

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Circle no. 6

X
Y

Ellinor Peripherals distributes in U. S.

Personal Touch Corp. of San Jose, CA, has announced an exclusive European distribution agreement with Ellinor Peripherals, Ltd., of Reading, England. The two-year agreement is expected to result in wholesale touch-screen monitor sales of at least $4 million. Ellinor's sister company in the Sintrom Group, Perex, Ltd., will assemble the Personal Touch membrane screens and interface electronics into the European line of 10-, 14-, and 20-inch Sony monitors for Ellinor's distribution to VARs, OEMs, and system integrators.

Ellinor is located at 4 Arkwright Rd., Reading, RG2 OLU, England. (0734) 863417. The Personal Touch Corp. is located at 4320-290 Stevens Creek Blvd., San Jose, CA 95129. 408/246-8822.

MicroTouch and Detector reach an agreement

MicroTouch Systems, Woburn, MA, has reached an agreement with Detector Electronics Corporation, subsidiary Intech Systems, Minneapolis, MN, to supply touch-screen systems, service, and support to the Intech customer base. According to Detector Electronics chairman Ted Larsen, "We are pleased to be able to offer our touch screen customers the continuity of service and support which will be delivered by MicroTouch."

Peer Protocols announces formation

Peer Protocols, Inc., has formed in Costa Mesa, CA, to provide small computer system interface (SCSI) support tools, products, and consulting to the SCSI community. Peer is a closely held corporation and will announce its first product in May at the SCSI Forum in Santa Clara, CA. Funding has been provided by private investors. Venture capital will be sought for production and marketing later this year. For further information, contact Herbert W. Silverman, 3176 Pullman, Suite 101, Costa Mesa, CA 92626. 714/662-1929.

Colorado Video relocates headquarters

Colorado Video, Inc., manufacturer of scientific video instruments, teleradiology equipment, and freeze-frame video communications systems, has moved to new facilities at 5490 Spine Road within Boulder, CO. The new building will allow for the expansion of research and manufacturing facilities. Colorado Video's mailing address will remain the same: P. O. Box 928, Boulder, CO 80306. Their new telephone number is 303/530-9580, and their new facsimilie machine telephone number is 303/530-9569.

Olive Electronics changes site and name

Chelsea Industries' Olive Electronics, Inc., has moved its electronic components distribution operation to a new facility in Maryland Heights, MO, and will now operate as Chelsea Industries Electrical Distribution Group. Chelsea is a broad line distributor of industrial electronic components which are sold primarily to industrial organizations, OEMs, and dealers. The new facility will be located at 2555 Metro Blvd., Maryland Heights, MO 63043. The new telephone number is 314/997-7709.

Genisco Systems and Westward Technology to share technology

Genisco Peripheral Systems, Cypress, CA and Westward Technology Ltd., Tewkesbury, England, have signed a memo of understanding exchanging technology efforts granting mutual distribution rights for a variety of trend-setting computer graphics products. "We expect this agreement to greatly impact the industry because Genisco's superior software expertise will complement Westward's outstanding experience in custom hardware and VLSI circuit design," said Michael Boice, Genisco marketing and sales vice president. The agreement will include mutual maintenance service and customer support, exclusive distribution rights and sales force training.

People

CompuServe, Inc., Columbus, OH, announces the following executive changes at its corporate headquarters and at its new software services business unit. Three new executive vice president posts have been created and filled by **Maurice A. Cox,** information services; **Robert J. Massey,** business services; and **G. Clark Woodford,** network services. **Joseph R. Beauchamp** is now vice president, systems, in charge of operations, languages, utilities, and network software. **Barry R. Berkov** is now senior vice president, product marketing and support, for the Information Services Division. **Tom Carr** is now controller and assistant secretary. **Bruce MacNaughton** is now director, computer operations and monitor software. **Charles W. Terry** is now software services business unit vice president in Cambridge, MA. **Gergory T. Tillar** is now national commercial sales vice president. **Alexander B. Trevor** has been appointed head of CompuServe's Support Services Division.

Interstate Electronics Corp., Anaheim, CA, has appointed **Robert Conrad** director of business development for Army programs.

Lenco, Inc., Jackson, MO, has appointed **Paul D. Gerlach** vice president and general manager, Electronics Division.

James J. McFalls and **Eugene J. Ridings** have been appointed Sylvania sales vice presidents at **N.A.P. Consumer Electronics Corp.,** Knoxville, TN. ■

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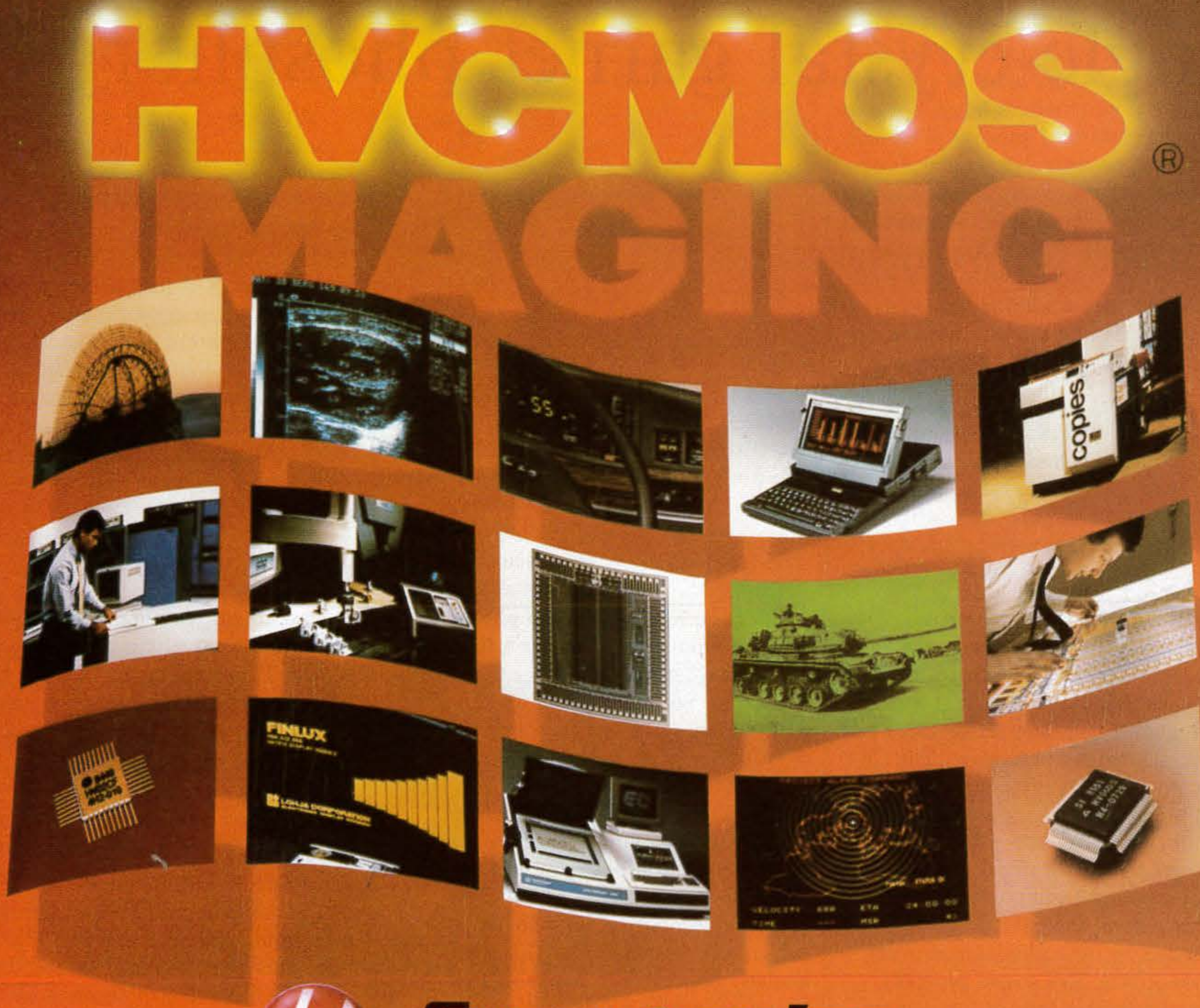

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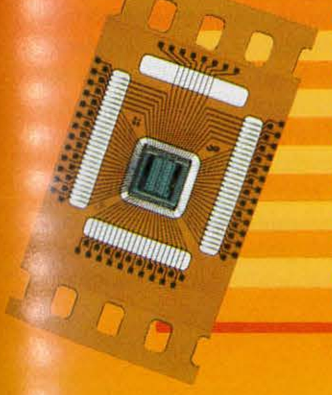

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HV10-18	140 & 160V	4 or 8 Channel Bilateral Analog Switch
HV30	180V	7 Segment Decoder with Open-Drain Outputs
HV51 & 52	225 & 300V	32 Channel Serial to Parallel Converter with High Voltage Open-Drain Outputs
HV53 & 54	40, 60, & 80V	32 Channel Serial to Parallel Converter with High Voltage Push-Pull Outputs

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Circle no. 10

Single-crystal garnet phosphors

BY ALBERT M. WITTENBERG

EVEN with the fierce competition from the newer display systems such as plasma, liquid crystal, and electroluminescent, the cathode ray tube (CRT) is still the dominant display source for video and multiline alphanumeric displays. The CRT has the advantage of presenting megabits of data at high writing speeds with good resolution, intensity, and contrast.

But there is no such thing as an ideal system, and crucial components do fail over time. Often, the CRT is limited in performance by the cathodoluminescent phosphor screen. This screen generally consists of a loosely formed conglomeration of crystalline powder settled onto the CRT faceplate from a liquid suspension. It is mechanically fragile and a poor thermal conductor. In addition, because of the incomplete mechanical contact to the tube faceplate, heat transfer to the outside world is low. Thus the powder phosphor screen is prone to thermal damage by heating from the electron beam. Although a function of material, thickness of the layer, and other physical factors, a general limit of 1 W/cm^2 of continuous beam power is considered the maximum allowable power density a powder phosphor can withstand before it becomes damaged. At 3–4 times this power level, the phosphor is usually destroyed completely.

Albert M. Wittenberg is a member of the technical staff in the Advanced Technology Development Laboratory at AT&T Bell Laboratories, Murray Hill, New Jersey, where he has responsibility for the development of CRT devices for commercial and military applications.

Under normal operation a phosphor tends to produce less light as a function of the total amount of charge that strikes the screen. For many CRTs operating at their normal rated values, screen efficiency will drop as much as 50% within 1000–2000 hours of operation. This reduction in screen intensity (often termed coulombic degradation) is accentuated when the electron beam traces a repetitive figure on the same area of the screen, eventually producing annoying voids in subsequent presentations. This is particularly noticeable in stroke-written operation, where a visible effect often appears after only 100–200 hours.

Besides the permanent damage that occurs from both normal usage and overexcitation, temporary loss in efficiency can occur with lesser power input. As the power level is increased on the phosphor and its temperature rises, the output intensity saturates and eventually begins to drop, until a point is reached at which the material may no longer emit any light, becoming completely quenched. This effect reverses itself when the beam is turned off and the phosphor is allowed to cool.

The porous nature of the powder phosphor also contributes to a limitation in both resolution and contrast. Before the light produced in a phosphor crystal by the electron beam passes through the faceplate, it scatters within the individual illuminated particles and eventually also within particles outside of the beam area. Thus the emitted-light region can be appreciably larger than the exciting electron beam. Even under the best circumstances, this effect increases the beam diameter by at least 20 μm, limiting the resolution that can be obtained with a powder phosphor screen. The scattering of the light by the phosphor crystals also tends to increase the background emission, thus reducing the contrast of the display.

In quest of a better phosphor

Obviously, overcoming these phosphor limitations is desirable. One approach has been to use activated epitaxial films of transparent single-crystal garnet cathodoluminescent phosphors on miniature CRTs. Initial studies on these phosphors were performed by workers at the Philips Research Laboratories in Eindhoven.[1] This effort was subsequently taken up by a group at AT&T Bell Laboratories.[2]

The first material studied to any extent by both organizations was yttrium aluminum garnet activated with cerium (Ce:YAG). It was observed that this material overcame all the shortcomings described above for the powder phosphors. The single-crystal phosphor can be excited with a high-power electron beam to provide a display of uniform output and exceptional brightness with very little coulombic degradation. In fact, it appears to have a lifetime many orders of magnitude greater than that of powders. The crystal has an extremely high melting point and good thermal conductivity. Thus it is able to withstand very high beam power levels without noticeable deterioration. Also, temperature saturation occurs at considerably higher incident power than with powder materials. The material is capable of resolution equal to that of the exciting electron beam, and because of its nonscattering nature, it produces a very high contrast image.

The transparent phosphor, although having these unique qualities, has some drawbacks. At present, it is not technically feasible to produce YAG single crystals larger than 75 mm in diameter. In addition, the external efficiency of the phosphor is significantly less than an equivalent powder phosphor, and although it can sustain unusually high power excitation to produce more light output than any powder phosphor, the electron beam at these current levels becomes broadened. Recent improvements in CRT gun design, however, have shown that this limitation can, to a large extent, be overcome.

Also, because the light generated by the electron beam is produced within the crystal, which makes up the entire faceplate, a large fraction of this light is trapped and not able to pass through the front surface to the viewer. In fact, all rays that strike the air side of the faceplate at a half-cone angle greater than 33° are totally internally reflected and eventually exit the crystal at its edges or dissipate themselves by absorption. Thus only 16% of the light produced in the epitaxial phosphor layer is transmitted through the front face of the CRT. This implies that in order to obtain the same light intensity as an equivalent powder phosphor, one would have to supply over six times the input power to the single crystal.

The single-crystal CRT is, however, capable of operating at extremely high power. These tubes have been run at continuous average incident beam power levels in excess of 1×10^6 W/m^2 without significant degradation. Under pulsed conditions, the tubes have been operated at more than 10^{10} W/m^2.

This characteristic of YAG phosphors to withstand large amounts of input power to overcome their low external efficiency is illustrated in Fig. 1, where the output light intensity as a function of incident beam power is compared for a Ce:YAG single-crystal phosphor and a typical TV-screen powder phosphor. At low beam power the powder phosphor is clearly brighter. But as the power increases, the powder output intensity reaches its saturation limit and finally becomes completely thermally quenched. The crystal continues to increase in intensity, passing the powder and continuing on for a number of decades.

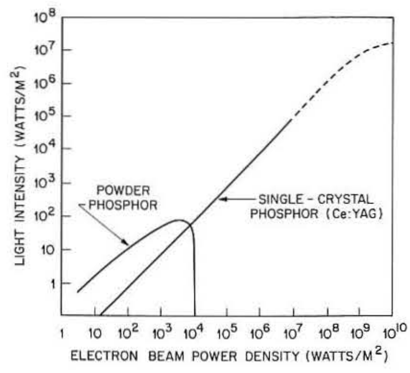


Fig. 1: Curves of total light intensity as a function of input beam power for a single-crystal garnet phosphor and a powder phosphor. The solid lines represent performance under continuous power, while the dotted line is for pulsed operation.

Single-crystal phosphor growth

The single-crystal phosphor consists of a base layer of pure YAG grown by the Czochralski technique. In brief, the procedure is to immerse a seed crystal of YAG into a solution of the same material, which is held at a temperature very close to its melting point (1975°C). As the seed is withdrawn, material crystallizes on it and forms into a boule whose dimensions are controlled by various process parameters. The boule is sliced into wafers of from 1.25 to 2.25 mm thick. Because the wafer will eventually be the faceplate of a CRT, its thickness is chosen so that it will not deform appreciably under atmospheric pressure.

The phosphor layer is obtained through the liquid-phase epitaxial (LPE) process.[3] This entails inserting a YAG wafer into a bath consisting of a mixture of oxides of lead, boron, yttrium, aluminum, and the particular rare earths that are to activate the layer. The liquid mixture is first heated to about 1250°C and then slowly allowed to cool to form a supersaturated solution. The YAG wafer is inserted into the bath and held there until the proper thickness of doped layer has deposited on the substrate.

The thickness of the LPE film is controlled in large part by the requirement that the electron beam not completely penetrate the layer. For 30-kV electrons in YAG, this penetration depth is about 3.5 μm. Thus to ensure complete absorption of the electron beam, the epitaxial film is grown to a thickness of approximately 5 μm.

As previously mentioned, 75-mm-diameter YAG boules are the largest that have been made to date. This size limitation is dictated primarily by technical difficulties in growing large defect-free crystals. Currently, work on rare-earth garnet materials for lasers has increased the attention being given to the growth of large-diameter crystals. This added interest leads us to believe that if an appreciable demand for larger YAG wafers should arise, the size limitation could almost certainly be overcome.

Phosphor performance

To achieve an optimal transparent phosphor, one searches for a material having the following characteristics:

1. It should have a high thermal conductivity to adequately transfer heat from the point of incidence of the electron beam to adjacent areas.
2. Its melting point should be sufficiently high so that excessive beam heating will not cause it to deteriorate.
3. It should have a low index of refraction so as to minimize light trapping.
4. It should be manufacturable with a minimum of defects, and these should be negligibly small.
5. It should be available in a large enough size to allow for an adequate display area.
6. It should be readily adaptable to accept a variety of activator ions.

Epitaxially grown monocrystalline YAG meets most of these requirements. It has good thermal conductivity, roughly one-third that of steel, its melting point is about 2000°C, and it can be grown almost defect free. Its index of refraction, 1.84, is higher than one would like, but this is not a fatal problem.

The LPE growth of rare-earth garnets provides a means of adding activators in a uniform and reproducible fashion. The process is well understood and adaptable to a number of different ionic species. In the case of YAG these are rare-earth ions and are the same as those used as activators in powder phosphors. Almost all the lanthanum series of rare-earth elements have been studied in single-crystal YAG, with varying degrees of success.

Cerium, added to YAG as Ce^{3+}, substitutes for a fraction of the yttrium in $Ce_xY_{3-x}Al_5O_{12}$, where x has been varied from about 0.005 to 0.020. Higher concentrations exhibit greater luminescence. But as the concentration of cerium oxide in the liquid phase is increased, an

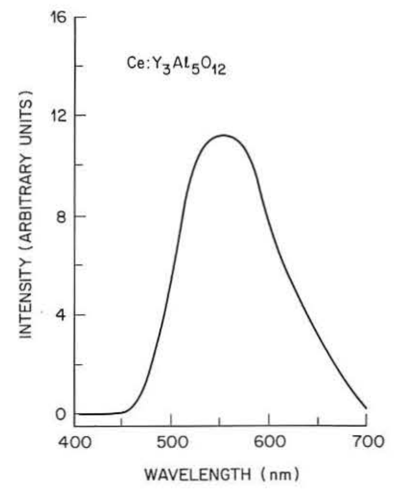


Fig. 2: Spectral curve of Ce:YAG single-crystal phosphor under electron-beam excitation.

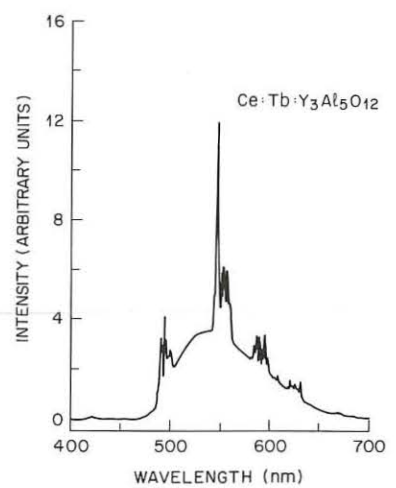
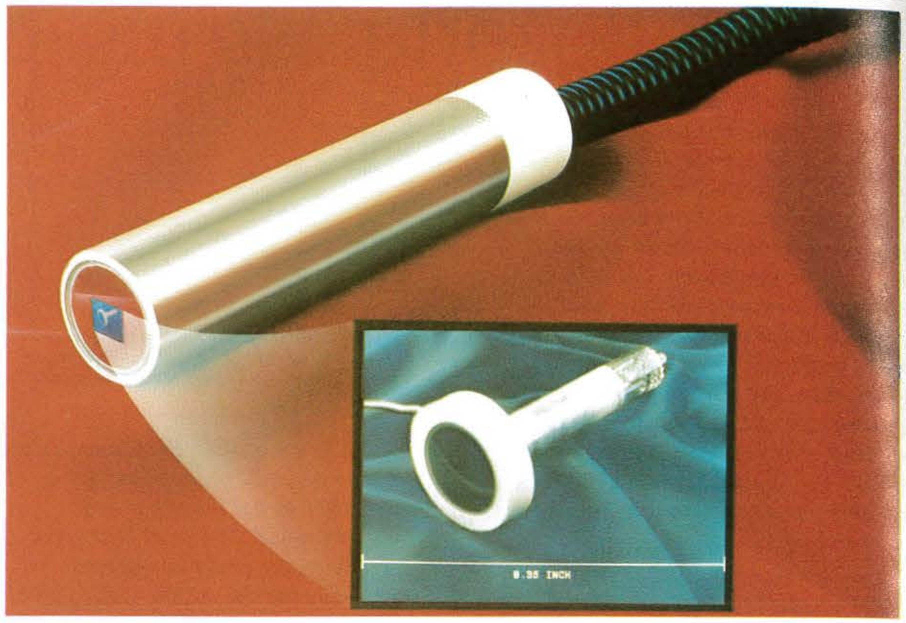


Fig. 3: Spectral curve of Ce:Tb:YAG single-crystal phosphor and electron-beam excitation.



AT&T Bell Laboratories

Fig. 4: A 3-in.-diameter single-crystal CRT imaged onto an AT&T Targa16 image capture board and then transferred, along with the scale, onto a 1-in.-diameter single-crystal CRT. The picture on the 1-in. tube is a standard 525-line TV raster display; resolution is approximately 1500 lines/in.

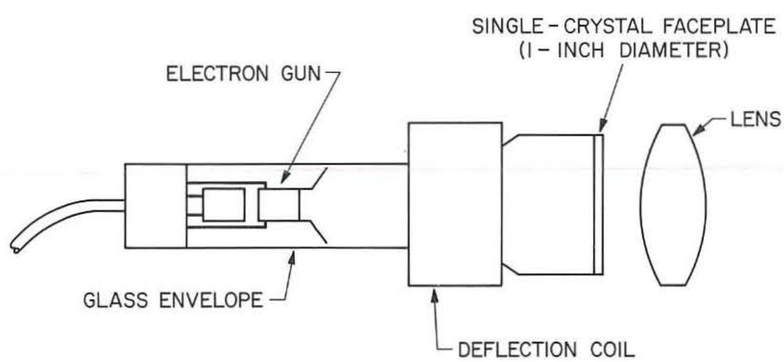


Fig. 5: Schematic of a virtual image viewing system that uses a 1-in.-diameter single-crystal CRT as the display source.

unidentified cerium compound precipitates and produces serious defects in the crystal, impairing it as a CRT material.

Ce:YAG luminesces with a broadband spectrum ranging from about 460 to 700 nm, with peak intensity near 550 nm [Fig. 2], which is close to that of the human eye. The color is rated as yellow-green, quite satisfactory for CRT displays. It is a fast phosphor, having a persistence of only 70 nsec.

Ce:YAG exhibits an overall internal efficiency, i.e., the direct conversion of beam power to visible light within the crystal, of about 6.5%. Internal light trapping reduces the overall external efficiency (the measure of the light that leaves the front surface of the crystal) to about 1%.

A fairly large number of rare-earth-activated garnet phosphors have been studied, some of which are listed in Table 1. The intensity of each phosphor, relative to a standard maintained in our laboratory, is presented for two electron-beam power-density levels, one well below saturation and the other near or into saturation. This allows for evaluation of the material over its generally useful intensity range. The values for phosphor efficiency presented in the table are determined at the lower input power level, so that the data are not influenced by the effects of saturation.

Terbium-activated YAG (Tb:YAG), which exhibits a sharp-line spectrum, is more efficient than Ce:YAG, but it is also appreciably slower, having a decay time of 3 msec. Terbium, in the mixed activator phosphor Ce:Tb:YAG, acts as a sensitizer ion to transfer electronic energy from terbium to cerium, increasing the Ce:YAG light output by 70%.[4] The spectrum of this material, shown in Fig. 3, is a composite of the broad-band Ce:YAG spectrum and the sharp-line spectrum of Tb:YAG. The overall color is described as a saturated green.

Adding gallium as a partial substitution for aluminum in YAG is another way of enhancing the radiation emitted by the crystal. This is evident from the table for both Tb:YAGG and Ce:Tb:YAGG, where the second G represents gallium in each of the compounds. Ce:Tb:YAGG is the most-efficient single-crystal garnet phosphor we have studied to date.

It has also been possible to develop phosphors having colors other than green from YAG-based crystals by the LPE process. Europium added to YAG results in an orange-red emission, whereas thulium substitution produces a blue emission. These are both relatively low-efficiency materials, but they have been found to be useful in those applications where resolution and color, not intensity, are a primary concern. A very useful white phosphor has recently been developed and is finding considerable application in areas where black-and-white video imaging is required. This phosphor [see Table 1] is designated as Pr:Tb:YAG, where praseodymium and terbium are partially substituted for yttrium in the garnet structure.

Table 1: Single-Crystal Garnet Phosphors

Phosphor	Relative Intensity ($1\times10^4 W/m^2$)	Relative Intensity ($1\times10^{10} W/m^2$)	Efficiency (%)	Color
Ce:YAG	0.68	0.74	6.5	yellow-green
Tb:YAG	0.93	0.62	9	saturated green
Ce:Tb:YAG	1.17	1.08	11	green
Tb:YAGG	0.97	0.97	9	green
Ce:Tb:YAGG	1.20	1.29	12	green
Pr:Tb:YAG	0.41	0.24	4	white

Single-crystal CRTs

We have had over 100 CRTs fabricated with single-crystal phosphor faceplates. The diameter of the faceplates has ranged from 25 to 75 mm. These CRTs have been used for laboratory tests or have been incorporated into operating electronic systems. The devices produced with these crystals are well suited for direct-view applications in which the tube is the source in a virtual image optical system; i.e., the tube faceplate, which for the case described here is a single crystal, is viewed through a magnifying lens. An example of such a system is shown in Fig. 4 and in the sketch in Fig. 5.

Although the dimensions vary, the tubes all have the same general structure. The tube envelope is formed from SBW glass manufactured by Glaswerke Wertheim oHG (Schott Group). It has a coefficient of thermal expansion closely matching that of the YAG crystal. (The coefficient of expansion of YAG is 7.5×10^{-6} °C^{-1} at 25°C). The metal wire used for electrical contact is VACON 70 manufactured by Vacuumschmelze GmbH.

The crystal is sealed to the glass with an intermediate crystallizing solder glass. The inner surface of the YAG crystal is coated with about 50–100 nm of evaporated aluminum and the tube assembled and processed according to standard practices.

A variety of electron guns have been used with these tubes. These have been both electrostatic and electromagnetic focusing types, with the deflection systems in all cases being electromagnetic.

One example of the use of these tubes has been in a virtual imaging system that incorporates a 25-mm-diameter single-crystal CRT to form a 20-mm-diagonal image [see Fig. 5]. This tube is capable of presenting 1000 clearly resolved lines, with 1500–2000 lines a reasonable possibility. The resolution limit of the system is entirely dependent on the performance of the electron gun. At low-input power, for instance at currents of a few microamps and acceleration voltages of 7 kV, the crystal can produce sufficient brightness to be clearly viewable even in a moderately high-ambient-light environment. At these power levels, a well-designed electron gun can produce a beam whose width (at half-peak intensity) is 10–13 μm, which will give the resolution indicated above.

The single-crystal phosphor CRT has also been used as a projection tube in a thin-profile CRT video monitor. The system, shown in Fig. 6, is 5.5-in. thick and contains a screen having an 11-in.-diagonal viewing area. The image is projected onto the screen from a 2-in.-diameter CRT by means of a lens and three mirrors that fold the optical path. The tube image is magnified approximately six times to produce a display having a brightness of over 50 fL.

Other systems for which we have designed single-crystal phosphor tubes include a stereo viewer, which incorporates two tubes as virtual imaging devices, a military binocular helmet-mounted display, and a number of demonstration units. As the demand for higher-resolution displays increases, especially in the medical, reprographic, and avionic areas, significantly more applications should arise where the single-crystal CRT stands out as the device of choice.

Fig. 6: Video monitor containing a 2-in.-diameter single-crystal CRT. The image from the tube is projected onto an 11-in.-diagonal screen.

References

[1]J. M. Robertson and M. W. van Tol, *Appl. Phys. Lett.*, Vol. 37 (1980), p. 471.

[2]The program described here has been the joint effort of numerous people, both in our organization and in other areas of Bell Laboratories. However, I would like to acknowledge particularly the efforts of Joseph Shmulovich, George Berkstresser, and Donald Huo, whose work has been the primary source of information for this article.

[3]S. L. Blank and J. W. Nielsen, *J. Crystal Growth*, Vol. 17 (1972), p. 302.

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True three-dimensional CRT-based displays

BY LARRY F. HODGES AND DAVID F. MCALLISTER

THE PHRASE "three-dimensional display" is often interpreted to mean a two-dimensional representation of a three-dimensional scene on a display device that uses cues such as shading, shadows, and linear perspective to give the observer an illusion of depth in the image. On the other hand, true 3D displays present an image in which the viewer perceives depth. This is accomplished either by producing a "solid" 3D image using holographic techniques or multiplanar displays in which the viewer obtains a different view of the scene by head movement; or by creating a "virtual" 3D image by presenting the observer's left and right eyes with different views. In this case the image is normally fixed and does not change with head movement. True 3D display techniques are becoming increasingly important in applications where depth perception is an important part of understanding relationships between objects in the scene. Examples include medical imaging, remote positioning, cartography, CAD, flight simulation, flight control, molecular modeling, and visualization of complex data sets such as point clouds which occur in seismic applications.

This article surveys recent developments in true 3D display of computer-generated or synthetic images that are based on CRT technology. Our interest is in real-time interactive manipulation of true 3D images, and hence we do not treat the equally interesting area of holography here. Although early 3D display systems were often of poor quality and did not allow interactive manipulation of the image in real time, recent advances in computer graphics, processing power, and electro-optical shutter devices are making possible the development of true 3D displays that are of a quality comparable with other information display systems. But before surveying the current technology, we should give a brief description of the perception issues that make these displays different from standard 3D information display systems.

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Accommodation, convergence, and parallax

Static flat images can convey depth to the observer by using visual cues that exploit his experience and knowledge of the real world. These cues are *image size, linear perspective, aerial perspective, overlapping, shading,* and *shadows*. In image size we use our experience and knowledge of the relative sizes of objects to judge the relative positions of objects in a scene. Linear perspective refers to the gradual reduction in size and apparent convergence of parallel lines as objects move into the distance away from the viewer. Aerial perspective is the hazy effect of distant objects caused by the scattering of light by small particles in the air. The overlapping of objects or the obscuration of one object by another helps to disambiguate relative distances from the observer, as do object shading and shadows in a scene.

True 3D images, however, provide one or more of the following additional depth cues: *accommodation, convergence,* and *binocular parallax*. Accommodation is the muscular tension needed to adjust the focal length of the crystalline lens in the eye in order to focus on an object in space. Convergence refers to the muscular tension for rotating each eye when focusing on an object in space. The angle between the two rays from each eye to the object is usually referred to as the convergence angle. When an observer looks at a scene, because the eyes are set apart, the images formed at the back of each eye are different. The brain uses the difference to produce depth perception in the observer. This effect is referred to as binocular parallax.

Categorization of three-dimensional displays

There are several ways in which to organize a categorization of true 3D display technologies [Fig. 1]. Most 3D displays fit into one or more of three broad categories: *holographic, multiplanar,* and *stereo pair*. For our purposes holographic and multiplanar images are "*real*" or "*solid*". Solid images provide the observer with binocular parallax, convergence, and accommodation cues that are consistent with the apparent depth in the image. Stereo-pair techniques create "*virtual*" 3D images. In a stereo pair each eye sees a different perspective view of the image. The views are computed and presented so that parallax and convergence cues are present but, because each eye is actually looking at a flat image, accommodation cues are not consistent with the apparent depth in the image.

Another way to categorize is whether the observer must wear some type of viewing apparatus. Displays that do not require viewing devices are referred to as *autostereoscopic*. Holographic, multiplanar, and some stereo-pair displays are autostereoscopic, but many stereo-pair displays require some kind of viewing apparatus, such as electro-optical shutters or eyeglasses with either specially colored or polarized lenses.

The CRT-based stereo-pair systems are further divided into two categories: time parallel and time multiplexed. Time-parallel systems present left- and right-eye views simultaneously and require special apparatus to deliver the correct perspective view to each eye. Time-multiplexed systems alternate the left- and right-eye perspective views on a single CRT display and use a shutter mechanism to synchronize the views to the correct eye.

All stereo-pair systems create a virtual 3D image by delivering different perspective views of an image to each eye of the observer. The way in which the two views differ is based on the horizontal displacement between the right and left eyes of the human viewer, which is called the interocular distance. The two views are often computed using two different centers of projection that differ only in the x direction (horizontal parallax), or by a rotational difference between the two views of approximately 6° about a vertical axis. (Although rotation is a common technique, it can create vertical disparity in a given point in the left- and right-eye images. This effect is called keystoning and can cause fatigue and headaches if viewed over a long period of time. In addition, approximately 10% of the population cannot fuse stereo pairs. In certain applications these factors should be considered.)

The history of stereo-pair display goes back to the early 1800s. Early devices include the Wheatstone stereoscope [Fig. 2] and the Brewster stereoscope [Fig. 3]. With the Wheatstone stereoscope, two photographs or stereo drawings were taken and displayed on a viewer which used mirrors to deliver the correct perspective view to each eye. The Brewster stereoscope replaced the mirrors with prisms (and later with convex lenses) and became popularly known as the parlor stereoscope. In the early 1900s people began to consider the idea of 3D images

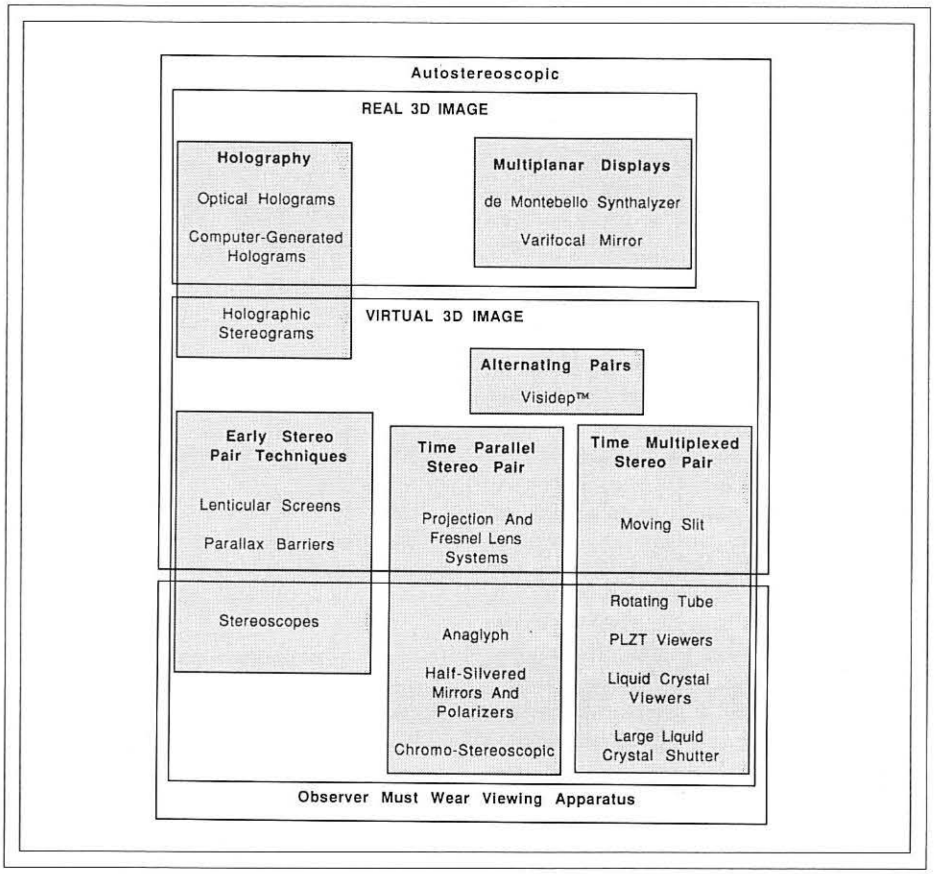


Fig. 1: 3D display techniques.

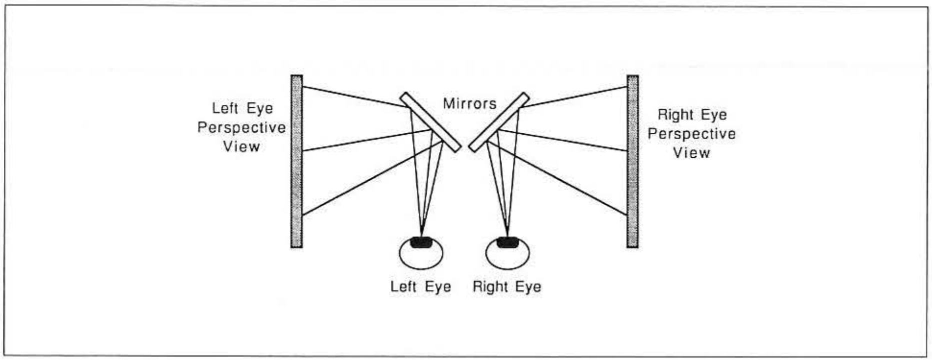


Fig. 2: Wheatstone stereoscope (1838).

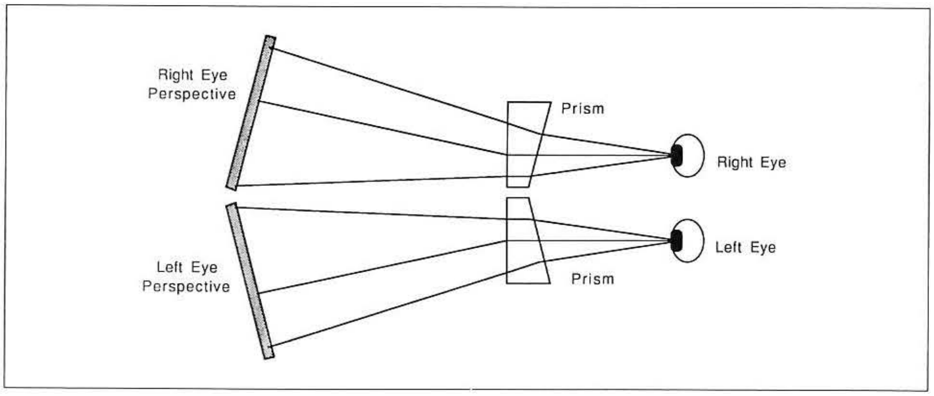


Fig. 3: Brewster stereoscope (1849).

without viewing apparatus. F.E. Ives proposed a method known as the parallax stereogram [Fig. 4]. A parallax stereogram consists of a fine vertical slit plate and an image, with left- and right-eye perspectives printed in narrow stripes and placed behind the slit plate. The slits force each eye to see only the correct perspective view of the image. A second early autostereoscopic display technique replaced the parallax barrier with a linear array of cylindrical lenses known as a lenticular sheet [Fig. 5]. It is usually made in such a thickness that its rear surface coincides with the focal plane of the lenses, so that the correct perspective view is directed to each eye.

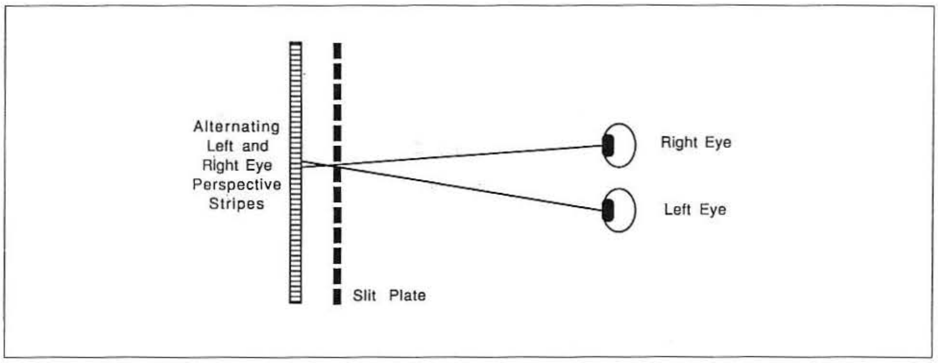


Fig. 4: Parallax stereogram (1903).

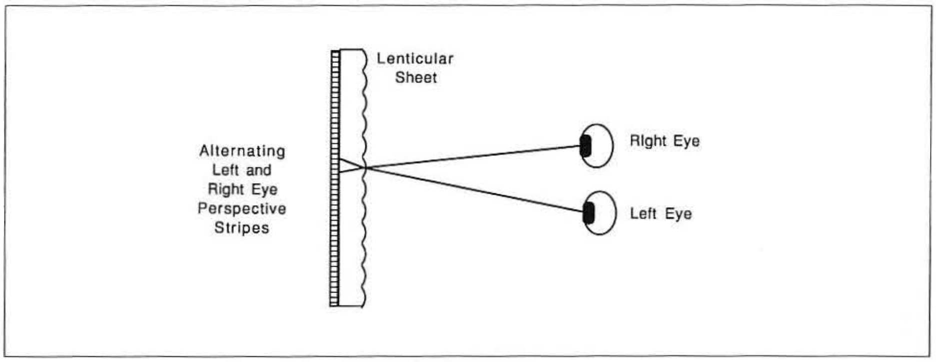


Fig. 5: Lenticular sheet display.

Time-multiplexed stereo pairs

Time-multiplexed systems that require a viewing shutter present the stereo-pair image by alternating right- and left-eye perspective views of an object on a CRT. Until recently, most implementations have had an alternation rate of 60 Hz (30 left-eye views and 30 right-eye views per second). This is easily done on a 30-Hz interlaced monitor by writing one perspective to the even scan lines and the other perspective to the odd scan lines. On a 60-Hz noninterlaced monitor, two complete views must be stored in the frame buffer memory so that the refreshed image switches between views at the beginning of each vertical refresh cycle. Both of these approaches suffer from flicker, because each eye sees an image that is being updated only 30 times per second. Commercial systems based on 120-Hz noninterlaced monitors have been developed by Stereographics Corporation and Tektronix.

To view the stereo image, the alternating left- and right-eye perspectives must be synchronized with a shutter system that occludes the left eye when the right-eye view is displayed and occludes the right eye when the left-eye view is displayed. Early systems used a rotating cylinder with right- and left-eye slits or other types of mechanical shutters. Later systems replaced the mechanical shutters with electro-optical shutters based on lead lanthanum zirconate titanate (PLZT) ceramic wafers. Each shutter assembly consists of front and rear dichroic polarizers wtih a PLZT ceramic wafer in between [Fig. 6]. The axes of polarization of the polarizer are rotated 90° with respect to each other and are oriented at 45° with respect to an electric field applied to the ceramic wafer. In the off state of the shutter, light traversing the front polarizer is blocked by the rear polarizer. With the application of a sufficient voltage potential, the PLZT ceramic wafer acts as a half-wave retarder, and light passing through the front polarizer is rotated 90° so that it passes through the rear polarizer. The shutters are designed to resemble eyeglasses in size and weight. The major disadvantages are that a cable is attached to the shutter glasses, and the shutters transmit only about 15–17% of the light energy.

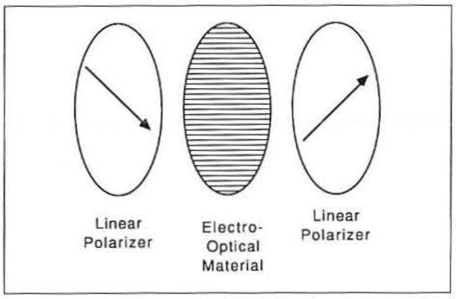


Fig. 6: Shutter glasses lens assembly.

During the past two years, PLZT shutters have been almost entirely replaced by shutter systems based on liquid-crystal π-cells. Two types of liquid-crystal shutters have been developed [Fig. 7]. One uses viewers that are identical in operation to those described for the PLZT shutters except that the PLZT wafer is replaced by liquid-crystal π-cells. Liquid-crystal-based shutters transmit approximately twice as much light energy as PLZT shutters, resulting in a much brighter image. Tektronix is currently marketing a pair of liquid-crystal shutter glasses and a controller for the Atari microcomputer for $150. Liquid-crystal shutters can also be produced that are large enough to be mounted on the front of a CRT screen. The shutter in this case is designed using liquid π-cells and one circular polarizer so that the left- and right-eye perspectives displayed on the screen are circularly polarized in opposite directions. The observer wears passive glasses with the left and right lenses circularly polarized to allow the proper views to be seen. The best-quality stereo-pair systems now available use this method in conjunction with 120-Hz CRTs to produce a 3D display that is comparable in image quality to raster graphics images.

An autostereoscopic stereo display system within the time-multiplexed category incorporates an electro-optical or mechanical slit that moves across the screen of a CRT at approximately 20 Hz [Fig. 8]. The slit is positioned 2–3 in. in front of the screen. Right- and left-eye

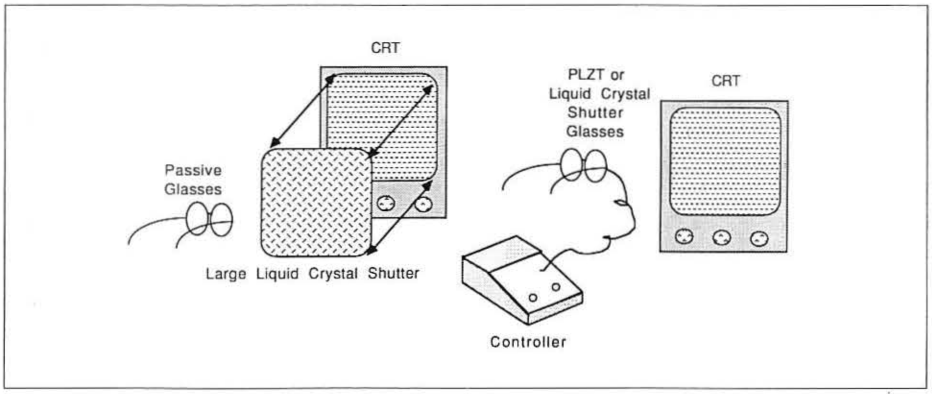


Fig. 7: Time-interlaced stereo systems.

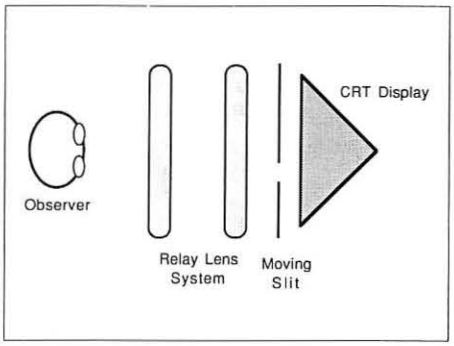


Fig. 8: Autostereoscopic time-interlaced display.

perspectives are displayed on the screen on opposite sides of the slit. The image on the screen is changed as the slit is moved across the CRT so that a different scene can be presented to each eye. In addition, images can be produced on the screen that can be seen from wide angles, up to 40° on each side of the slit. Thus, more than two views can be seen from different angles, which provides look-around capability for several viewers at the same time. An adaptation of the slit system uses a relay lens pair to project the image so that it appears to float in space. A display based on this method has been developed and demonstrated by SOCS Management Company.

Time-parallel stereo pairs

Time-parallel systems present left- and right-eye views simultaneously on either a single or separate CRT screens. Such systems normally require special viewing devices to deliver the correct perspective view to each eye. Time-parallel systems include anaglyph displays, certain types of polarized displays, displays using lenses and barriers such as the Star system, and chromostereoscopic displays.

In anaglyph displays the right- and left-eye perspectives are filtered with complementary or near-complementary colors and are superimposed on a CRT screen. The observer wears glasses with filters that match the projection filters. For black-and-white images, red and green filters are usually used. For color images, red and cyan or green and magenta filters are used. A problem with this technique is that it distorts the colors of an image.

Polarized time-parallel displays have been developed using two CRTs arranged at right angles to each other and a partially silvered mirror [Fig. 9]. Polarizers are placed on each monitor, with the filters arranged at right angles to each other. The half-silvered mirror is placed between the monitors so that it refelcts one

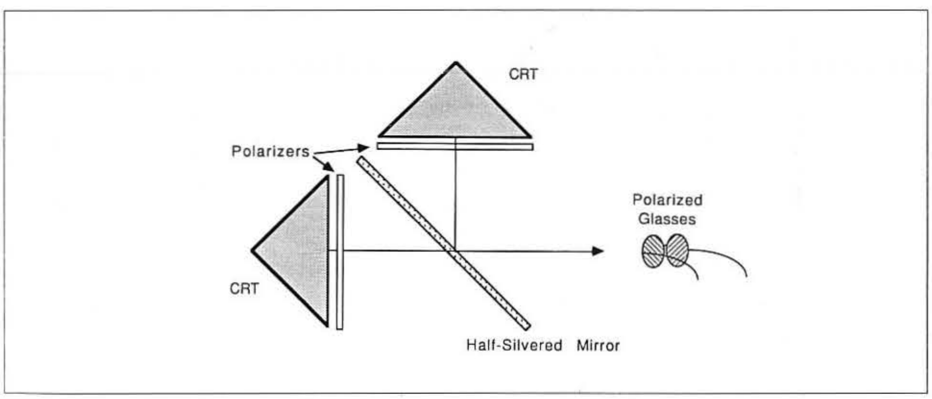


Fig. 9: Dual-CRT time-parallel display.

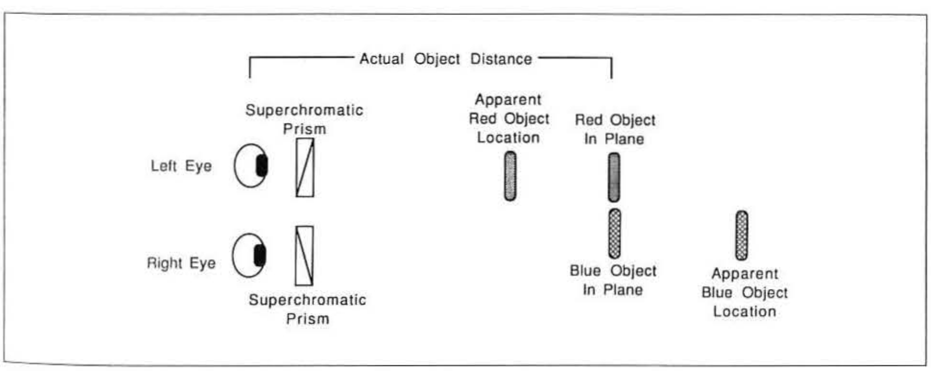


Fig. 10: Chromostereoscopic display.

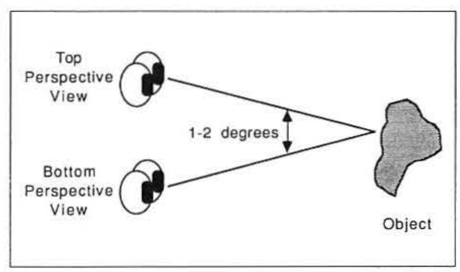


Fig. 11: Vertical parallax for alternating-pair display.

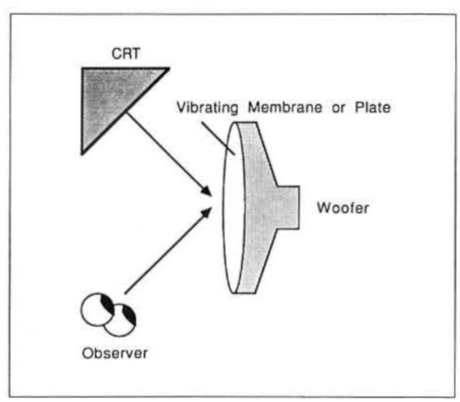


Fig. 12: Varifocal-mirror display.

perspective view and transmits the other. The observer wears corresponding polarized glasses so that each eye sees the correct perspective view.

The Star system is an autostereoscopic system that uses dual CRTs to produce the left- and right-eye images, a dynamically changing baffle system for each CRT, and relay lenses to focus the left- and right-eye images on a screen using rear projection. As a head sensor tracks the observer's head movement, the baffle system is modified accordingly, and the image of each baffle is projected so that the left eye cannot see the right eye's image and vice versa. The system is available commercially from Perspective Displays, Inc.

A recent stereo innovation is the presentation of stereo pairs based on a chromostereoscopic process developed by Richard Steenblik while at the Georgia Tech Research Institute. With Steenblik's technique, the depth of objects in a scene is encoded into a single perspective of an image based on the object's color. Special prism glasses are worn by the observer that impart a chromatically dependent angular shift to the light passing through them. The shift amount betwen the right- and left-eye views produces a stereo pair. If we assume that the extremes of the visible spectrum are red and blue, then we can tune the prism glasses so that red images appear in the foreground and blue objects appear in the background of a scene or vice versa [Fig. 10]. Colors other than red and blue are mapped to depth positions in accordance to their spectral proximity to these colors. The prism glasses can also be tuned to vary the overall amount of depth in the image.

Alternating pairs

An alternating pair is an autostereoscopic technique in which the image consists of two alternating perspectives of a scene. The technique differs from stereo-pair techniques in that the alternating perspectives are presented to both eyes simultaneously utilizing vertical versus horizontal parallax displacement [Fig. 11]. Video recording and display methods based on this technique have been patented under the name of VISIDEP™. To produce an alternating-pair image, two perspectives of a scene are produced that differ by a rotation of 1°–2° about a horizontal axis. The 3D image is presented by alternating the two perspectives on a display screen. The quality of the 3D image perceived by an observer is highly dependent on the rate at which the images alternate. If the alternation is too slow, the 3D effect is not apparent. If the alternation is too fast, the image becomes garbled. Most individuals perceive the effect if the perspectives alternate between 4 and 30 times per second. A rate of 10 times per second seems to be optimal for the majority of viewers.

A major drawback is the rocking motion introduced into the 3D image by the alternation between the persepctives. The rocking is less apparent if there is motion within the image. Also, although relative depth between objects in the image is unambiguous, individual objects appear flat, so that the image appears to be composed of multiplanar carboard cutouts. However, the system does not require sophisticated high-refresh-rate CRTs with fast phosphors.

Multiplanar displays

Multiplanar displays create a 3D image by partitioning a scene into multiple two-dimensional cross sections. The cross sections are physically and/or optically positioned in space so that a 3D image is perceived by the observer. Early multiplanar displays were based on a revolving series of cross-sectional images placed on a support shaped as an Archimedian spiral. A shutter system was synchronized with the rotation of the spiral, allowing the observer to view the appropriate cross section as it reached its correct position in space. A multiplanar display based on this technique is the Synthalyzer constructed by de Montebello in the 1970s.

Current multiplanar displays are usually based on the concept of the varifocal mirror invented by Traub while at Mitre. Varifocal-mirror displays combine a vibrating circular mirror, which is stationary at its perimeter, with a CRT [Fig. 12]. Traub discovered that if we use a circular flexible material fastened at the edges, the mirror can be made to approximate a spherical mirror with a varying focal length; hence the name varifocal. As the mirror vibrates, it changes focal length. These vibrations are synchronized with the display of an object on a CRT so that each point on an object is reflected from the mirror at a position corresponding to the depth of that point.

The mirror is vibrated by air pressure generated from a simple acoustical woofer which can be driven at low frequencies. A simple sine wave is passed through a high-quality amplifier and drives the woofer. Physical constraints limit the size of the mirror to a maximum of 18 or 19 images. A larger mirror may cause sympathetic vibration in surrounding structures. Acoustical considerations place the frequency of the vibration of the mirror at approximately 30 Hz. A very fast phosphor is required to preclude image smear. Currently, the only phosphor available with sufficiently fast decay is a green phosphor, so that only monochrome displays are available. Efforts to add color using color wheels or liquid-crystal π-cells have been marginally successful.

Varifocal-mirror displays differ from stereo-pair and perspective displays in several characteristics. Hidden line and surface removal have no meaning, because the observer can change his position and see a different perspective. Because the mirror is constantly moving in space, resolution is limited by both the CRT resolution and the speed of point plotting by the CRT. Current CRT technology limits the number of image points to less than 40,000, and hence only wireframe images are possible. In addition, images are translucent, which can cause confusion in viewing scenes with high information content. A commercial varifocal-mirror display driven by a microprocessor is currently being developed by Bolt, Beranak, and Newman, Inc.

Summary

Many competing technologies can provide true 3D displays of synthetic images. Those technologies that are cost effective and permit real-time interactive manipulation of high-resolution computer-generated scenes will survive. The remainder will become passing technological curiosities. The recent development of large circularly polarized liquid-crystal shutters combined with 120-Hz monitors and fast graphics frame buffers has made time-interlaced stereo-pair systems the most competitive. Advances in technology may soon, however, make one of the autostereoscopic systems more viable. One of the more promising areas appears to be the replacement of phosphor-based systems with laser-based displays. For example, laser projection systems could possibly be used to add color and resolution to varifocal mirror displays. Regardless of which technologies survive, true 3D display is no longer a curious innovation, but an important and established area in the field of information display. ■

Thermal-transfer technology comes of age

BY JOHN W. O'LEARY

IF THE FUTURE of thermal-transfer technology can be expressed as a color, try rosy as the hue that best describes the potential of this fledgling technique in the art of printing, which was developed in 1975 by Fuji Kagkushi Kogyo Co. of Osaka, Japan. By way of a basic definition, thermal-transfer printing can be described as a non-impact printing technology that uses thermal energy to transfer ink from an inked coated subtrate to a receptor sheet. Perhaps even more understandable would be this simplification for a typewriter or word processor—a technology that uses heat to melt ink from a ribbon to a sheet. Impact dot-matrix or daisy-wheel printers and conventional typewriters print by the hard impact of the typing element to the ribbon, which in turn forces ink from the ribbon to the paper. In thermal printers the ink transfer is caused not by the impact of the printing element to the ribbon, but by the heating up of elements on the print head to melt the ink on to the paper [Fig. 1].

A profusion of ribbons

Of the many different thermal-transfer printing devices that have been released or are under development, almost all require a unique ink formulation. Highly specialized ink making, coating, and slitting equipment is necessary to produce consistently high-quality monochrome and multicolored ribbons. Originally, thermal printers used paper-based ribbons, but most are switching to film because of its better cleaner print. Paper ribbon is available in 10- and 3-μm thicknesses, with 10 μm being the more popular. Polyester film is available in both 3.5- and 5.7-μm thicknesses. Thermal media use such thin materials to allow uniform and efficient transfer of heat from the thermal print head, through the substrate, to the ink, which is then melted to the paper.

Various considerations dictate the thickness of ribbon chosen for a particular application: (1) energy requirements to transfer the ink; (2) a preference for a particular length of ribbon (for example, a ribbon 4 in. in diameter would be a great deal longer using 3.5-μm than 13-μm paper); and (3) cost considerations. Generally speaking, the thinner the material, the more expensive it is on the square meter basis, but less energy is required to melt the ink because there is less resistance or "insulation."

Color thermal ribbons are usually composed of three process colors: yellow, magenta, and cyan (plus black in some applications). By mixing these three colors using the subtractive color mixing principle, virtually any color, tint, or shade can be achieved [Fig. 2]. The colors are usually arranged in sequence, one color block after another, that is repeated throughout the ribbon. First the printer prints all that needs to be yellow; then backs up the paper, advances the ribbon, and prints all that needs to be magenta; then backs up

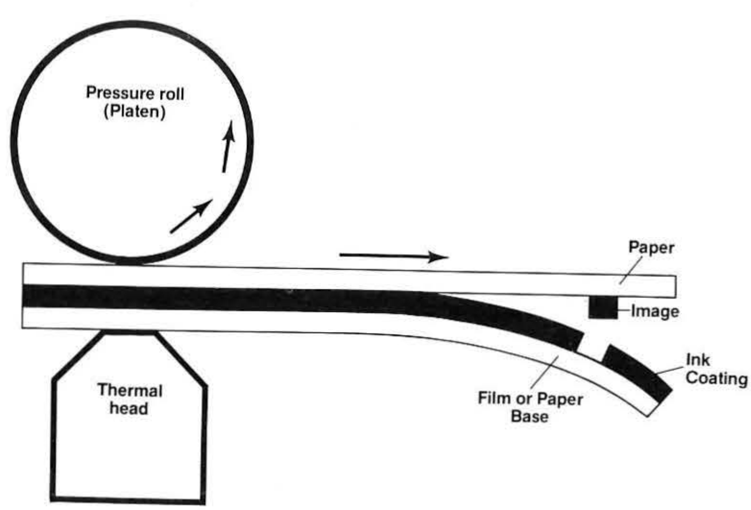


Fig. 1: Basic principle of thermal-transfer printing.

John W. O'Leary is president and CEO of International Imaging Materials Inc., Tonawanda, New York, the North American licensee of Fugi Kagakushi Kogyo Co. of Osaka, Japan.

the paper, advances the ribbon, and prints all that needs to be cyan. Most ribbons have block sensors that the printer detects to determine which color it is about to print. If a particular color is not needed, this process does not permit any later use of that color block.

Why pick thermal?

Thermal-transfer advocates cite seven major advantages of thermal printers over their competitors (their order of importance depends on the priorities of the purchaser):

- *print speed,* permitting up to 100 characters/sec;
- *low cost,* thanks to relatively fewer moving parts in the printer;
- *near-letter-quality printing,* which is improving all the time;
- *high degree of equipment reliability* because of basic design simplicity;
- *top-quality multicolor capability,* providing a high standard of color printing;
- *great flexibility;*
- *a noise-free atmosphere,* which may be the most important consideration of all when a quiet environment is desired.

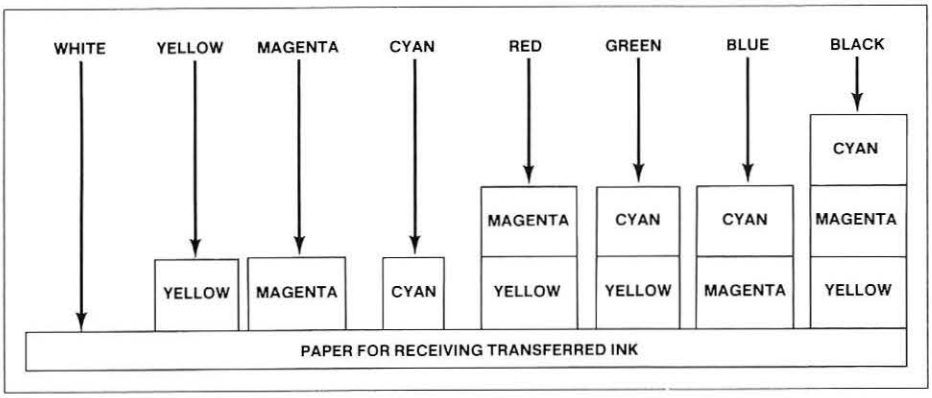


Fig. 2: *The principle of subtractive color mixing.*

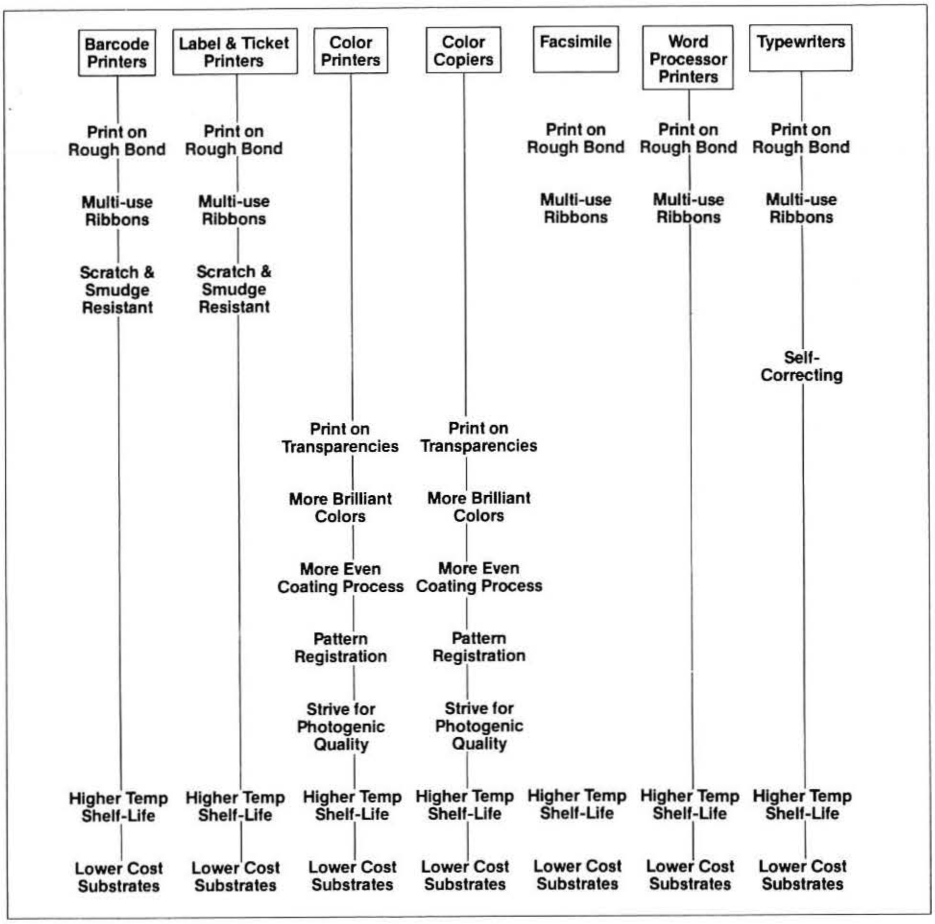


Fig. 3: *Thermal-transfer ribbon developments.*

Beyond bar codes

Thermal-transfer printers are used in a wide variety of applications—bar code printers, label and ticket printers, color hard-copy printers, color hard-copy copiers, facsimiles, word-processing printers, typewriters, and monochrome plotters. The advantages and disadvantages of this technology seem to have a direct bearing on the perceptions of the pros and cons of the process. For example, thermal-transfer technology has been slow to gain wide acceptance in the United States for typewriters and word processors because the need for a smooth-surface paper to assure the highest print quality is not always acceptable to some customers. Stocking different types of paper to accommodate different printers is seldom viewed as a plus.

The fastest-growing use of thermal printing is for bar-code and ticket printers for such diverse jobs as printing on-demand bar-code labels, airline tickets and boarding passes, clothing care labels, and entertainment tickets. Generally, line printers are used in these applications. Thermal-transfer inks produce the consistently dark durable scratch-and smudge-resistant image necessary for these applications, especially in bar coding.

Cannon's model 610 is the first thermal-transfer facsimilie to be marketed in the United States. Xerox, Ricoh and NEC have also introduced thermal-transfer facsimile machines. Overall market opinion of these new units is very positive because thermal-transfer image quality is superior to that of direct thermal, and despite present higher operating costs of thermal transfer, customers are willing to pay for quality and believe costs will decrease in future.

The first monochrome plotter introduced into the U.S. market was Benson's B-90 in early 1985. In 1986 Honeywell introduced their Visigraph plotter, which was designed and built in the United States.

But probably the greatest potential for thermal-transfer technology is in the area of color hard-copy printers, plotters, video printers, and copiers—wherever and whenever full-color printing is desired. To date ten companies market color hard-copy equipment—Shinko, Calcomp Colormaster plotter, Matrix Instruments, Seiko's new 300-dots/in. unit, Mitsubishi

International's CHC-65 and CHC-335, IBM's CAD/CAM plotter, Sharp's color copier, Sony's Mavigraph video printer, Versatec's Versacolor 300-dots/in. unit, and Mitsubishi Electric's G-500 and G-650. These offer major improvements:

- *increase in resolution* (up to 300 dots/in.);
- *increase in print speed* (1 pg./min.);
- *decrease in hardware costs;*
- *greater paper-handling capabilities* (i.e., cutsheet, roll);
- *vast improvements in overall print quality;*
- *greater availability of application software;*
- *a wide variety of printer interfaces* (i.e., parallel, video).

Advocates of thermal color printing see a potential that is almost unlimited. As an example, they cite the development of an electronic camera taking a still picture then storing it on a computer disk. The picture is viewed later on a TV screen, and using a thermal-transfer printer, photo-like copies are printed on a selective basis. This spring Kodak has introduced such a system to print ID cards. Extensive research in this field is also being conducted in Japan, and in the end this may prove to be the largest use of thermal-transfer technology, dramatically reducing the cost of color photography.

Room for improvement

Each application seeks its own highly specialized improvements in ribbons [Fig. 3]. All of these required improvements are under development.

- *Ability to print on rough-bound papers.* This requirement is especially necessary for typewriters, word processors, and computer printers. Conventional thermal-transfer printing does not adequately bridge the hills and valleys of rough-surface papers.
- *Multi-use of thermal ribbons.* Conventional thermal-transfer ribbons are used once, then discarded. Research studies indicate that these ribbons have the potential for use 3–5 times with little or no decrease in print quality. Multi-use ribbons would be especially effective in typewriters, word processors, computer printers, bar-code printers, and ticket printers. Fuji Kagaskushi has been issued a U.S. patent for such a ribbon and has made samples available for printer development.
- *Lift-off correction ribbons.* One of the most popular features of modern office typewriters is the ability to correct printed errors, but current thermal-transfer typewriters lack this ability. Instead, as one types, the information appears on an electronic display which can be checked and edited before actually printing, but once the characters have been typed on paper, they cannot be corrected. Recently ALPS, the largest manufacturer of printing devices in Japan, demonstrated a thermal printer with a correctable ribbon. The ribbon is capable of printing characters on paper, then by heating to a different temperature, taking the ink off the paper—thus lifting the characters—and putting the ink back onto the same ribbon.
- *Printing on overhead transparencies.* This requirement is especially important for color-printing applications, because the charts and diagrams generated are often used for overhead projections. Transparencies have a smooth plastic non-porous surface. Inks must be available that can adhere well to the plastic surface without coming off. Also, because the color printed on paper or film is not always the same color that is projected overhead, the colors must be able to retain their original hue even on transparencies.

The bottom line, and how to get there

The future of this emerging and rapidly growing technology, like all others, is dependent on a familiar consideration—cost. In the area of cost, surely the international monetary situation is a vital element. The technology and almost all the raw materials used to manufacture thermal-transfer ribbons come from Japan. Over the past 2 years there has been a substantial weakening of the U. S. dollar against the Japanese yen, recently reaching a 40-year low. This has significantly increased the cost of both thermal-transfer printers and ribbons; however, because most of the other types of printers are also made in Japan, they share this same disadvantage.

A totally different but important cost factor arises in design conflicts between the printer and ribbon manufacturers. This usually occurs when a printer designer delays too long his involvement with the ribbon designer. A well-coordinated early development program can produce a compatible and highly functional low-cost ribbon. Consider this overly simplistic situation: ribbons can be slit from jumbo rolls 660 mm wide. If one were to design a printer that would require a ribbon 230 mm wide, the ribbon manufacturer would be able to slit two widths of the 660-mm-wide jumbo roll, leaving 200 mm on the jumbo roll. This is, of course, too narrow for another 230-mm-wide ribbon, a waste factor of 30%—a cost that will be built into the price of the finished product. I call that the lack-of-coordination cost.

In addition to avoiding this kind of carelessness, other factors can reduce the cost of thermal ribbons. As with any other technology, a systems approach must be followed. To achieve optimum performance, the print head, mechanism, paper, and ribbon cannot be developed independently. The cost of thermal-transfer ribbons is directly related to the design of the ribbon, the substrate chosen, the ink formula, and the method of coating. Also, the application and receiver paper have a great influence on the makeup of each thermal-transfer ribbon.

No less helpful will be the reality of volume production. This will help to absorb the high investments required to manufacture thermal ribbons. And as more U.S. companies recognize the future of and become engaged in thermal-transfer technology, domestic raw materials will become available.

Making direct cost comparisons is confused by the fact that thermal-transfer ribbons are used in so many different applications. One has to identify the specific application before correctly comparing cost. For instance, thermal-transfer typewriters use thermal-transfer ribbons. The competing products use correctable ribbons and lift-off tape or thermal-resistive ribbons. In this case, thermal-transfer ribbons are probably less expensive than the competitive type of ribbon. When thermal-transfer ribbons are used in color copiers, however, the cost of the ribbons is more than that of the toner used in a toner-based color copier, but the copier itself costs much less (under $10,000 vs. over $35,000) and is more reliable.

What can be said about the economics of thermal-transfer printing is that thus far they appear to be very competitive, as evidenced by the broad market acceptance of the technology. It is doubtful that any printing technology, even much more mature technologies, has been used in as many applications as thermal transfer. This is particularly impressive when one considers just how very young thermal transfer still is. ■

Are we where we should be?

interviews with display industry leaders—part two

TO CELEBRATE *the 25th anniversary of the Society for Information Display, we asked 25 leaders of the display community these four questions:*

1. What was the single most important event in SID's history and how has this affected the Society and the display industry?

2. What was the most important event to the display industry in the last 25 years, and who has been the single most significant person?

3. What is the single most important event or development you expect to see in the display industry in the next five years?

4. What is SID's biggest problem today?

Not all of our interviewees answered every part of every question but they all made valiant efforts, especially since the questions were intended to put them on the spot. We have shortened some answers substantially, but have done our best to retain not only the main points of the interviewees' answers, but also their personalities.

Last month we published the responses of the first 13 interviewees. This month we conclude the series.

Leo Beiser
President
Leo Beiser Inc.
Flushing, NY

1. Establishment of rigorous procedures by SID for the dissemination of developments in display technology—in paper selection, presentation, and publication. This professional attitude has been regenerated within the Society, attracting more innovative contributors to the technology who are highly motivated toward effective information dissemination.

2. Adaptation of the CRT to the display world. Although significant alternatives exist, the CRT continues to dominate the high-resolution real-time display and remains the standard against which others are compared. Periodic enhancement of monochrome, color, and flat configurations empowers the CRT to perpetuate its prominence.

Otto H. Schade, Sr., formerly of RCA Laboratories and recipient of the 1975 SID Special Recognition Award, for his milestone contributions to quantifying the characteristics of electronic imaging systems and for his advancement of electron optical imaging systems.

3. Increased interactive display, implemented with human articulation such as manual and vocal control. The advancing touch-sensitive systems exemplify this trend.

4. Augmenting its strong device orientation with systems and subsystems innovation, to reach a broader segment of the information display community.

Ifay F. Chang
Director of Research
Institute of
Systems Science
National University
of Singapore
Past President, SID

1. A sequence of events had a very important effect on the Society—the merger of SID's symposium and conference management with the SID headquarters offices. The people who are active in working for the symposium and conferences are also nominated and elected as headquarters officers and committee chairmen. This movement started about 1978, at the end of Bernie Lechner's presidential service. As a consequence, the Society has gained a better feel for the pulse of the display industry, the symposium and conferences have improved and grown tremendously, and our membership has doubled over the years.

2. The invention of the liquid-crystal display and the subsequent commercialization of the twisted-nematic liquid-crystal display device. I regret that I wasn't the first inventor of it and I was working on a different track—electrochemichromic displays. Commercializing the TN-LCD was not only important to the display industry, it revolutionized several other industries such as electronic instruments, calculators, and watches.

The founding fathers of SID deserve a special commendation for establishing what has grown to be an important technical society over the past 25 years. Thus, our first president, Harold R. Luxenberg, and his contemporaries are the most significant persons for this Society.

3. The electronically integrated all-points-addressable full-color flat-panel display. Several underlying technologies are all ready for this development, and a huge market is waiting.

4. The Society is somewhat over-conservative; there is a lack of vision about the future. Of course, we have taken strides toward adapting to changes, such as taking the printer/hard copy industry into our symposium forum, but are we doing enough? Are we keeping pace with the world in the integration of computer technology and communication technology? Are we overlooking the key role that displays and printers are playing in the information services industry? Are we, as an international society, developing a long-term strategy for facing the technological shifts that are happening in the world? I hope that at the 25th anniversary, we will all reflect and look forward and come up with some plans for our next 25 years of prosperity.

C. J. Gerritsma
Head of Display Group
Philips Research Laboratories
Eindhoven
The Netherlands

1. The decision to organize international interdisciplinary seminars, where specialists can discuss new and important developments in display technology. The Society is the only organization in the field of research, development, and application of displays that is successfully promoting contacts between representatives of various display industries.

2. Research, development and production of LCDs.

The RCA team, under George Heilmeier, that started LCD activities in the late 1960s.

3. Further development of color LCD for television application based on active addressing.

4. To consolidate its unique position, to demolish local/national barriers, and to acquire young and enthusiastic supporters of SID.

Walter F. Goede
Section Manager
Electronics Development
Northrop Electronics
Hawthorne, CA
Treasurer, SID

1. That 25 years ago a bunch of people had the foresight to see that information display and its associated disciplines would be an important part of the computer revolution—and that there wasn't a technical society where people could get together to help chart the future course of these developments. SID has always had a basic charter to provide a forum for just the most new and recent trends in research and development, and has tried to stay away from being a marketing conference where people come and say, "this is my latest whiz-bang product, and I've got an order form here if you'd like to buy five." Engineers and scientists can come and feel they can talk with their peers about problems they've encountered and how they've gone about trying to solve those problems.

"SID has tried to stay away from being a marketing conference where people come and say, 'this is my latest whiz-bang product and I've got an order form here if you'd like to buy five.' Engineers can come and feel they can talk to their peers about problems and how to solve them."
—Walter F. Goede

2. First, the invention of the ac plasma display at the University of Illinois by Bitzer and Slottow—the first potential alternative to the cathode ray tube. Next, the first workable electroluminescent panel, which was announced by Sharp at SID about 1974 and gave a shot in the arm to the entire display community. Finally, the continued evolution of the cathode ray tube. Most people would think that something that had been invented nearly 100 years ago would no longer be making steady advances in performance. In fact, the evolution of the CRT, particularly in its high-resolution color and in its ability to be made at very nominal cost in a large variety of formats, has been a very significant event in the display community.

3. The first realization of relatively high-performance flat-panel displays with both color and gray-scale characteristics that will offer an alternative to the CRT in reasonably large quantities.

4. Facing the transition from the R&D stage—focusing on the technological innovations required to develop viable pieces of hardware—to the more global issues of the systems world. We've made a big step toward including printer and hard copy technology, but we have to go further and pull in many other disciplines like human factors, input/output devices, and software.

Philip M. Heyman
Head, Advanced
Technology Research
David Sarnoff
Research Center, Inc.
Princeton, NJ

1. The rise of the current symposium form of SID meetings, which started about 1970. The Symposium has been the backbone that's held the organization together.

2. The advent of the integrated circuit and the microprocessor has been a boon to the display industry. They control the displays so you can do more with them and have created a demand for displays in large numbers.

3. The flat panel will actually replace the CRT in some consumer applications, not as a novelty but for sound engineering reasons. About five years out I can see some of the small-sized (9-in.) color CRTs being displaced by the liquid-crystal panels that are becoming quite good.

4. Our inability to expand our spheres of influence and increase our membership beyond 2,500, plus or minus 10%. Related technologies seem to be going to organizations like SIGGRAPH and workstation groups. We haven't found a way to pull them into our camp.

"Membership fees must be increased to support an even more substantial level of activity."
—Koh-Ichi Miyaji

Andras I. Lakatos
Manager
Thin Film Device Area
Xerox Corp.
Webster, NY

2. There are three events of almost equal importance. First is the tremendous growth and evolution of the CRT during the last 25 years. That technology has been much more durable than people imagined 25 years ago. Second is the fairly rapid development of low-power flat-panel liquid-crystal displays. Third is the development of the IC industry, which had a tremendous impact on the development of all kinds of displays, including the CRT.

3. The development of a good quality and fairly low-cost high-resolution color flat-panel display.

4. About three-quarters of the members are in the United States but most of the display industry has migrated out of the United States. Therefore, many of the present members are no longer in the display field.

Ted Lucas
Editorial Consultant
Information Display
Cedar Glen, CA

2. The evolution of the computer from a roomful of electronics to a personal computer that sits on a desk. This has led to the explosion of the computer market and has made it possible to sell display hardware on a very wide basis.

Alan B. Dumont, for his contributions to CRT technology and the development of his company, which pioneered in CRT manufacturing and TV broadcasting after World War II. The successor to his company still exists as part of Thomson-CSF.

3. Flat screens and large screens because they have commercial and military advantages of application.

4. Expanding its horizons so as to attract more new members.

Koh-Ichi Miyaji
President
Shibaura Institute
of Technology
Tokyo, Japan

1. The appearance of the color CRT and color television 25 years ago, which laid the foundation for the prosperity of the display industry.

2. The appearance of liquid crystals. Dr. George Heilmeier, who reported on liquid-crystal work for the first time while working for RCA.

3. The introduction of commercial flat-panel-display television for the home.

4. Membership fees must be increased to support an even more substantial level of activity.

Elliott Schlam
Division Director
IDP and Displays
U.S. Army LABCOM
Fort Monmouth, NJ

1. Not a single event, but the combination of events that rapidly led to the recognition of display technology as essential for the information age that we're in now, and the resulting growth of our Symposium.

2. The demonstration of full-scale multiplexibility of flat-panel displays in all of the three prime technologies: plasma, electroluminescence, and liquid crystals. The most important of these is the one that occurred first—the fully multiplexed ac plasma display as discovered and reported by Bitzer and Slottow.

3. The demonstration of flat-panel color displays with a display quality equal to or better than that of current cathode ray tubes.

4. Insufficient exposure of SID to the industrial issues associated with displays, such as standards, manufacturability, and computer graphics. Our Symposium is still one-twentieth the size of the SIGGRAPH Symposium, for example, and that is a problem which has to be dealt with.

H. Eugene Slottow
Professor of Electrical Engineering, Retired
University of Illinois
Urbana, IL

1. SID's evolution, around 1970, into an effective professional society that was able to increase professional interaction among technologists, and allowed a flowering of invention.

2. I'm afraid I can only narrow it down to three important events: the invention and development of LCDs, the invention and development of large plasma displays, and the development of micro-fabrication technologies such as photolithography and screen printing.

3. The proliferation of large high-quality flat-panel television displays.

4. The biggest technical problem has been a long-standing one: finding economic techniques for driving and addressing flat-panel displays.

Aris K. Silzars
General Manager
Hybrid Components
Tektronix, Inc.
Beaverton, OR
Chairman, SID '87

1. The SID Symposium and the International Display Research Conference, in terms of impact on the display community.

2. Development of the liquid-crystal display, which was an entirely new direction in display technology that offered entirely new display applications.

I'm always cautious about singling out one or two individuals, but George Heilmeier of RCA is often mentioned as one of the original workers on liquid crystals. More recently, Terry Scheffer has received a lot of attention for the development of supertwist liquid-crystal technology.

3. The application of displays to automotive electronics, which I think will absolutely blossom over the next five years. There'll be various kinds, but I think the premier technology will still be liquid crystal. Another very significant development will be color thermal-transfer hard copy of photographic quality.

4. That SID still tends to attract people who are very device oriented. It does not yet attract the applications-oriented systems-type engineers and scientists. For example, we've had a very difficult time attracting the automotive engineers who are now very, very heavily into display technology. We should be reaching more, upward into the systems level. We do well in the military systems area, but we tend not to attract systems people in consumer electronics, for instance, to our conferences or into the Society.

"SID tends to attract people who are very device oriented. It does not yet attract the applications-oriented systems-type engineers."
—Aris K. Silzars

Alan Sobel
Vice President
Operations
Lucitron, Inc.
Northbrook, IL

1. When I began working in displays the IEDM was the place where display papers went because SID was a very minor event. Now, there's almost no display content in the Electron Device Meeting. There's almost no display content in the Device Research Conference. Almost all of the play has moved to SID and to the now annual International Display Research Conference. What that says is that we have become a major, if not the major, forum for display technology.

2. The invention of the cathode ray tube, which is still by a long chalk the dominant display medium—the thing all of us flat-panel display enthusiasts have to knock off someday or at least coexist with. There have been two other major developments in the display world. The first was the advent of consumer television, which was the major force in knocking down CRT and circuitry prices to the point where we can all use them. The second was the proliferation of electronic graphic displays for computers, which constitutes an enormous improvement in the way computers work.

David Sarnoff, because it was Sarnoff's drive to produce television, and then color television, as a commercial item, that really kicked the entertainment display business into high gear. A lot has followed from that.

3. I think we'll see a lot more serious, good, high-quality, less-expensive flat electronic displays. I don't think that in five years flat displays will really knock off the CRT. In small displays the liquid crystals are going to dominate the laptop and desktop and so forth in the computer world. We're going to get to really high-quality graphics and larger displays. In the 17- to 25-in. diagonal areas CRTs are going to dominate. Above about 35 in. I hope that Lucitron's gas electron phosphor technology will dominate up to about a 10-ft. diagonal. Large flat-panel displays are going to change the way people use computers because they are going to make it possible to use computers in groups.

4. The insufficient number of members, especially in the user community. We have tended to be too research-oriented and not directed well enough to the practitioner. There is no good place where somebody can go who is designing a product, not five years down the road but six months down the road; where he can find out what he can get now and really be able to evaluate different manufacturers' performances and claims. That's the gap I wish we could fill.

Lee T. Todd, Jr.
President
DataBeam Corp.
Lexington, KY
Program Chairman, SID '87

1. I've only been in the Society about 12 years. Since that time, SID has moved to a much stronger seminar program, and a much larger international audience. It has already expanded into the area of hard copy—we now have multiple printer sessions—and we are making automotive areas an active part of our conference this year.

2. The movement of the predominant research and development effort from the United States to Japan. A lot of display research has begun to be done on an international basis, and SID has expanded to cooperate with that international development.

3. Much higher quality television, and acceptance in the home of larger television images.

4. Finding ways to incorporate people from other disciplines that are using displays but that are not involved in our Society.

"The whole Society needs to be reenergized along the lines of promoting high-fidelity audio and video. Which is sort of super information display."
—Erwin A. Ulbrich

Erwin A. Ulbrich
Principal Staff Engineer
McDonnell-Douglas
Long Beach, CA
Past President, SID

1. Attracting the Japanese to the Society and welcoming them as an integral part of it. The current make-up of the Society, when you read the proceedings, is at least half Japanese. I don't believe that would be true with the IEEE, or with many other professional societies.

2. When, in '69 or '70, cheap memory came along and knocked the pins out of the American display community. Everybody who was in the information display business lost money because they were selling $50,000 machines and these cheap terminals came along that cost about $1,000. But it was a thing that spawned a whole industry.

3. The introduction of high-fidelity audio and video information display.

4. The whole Society needs to be reenergized along the lines of promoting high-fidelity audio and video. Which is sort of super information display. Maybe you'd rather call it information presentation. But it will be the next real stage of expansion and whether or not SID is there it's going to happen, and we ought to be a larger part of it.

Aron Vecht
Reader and Head of
Material Science Division
Thames Polytechnic
London, England

1. The full participation of the Japanese in SID activities. The first and outstanding example occurred in 1974 when Sharp presented the first Japanese EL paper.

The display industry is now totally dominated by what is done in Japan. It's unfortunate that many of the display ideas that were initiated in the U.K. and the U.S. have been developed and marketed in Japan. The Japanese came here to learn from us, and then they overtook us and left us standing.

2. The advent of color television just about 25 or 30 years ago.

George Gray (Professor of Chemistry at Hull University, Fellow of the Royal Society), who developed liquid crystals for displays.

3. We're going to have liquid crystals in large-area displays in 5 or 10 years' time, and we don't know how to multiplex it. It will be a battle between the ferroelectric and the TFT driven, and the one that wins will dominate the next generation of large-area liquid crystals.

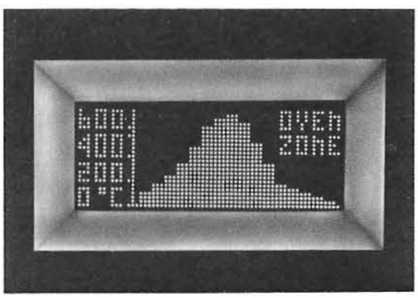
4. It has two. On the technological side, it has not bridged the fundamental science/technology gap. It's firmly rooted in technology, and has not really brought in the materials scientists and the physicists as well as it might. So, we have very few fundamental all-embracing papers the way we should have.

Problem number two is the international problem. The Europeans and Japanese do not adequately participate in the running of the Society, though they certainly come to the conferences. We have moved into the international sphere, but we're not internationalized yet. This is 95% an American organization, and we have to solve that problem. ■

Fully populated dot-matrix display

Babcock Display Products, Inc. announces the development of fully populated dot-matrix gas discharge display components in economical package sizes. Because of the trim dimensions, these displays are ideal for applications where front panel space is at a premium, but the demand for more content is a must (the photo depicts a 24×64 configuration).

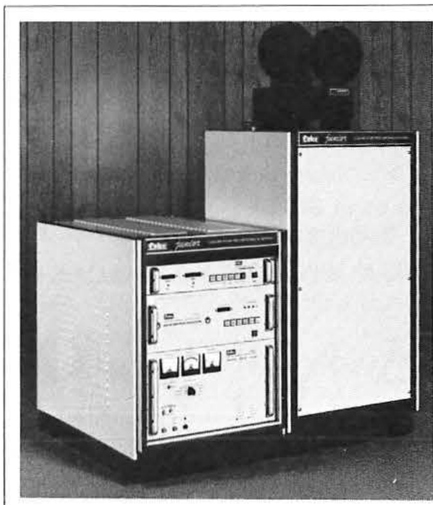
The following pixel configurations are available (columns by rows): 24×64, 32×32, 32×96, and 96× 96.



Babcock Display Products, Anaheim, CA
714/491-5100 **Booth 88**
Circle no. 12

Color film recording system

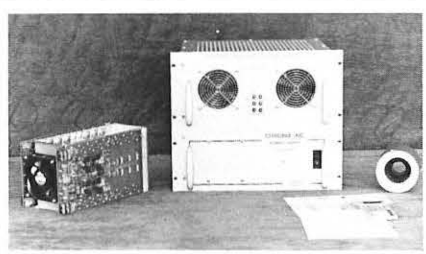
The Celco Junior is designed to fill a specific need where high-throughput and high-quality 16 mm, 35 mm, or 4×5-in. computer-generated imaging is required. A dynamic combination of low cost, compact size, ease of operation, and accurate film registration, with an addressability of 8192×8192, coupled with Celco reliability, make this system ideal for the most demanding animation and business graphic applications.



Celco, Upland, CA
714/985-9868 **Booths 70/71**
Circle no. 13

Magnetic deflection amplifier

The CD-100 series deflection amplifiers can deliver from ±2 to ±20 A at ±75 V_{dc} supply voltage. These amplifiers have current limiting and over-temperature thermal shut down, making them virtually indestructable. With over 80-dB power-supply ripple rejection, these amplifiers can be driven with inexpensive unregulated power supplies that we also provide. For accurate beam measurement (<1 mm) we recommend our PS-200RG regulated power supply. Add our RS-100 resonance flyback switch (flyback <2 μsec) and our CV-100 video amplifier (60 MHz BW) and you have a complete CRT test station.



Citronix, Inc., Orangevale, CA
916/961-1398 **Booth 93**
Circle no. 14

CRT products from Clinton

The Clinton display will showcase:

- *The Square Sixteen.* A new bulb that displays as much information as a 17-in. CRT, in a size no wider than a conventional 15-in. CRT.
- *The Spectrum.* Segmented screening that offers a practical alternative to conventional color CRTs in specialty applications.
- *14″ 90° 20 mm/15″ 90° 20 mm Flat Profile Design CRTs.* Designed for less power consumption and a distortion-free display screen.
- *Current-Sensitive Phosphor.* Variations of color achievable through simple current variations.
- *Page White Phosphors.* A cross section of the various page white phosphors available from Clinton Electronics.
- Plus a variety of new CRT products adaptable to a multitude of applications.

Clinton Electronics Corp., Rockford, IL
815/633-1444 **Booths 85/86**
Circle no. 15

Electroluminescent sealed IR touch module

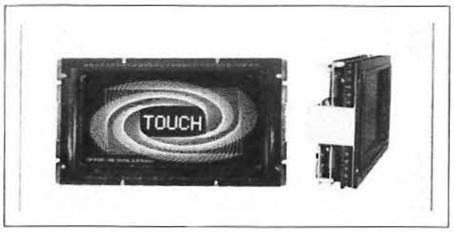
Digital Electronics Corporation (DeeCO) has released the latest innovation in flat-panel display subsystems, the new SealTouch™ IR touch display module. Called "SealTouch" for its one-piece molded IR sealed bezel and filter assembly, this new product provides a solution to the common problem of preventing moisture and dust from contaminating the IR touch sensor array.

This new IR touch entry panel is specifically designed for 512×256 dot-matrix EL displays and DeeCO's second-generation graphic and text controller.

The M3EL512X256 EL module incorporates the patented SealTouch mechanical design and new expanded touch-software features such as "pop-up" menus, enter, exit and track/touch modes, automatic button draw, button pages, callable on-screen keyboards, smooth scroll, and a command set including 68 graphic primitives.

The SealTouch display subsystem measures only 10.278 in. wide, 5.078 in. high, and 2.50 in. deep, providing the smallest footprint available. Only +5 and +12 V_{dc} are required for power.

The M3EL512X256 EL module, with SealTouch, is available now for $3345 (Qty. 1). Delivery is 30 days ARO.



Digital Electronics Corp., Hayward, CA
415/786-0520 **Booths 77/78**
Circle no. 16

High-voltage power supplies

DISCOM's new series of power supplies are packaged in industry standard fully shielded housings. The line includes HVPSs for monochrome, color, high brightness, and projection applications featuring 100-kHz conversion frequency for lower ripple (0.01%) and faster response (0.5 msec).

DISCOM/Display Components, Westford, MA
617/692-6000 **Booths 17/18**
Circle no. 17

Miniscan modular display system

Responding to a market demand for a high-resolution miniature display system, EEV Inc.'s sister company MOV in cooperation with Brandenburg, has introduced Miniscan. This combination of a small electrostatic light-weight CRT attached to the drive electronics by an umbilical cable gives a modular video system for specialist equipment.

The immediate benefit is that because of its small size and weight, the CRT can be mounted in positions not previously practicable, while the drive electronics/power unit can be installed remotely where constraints of power and weight are not so severe.

The miniature high-resolution electrostatic Miniscan CRT gives 800 TV lines on a 1-in.-diameter tube. The use of electrostatic focusing and deflection means lower size, weight, and power consumption than electromagnetic tubes.

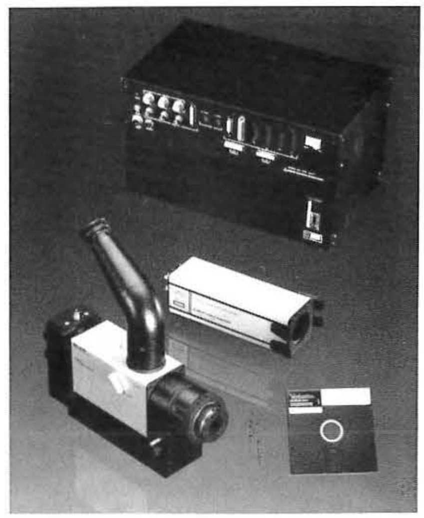
Miniscan accepts standard composite video: 525 lines/60 Hz or 625 lines/50 Hz, or non-composite video with line and field drives. It can be driven in X, Y, and Z modes.

EEV, Inc., Elmsford, NY
914/592-6050 **Booths 57/58**
Circle no. 18

Automatic convergence measurement system

EG&G Gamma Scientific's C-11CNV System was developed to quickly and accurately measure the spatial convergence of up to three different spectral components of stroke and raster color displays. This system allows, for the first time, accurate and repeatable convergence measurements to be made without external connections to the monitor deflection amplifier circuits.

The C-11CNV System consists of an IBM-PC with Spatl/Conv software, a specially configured GS-4100 radiometer, a GS-4555 tri-photomultiplier assembly, a GS-2110A telemicroscope, and a GS-6020 X-Y positioner. The GS-4100 provides separate high voltage to each PMT, electric shutter control, automatic zero compensation, and signal averaging. It also



reads the three PMTs simultaneously and transmits the acquired digital intensity profiles to the IBM-PC where they are analyzed and displayed in graphic and numeric form by the software. By employing a scanning knife edge in the image plane of the measurement system, convergence can be determined in less than 15 sec with a spatial accuracy exceeding that previously known for such applications by at least a factor of 10.

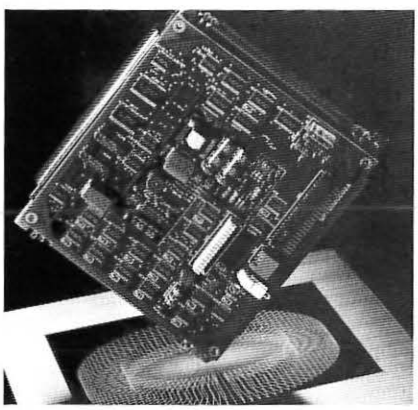
EG&G Gamma Scientific, San Diego, CA
619/279-8034 Booths 83/84
Circle no. 20

Graphic and dot-matrix modules

Futaba offers a wide assortment of display tubes in many sizes and formats. Also, Futaba offers display modules with all the electronics required to refresh the display and easily interface with the host system.

Both front glass phosphor, which provides maximum viewing angle and uniform surface appearance, and conventional back glass phosphor, with optimum brightness and software dimming capabilities, are available. All Futaba graphics modules offer complete drive electronics, bit-mapped control with DC/DC converter. All active components are surface mounted onto a single board.

Utilizing Futaba's dot-matrix displays, a completely intelligent line of dot modules is available. Each includes all drive, power supply and microprocessor components surface mounted onto a single board. Surface-mounted technology results in higher reliability and allows for a smaller overall package and lower cost. All dot modules require only a 5 V_{dc} power source and can accept parallel or eight possible serial baud rates.



Futaba Corporation, Farming Hills, MI
313/553-3038 Booth 87
Circle no. 22

Specialized CRTs

Hughes Aircraft Co. specializes in the design, development and manufacturing of CRTs to meet your particular system requirements. The Hughes approach begins by designing components and component features to meet the needs of an individual application and thus assures that the final product will be just right for the job.

The specialized tubes illustrated are made for helmet-mounted display applications. Hughes produces one of the smallest CRTs available. These tubes are well known for their high-quality resolution and brightness. Each is available fully assembled with magnetic shield, magnetic deflection, and electrostatic focus. These products have been utilized in both Europe and the United States for military programs such as the AH64 Helicopter.

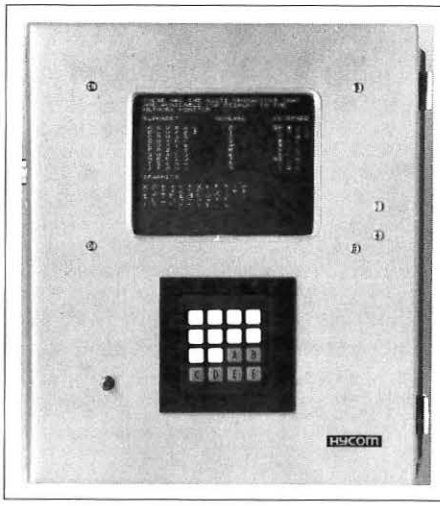
Hughes welcomes the challenge to create a high-quality tube to match your specific needs.

Hughes Aircraft Co., Carlsbad, CA
619/931-3267 Booths 73/74/75
Circle no. 23

Circle no. 24

TFEL display network monitor

The Hycom Network Monitor is used to display host computer data at multiple remote locations. A network of 64 monitors can be used, linked together by RS-232/RS-422 data lines. The Network Monitor is a rugged display subsystem for use in an industrial environment. It



products on display

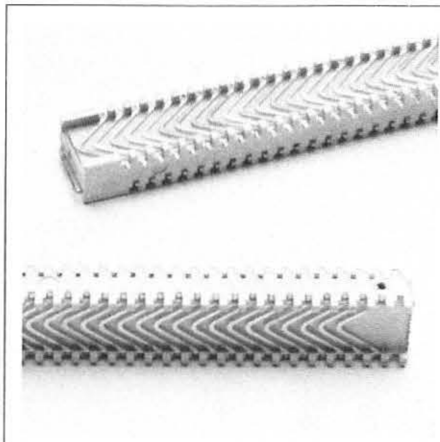
employs a solid-state TFEL display screen, and is packaged in a sturdy steel NEMA enclosure.

The Network Monitor allows multiple remote stations to share the host-computer data base as a "bank" of reference information by requesting specific data pages to guide local work. Three pages of the data base can be stored in local memory for display as needed. A local keypad enters page requests and selects the display page. This keyboard cannot alter (or accidentally destroy) the host data base.

Hycom, Inc., Irvine, CA
714/261-9321 **Booth 102**
Circle no. 28

Interconnect for flat-panel displays

With ITT Cannon's parallel interconnect it takes less than 1 min to assemble a high-density low-resistance interconnect for flat-panel displays, with no soldering required. The parallel interconnect expands and contracts with the glass or printed circuit boards, ensuring a positive contact interface. The fast accurate assembly and high dependability results in lower installation costs.



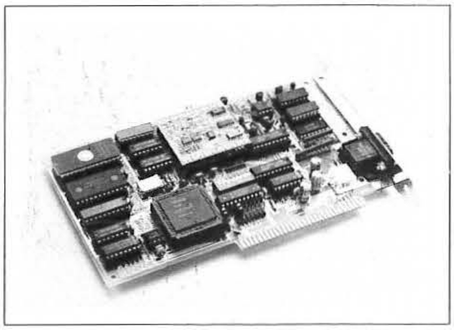
ITT Cannon, Fountain Valley, CA
714/964-7400 **Booth 12**
Circle no. 29

Circle no. 30

Controller board

Interaction Systems, Inc. announces the first IBM PC-compatible plug-in touch controller board to add capacitive touch-input capability to the IBM PC and compatibles. The Model 4003 Touch Controller Board has been specifically designed to facilitate the addition of touch input to IBM PC-compatible systems. By simply inserting the 4003 board in an IBM bus slot, attaching a standard Interaction Systems touch screen to a monitor, and connecting the touch screen to the controller via a single cable, the user is immediately able to input and access data via touch. This new design eliminates the need for complex hardware integration, added power supply, the use of already limited serial ports, and costly modifications necessitated by monitor limitations.

Significant new features incorporated in the Model 4003 include: elimination of all manual adjustments, standard scaled resolution of 256×256 and drivers designed to optimize the Model 4003 controller performance in the MS-DOS environment. Prices in OEM quantity range from $295–$395.

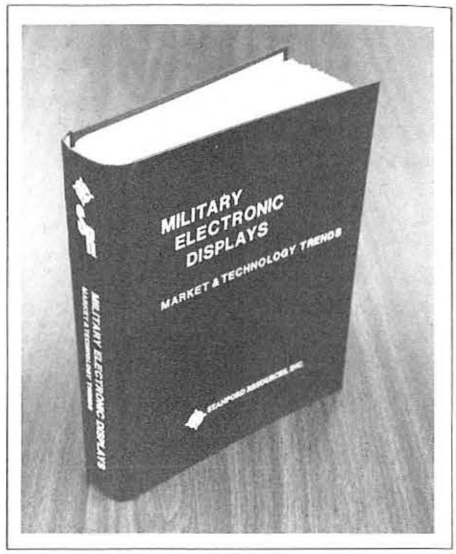


Interaction Systems, Inc., Brighton, MA
617/789-5900 **Booth 107**
Circle no. 31

Military electronic display study

Stanford Resources' most recent multiclient study, "Military Electronic Displays—Markets and Technology Trends," provides a coherent and understandable structure and forecast of the U.S. military markets for electronic displays and display systems.

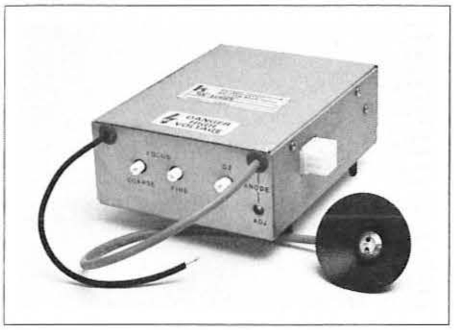
An extensive interview program was conducted to insure that an accurate assessment of the current situation was obtained and that a reliable forecast of market size and opportunities could be determined. All of the key manufacturers and suppliers of electronic displays for this market segment were interviewed. Government and service personnel with an important role in display selection, funding and selection were also interviewed. More than 30 of the primary display decision makers at the major system companies were contacted.



International Planning Information, Inc., Redwood City, CA
415/364-9040 **Booth 40**
Circle no. 32

High-voltage power supply

The Keltron HR25 is designed for optimum performance of all shadow-mask color CRTs, including the newest high-resolution screens. With conservative

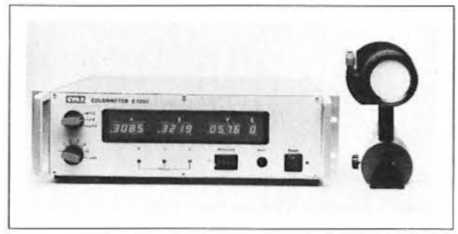


design and top quality, the HR25 with its standard options can be customized at low cost to provide all the required voltages for the CRT.

Keltron Corp., Waltham, MA
617/894-8700 **Booth 108**
Circle no. 34

Colorimeter using mosaic filtering

The C 1200 colorimeter uses mosaic filtering to yield virtually perfect tristimulous functions to nearly eliminate color measurement error due to filter correction. The C 1200 is accurate to ±0.005 for tungsten, fluorescent, and HID lamps, and to ±0.002 for highly colored sources such as color TV phosphors (CIE 1931 x,y coordinates). Because all three tristimulous functions are measured simultaneously, errors due to time-dependent variations are completely eliminated. A standard measuring rate of 2.5 measurements/sec is acheived with this system. The model C 3300 can achieve 100 readings/sec. Coordinates x,y, and Y are displayed on the front panel (4 one-half digit display) or sent to the computer via BCD or as an option, IEEE-488. Operations are computer controllable via IEEE-488.

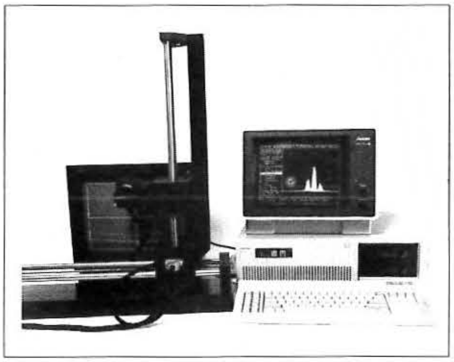


LMT, San Diego, CA
619/271-7474 **Booth 90**
Circle no. 35

Circle no. 33

CRT analysis system

Microvision of San Jose, California has just announced the SUPERSPOT 100 system for making rapid automatic convergence measurements on color CRTs. Direct reading of line width and MTF for both color and monochrome CRTs as well as measurement and adjustment of focus, pincushion, beam drift, and convergence are all quickly made with this versatile CRT analysis system. The total concept approach of the SUPERSPOT 100 is designed to meet the specific measurement needs of the display industry. Laboratory, quality control and production are all prime candidates for this exacting fast solution to the CRT measurements.



Microvision, San Jose, CA
408/374-3158 **Booths 50/51**
Circle no. 36

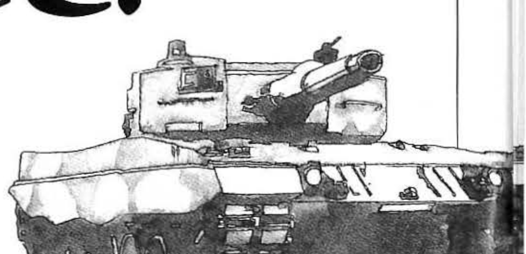
Transparent conductive coating

Optical Coating Laboratory, Inc. expanded its line of TEMPEST shielded windows for EMI/RFI suppression, with the introduction of a new transparent conductive coating. This coating is optimized for high-quality EMI/RFI suppression to meet TEMPEST requirements.

OCLI's newest product has a unique proprietary conductive coating which totally eliminates moiré patterns while blocking EMI/RFI radiation. Coupling this coating with OCLI's HEA® (high-efficiency antireflection) coating provides the user with a non-glare non-diffusing highly secure window.

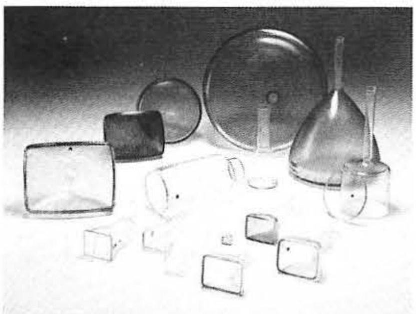
These OCLI panels can be bonded directly onto the face of the CRT or factory installed into the manufacturer's bezel.

OCLI, Santa Rosa, CA
707/525-7526 **Booths 63/64**
Circle no. 37



CRT bulbs

Owens-Illinois manufactures every type of glass for display devices, glass bulbs, face plates, plano-plano, neck tubing and



precision neck tubing. We also manufacture more than 130 types of special CRT bulbs ranging in size from 1 to 43 in. for color and monochrome TVs, and special CRTs.

Owens-Illinois, Columbus, OH
614/443-6551 **Booths 81/82**
Circle no. 39

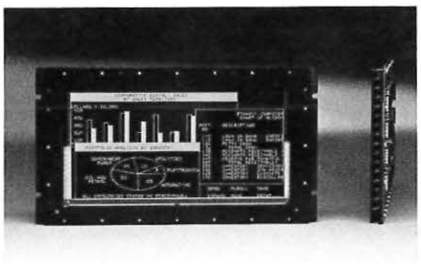
A 1.5-m plasma display

A 1.5-m ac gas-discharge (plasma) display has been jointly developed by Magnavox Electronic Systems, Fort Wayne, Indiana, and Photonics Technology, Northwood, Ohio. This is the world's largest nonprojected fully populated flat-panel display.

Photonics Technology, Northwood, OH
419/666-0762 **Booths 111/112**
Circle no. 40

Thin-film electroluminescent display

Planar's newest thin-film electroluminescent display, the EL6648MS, is capable of receiving control signals from a CRT controller using 30% less power draw than previous models. A 2000-character display typically uses approximately 10 W. The display contains 131,072 (512×256) completely bit-mapped addressable pixels and provides a clear crisp image.



The EL6648MS replaces the bulky CRT for virtually all microcomputer-based product designs. Because the display is compact, just 0.75-in. thick and a mere 18 oz. in weight, the overall system size can be kept to an economical minimum. Among the benefits offered by this display are ease of installation, reduced system integration cost, freed space for extra functionality, and increased portability.

The EL6648MS offers superior graphics and is, therefore, ideal for simplifying operator control of complex equipment often used in industrial control, instrumentation, terminal, and medical applications.

Planar Systems, Inc., Beaverton, OR
503/690-1100 **Booths 96/97/98**
Circle no. 41

High-voltage power supplies

PTK manufactures high-voltage power supplies for commercial display applications. Power supplies can be easily

modified to meet particular specifications. MIL-SPEC power supplies, as well as custom designs, are also available.

PTK/Rantec Div., Los Osos, CA
805/528-5858 **Booth 94**
Circle no. 45

Flying-spot scanner

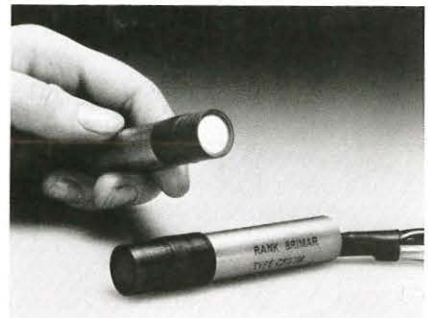
Series C82209 flying-spot scanner is a 5-in.-diameter magnetic-deflection and electrostatic-focus CRT. Features include an ultra-fast decay phosphor screen. Light emission from the phosphor is near-white in color. Applications include the generation of television-type display of motion-picture film and related sources.

RCA New Products Div., Lancaster, PA
800/233-0155 **Booths 65/66**
Circle no. 46

A 0.5-in. CRT package

A new miniature CRT package has been developed by Rank Brimar for applications where a very small light-weight tube is required; for example, helmet-mounted display in fixed-wing high-performance fighter aircraft and battle tanks.

The new tube and coil package has an outside diameter of 17 mm (0.67 in.), a length of 80 mm (3.15 in.) and a useful screen of 11.5 mm (0.45 in.) diameter on the fiber-optic faceplate. The total weight



Circle no. 47

THOMSON-CSF

THE FURTHER WE GO, THE FURTHER YOU GO.

Thomson-CSF is your winning partner for professional display tubes and devices. Whether your applications are in radar, avionics, defense, industry or medicine, you can be sure of our technology for reliability and performance, even under the most adverse conditions.

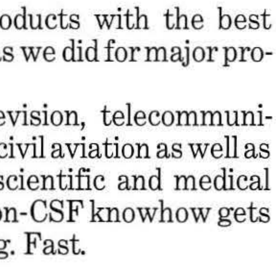
Our vast CRT range incorporates the latest models for video projection, short head-up and head-down displays, helmet-mounted displays, ground/airborne monochrome and color radars, photographic data recording, instrumentation, etc.

And our proven AC plasma panels offer the ultimate in readability and ruggedness for medium and high density graphics display, in all environments.

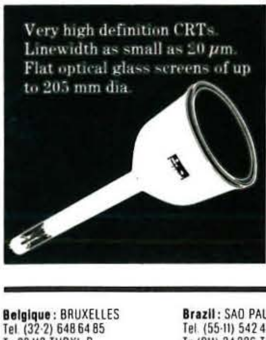
With manufacturing plants in Europe and the US, we are at hand to let you benefit from our quality products with the best customer care. Just as we did for major programs worldwide.

In radio and television, telecommunications, military and civil aviation as well as in a wide range of scientific and medical applications, Thomson-CSF knowhow gets your systems moving. Fast.

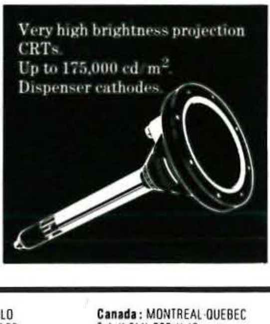
Special monitor CRTs including ruggedized color radar and helmet mounted displays



Ac ruggedized display panels. Tireless, flicker-free display Up to 1,280 x 1,280 dots.



Very high definition CRTs. Linewidth as small as 20 μm. Flat optical glass screens of up to 205 mm dia.



Very high brightness projection CRTs. Up to 175,000 cd/m^2. Dispenser cathodes.

The sharpest image devices in the world.

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Italia: ROMA Tel. (39-6) 639 02 48 Tx 620 683 THOMTE I

Japan: TOKYO Tel. (81-3) 264 63 46 Tx 2 324 241 THCSF J

Sverige: TYRESÖ Tel. (46-8) 742 0210

United-Kingdom: BASINGSTOKE Tel. (44-256) 29 155 Tx 858 865 TESAFI G

U.S.A.: DOVER Tel. (1-201) 328 1400 TWX 710987 7901

Circle no. 48

of the sealed package is only 35 g (1.25 oz). Within this small volume the high-performance tube will display a high-brightness standard raster.

The design of this tube is based on the existing Rank Brimar 1-in. helmet display package currently supplied for the Apache helicopter program.

Rank Brimar Limited, Manchester, U.K.
061-681-7072 **Booths 5/6**
Circle no. 49

Circle no. 51

V-Beam Index CRT for avionics display

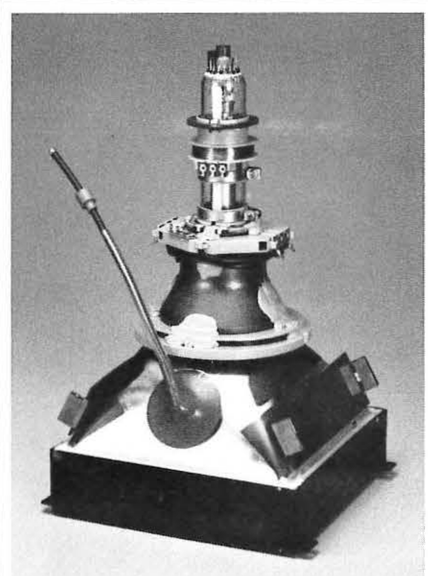
A new 6.3 × 6.3 in. V-beam index CRT has been developed for avionics use. The beam-index CRT has the high beam efficiency of a phosphor screen but without a shadow mask or the inherent problems of a conventional CRT such as mask vibration, mask thermal expansion, and susceptibility to magnetic fields.

The white peak brightness of the new CRT is 1,000 fL, which is 4–6 times that of a conventional CRT. A beam current as high as 1,000 μA if accelerated by 33 kV, the power on the panel being 33 W.

The new CRT's high brightness was achieved by reduction of beam spot size and by optimizing the phosphor coating weight.

A contrast ratio of 5:1 was attained under a halogen lamp of 50,000 lux when a 10% contrast filter was positioned in the front of the panel.

The new CRT's deflection angle is 75° and it has a triplet pitch of 0.42 mm with a total of 378 triplets.



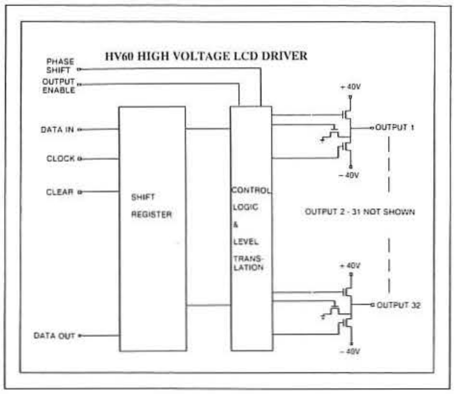
Sony Corporation, San Diego, CA
619/487-8500 **Booths 61/62**
Circle no. 50

High-voltage LCD driver

Supertex has developed a monolithic high-voltage integrated circuit, the HV60, that provides the circuitry and voltage required to drive dichroic and supertwisted LCD technologies. This device, designed with the Supertex proprietary HVCMOS process, provides a three-state output signal +40 V, −40 V, and return-to-ground.

The HV60 contains 32 channels. These channels can be selected by the data of the shift register which selects the high or low values on the output. The phase-shifted input controls additional circuitry which provides the return to ground signal and the phase control. Input logic is controlled by ±5 V signals, compatible with many present systems.

Samples of the HV60 are available now in both surface-mount and dual-in-line package. Consult factory for prices and availability.



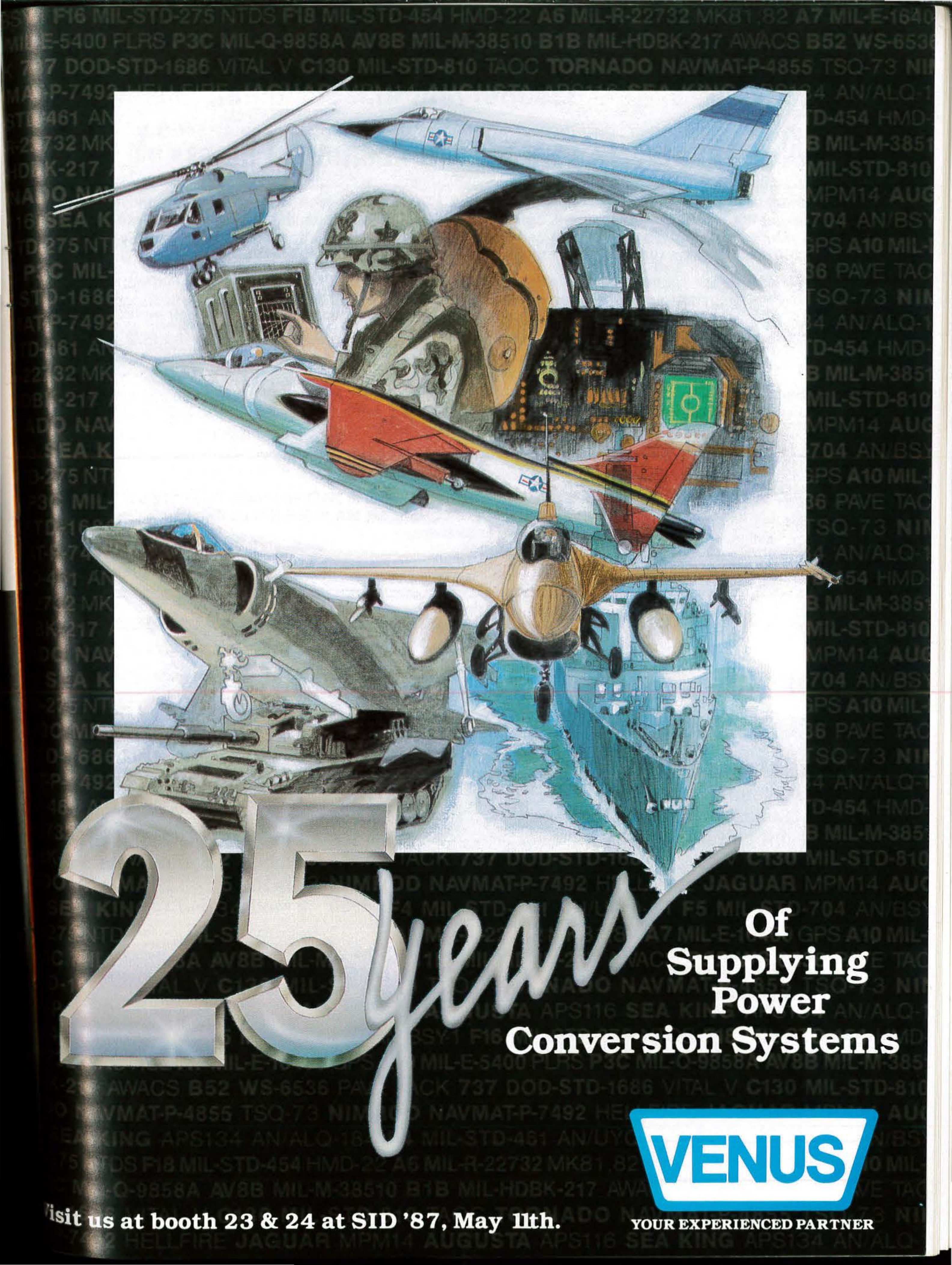
Supertex, Inc., Sunnyvale, CA
408/744-0100 **Booth 48**
Circle no. 54

Video printer with 64-tone gray scale

The TP-115 video printer connects to the video output of a CRT display or TV monitor via a BNC cable and delivers a hard-copy printout of the screen with a 64-tone gray scale.

The printed area is approximately 8.5×6.5 in. and the printing time is 40 sec. A choice of positive or negative printing is provided along with controls for image contrast and brightness. The TP-115 will accept both interlaced and not-interlaced composite video signals. High-contrast (black and white) printing is also possible.

The fine detail and range of tones of the printed image makes the TP-115 ideal for medical and industrial applications


25 years
Of Supplying Power Conversion Systems
VENUS
YOUR EXPERIENCED PARTNER
isit us at booth 23 & 24 at SID '87, May 11th.

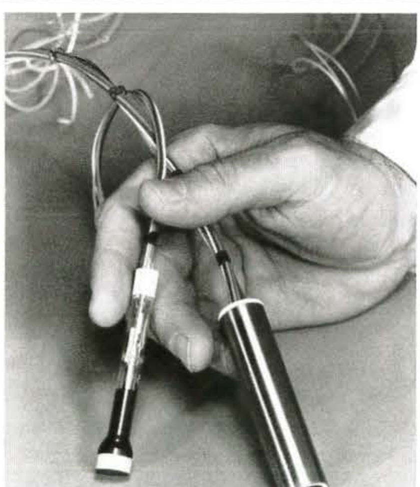
that use x-ray or ultrasonic diagnostics. The TP-115 is available within 30 days from receipt of order and is priced at $5900 in single quantities.

Test & Measurement Systems, Inc., Sunnyvale, CA
408/720-8877 **Booths 32/33**
Circle no. 59

Sub-miniature assembly for helmet-mount displays

Thomas Electronics, Inc. has just announced the production of an ultra-lightweight sub-miniature assembly that is 0.7 in. in diameter and is less than 3.0 in. in overall length. The tube was developed for helmet-mounted displays for use in helicopters and fixed wing aircraft.

The IM70P53MFO tube provides an 0.0008-in. line width across a 0.4-in.-diameter useful area and a 500 fL area brightness through the integral fiber-optics faceplate. A low inductance coil is precision aligned within a mu-metal shield. Maximum weight, excluding lead, is 40g.



Thomas Electronics, Wayne, NJ.
201/696-5200. **Booths 54/55**
Circle no. 61

Avionic CRTs

Thomson Electron Tubes and Devices Corporation has developed a diverse line of CRTs and plasma panels for various military and industrial applications—which includes CRTs for avionics, command and control, photo-recording, projection, air-traffic control, and a host of other applications. New this year will be a fully shielded MIL-SPEC 19-in. color shadow-mask assembly. The color assembly includes a 19-in. PIL CRT, deflection yoke, convergence coils, conformal shield, leads, and connectors potted as an integral unit.

Thomson Electron Tubes and Devices Corp., Dover, NJ
201/328-1400 **Booths 15/16**
Circle no. 62

Medical imaging test pattern generator

The Vii Model 110A test pattern generator provides a convenient low-cost capability for application of the SMPTE pattern to medical imaging systems of virtually any scan rate, bandwidth, and aspect ratio. To date, application of the pattern has been limited to larger scale systems with resident ability to develop and store the great amount of information required to generate the pattern.

A most important consideration is maintaining a daily file of test images.

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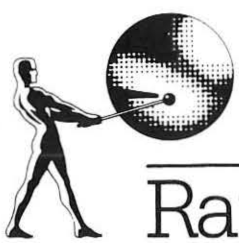

Rank has integrated its professional CRT and Drive Equipment businesses into a unified, more powerful Company – Rank Brimar Ltd – which concentrates the resources of Rank Electronics Tubes at Sidcup in Kent, England and at Scotts Valley in California, USA together with the existing Rank Brimar capability at Middleton in Manchester, England.

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- Transient digitizers
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- Hard copy
- Military and custom

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See us at SID
New Orleans,
May 12–14
1987

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Test and Measurement CRT
M.S. 46-539, P.O. Box 500
Beaverton, Oregon 97077
Phone: (503) 627-6868

Tektronix
COMMITTED TO EXCELLENCE

Circle no. 65

products on display

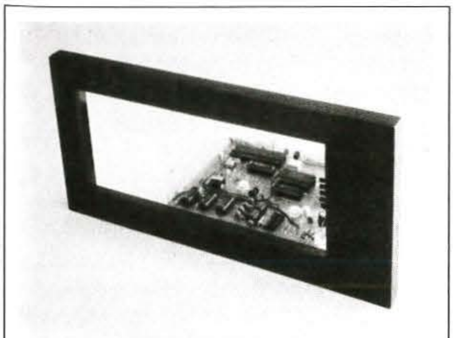
The model 110A has provision for time and date overlay to document when performance was verified. The unit is configured so that it may be permanently installed in a system. Interface to a personal computer (IBM PC-XT or MacIntosh) allows easy change of scan rate, pattern selection, and floppy disc storage.

Visual Information Institute, Xenia, OH
513/376-4361 Booths 52/53
Circle no. 66

Touch screen for rugged environments

Wells-Gardner Electronics announces the new ES Series Cyclops Touch Screen—offering optical reliability and quality at an affordable price. With only *one* LED and *one* solid-state CCD detector, the ES Series is priced under $100 in OEM quantities, and yet offers superior performance over alternative technologies: high resolution (100 x 70), low power consumption, 100% optical clarity, high reliability (55,000 hour MTBF), and more.

Currently available in a 4 x 9 in. size for flat-panel displays, the Cyclops ES Series needs no field calibration and is designed for rugged environments where surface damage and vibration resistance are important concerns. Additional sizes are available upon request.



Wells-Gardner Electronics, Chicago, IL
312/252-8220 Booth 106
Circle no. 67

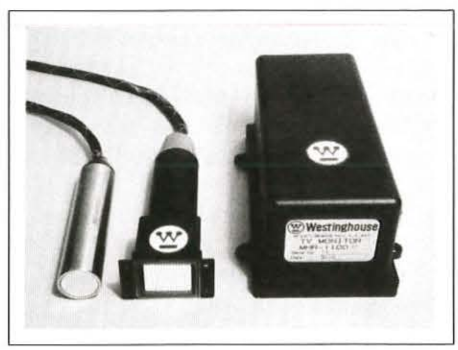
A 1-in. military CRT display

A compact high-resolution military display with a CRT only 1 in. in diameter is available from Westinghouse Electric Corporation.

The new MHR-1100 monitor is one of the smallest available military CRT displays in the industry. The complete monitor with tube measures $3 \times 3 \times 7$ in. deep.

An optional unit, the MHR-1100XR, can be ordered with the encapsulated tube at the end of a 6-ft. cable, so that use of panel space can be minimized. A 1½-in.-diagonal display is also available.

Both configurations have a wide input power range of 18–32 V_{dc} plus RS-170 or CCIR video format. Contrast and brightness controls can be located as far from the electronic circuitry as design demands, with no loss of bandwidth and no EMI complications.



Westinghouse Electric Corp, Horseheads, NY
607/796-3350 Booths 34/35
Circle no. 68 ■

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May

SID '87: Society for Information Display International Symposium, Seminar and Exhibition. Palisades Institute for Research Services, Inc., 201 Varick St., Suite 1140, New York, NY 10014. 212/620-3388
May 11-15 New Orleans, LA

1987 Technical Symposium Southeast on Optics, Optoelectronics. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
May 17-22 Orlando, FL

SPSE '87: 40th Annual SPSE Conference and Symposium on Hybrid Imaging Systems. Pam Fornas, SPSE, 7003 Kilworth Lane, Springfield, VA 22151. 703/642-9090.
May 17-22 Rochester, NY

Opportunities in Flat-Panel Displays—Short Course. N. Ronnie Sarkar, Arthur D. Little, Inc., 15 Acorn Park, Cambridge, MA 02140. 617/864-5770 ext. 2377.
May 18 Boston, MA

Digital Facsimile—Short Course. Institute for Graphic Communication, 375 Commonwealth Ave., Boston, MA 02115. 617/267-9425.
May 18-20 Bedford, MA

Human Factors in Displays and Controls—Short Course. (Larry Tannas, Instructor) UCLA Extension, Short Course Program Office, 10995 LeConte Ave., Rm. 639, Los Angeles, CA 90024. 213/825-3344.
May 18-22 Los Angeles, CA

NAECON '87: A National Forum for the Exchange of Aerospace Electronics Information. Cindy Porubcansky, Wright-Patterson AFB, OH 45433. 513/255-4848.
May 18-22 Dayton, OH

Intelligent Digitizing/Intelligent Infrastructure—Short Course. F-M Automation Newsletter, 9501 W. Devon Ave., Suite 203, Rosemont, IL, 60018-4804. 312/823-0555.
May 19-20 Boston, MA

EMC Expo '87. Sandra Hamilton, EMC Expo'87, P.O. Box D, Gainesville, VA 22065. 703/347-0030.
May 19-21 San Diego, CA

Fiber Optic Communications—Short Course. Marilyn Martin, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA, 90231-3614. 800/421-8166.
May 19-22 San Diego, CA

PC-Based Tools for Software Analysis and Design—Short Course. Nicolette Worley, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213/417-8888.
May 19-22 Washington, DC

Hard Copy Processes for the Future—Short Course. Institute for Graphic Communication, 375 Commonwealth Ave., Boston, MA 02115. 617/267-9425.
May 20-22 Bedford, MA

Metal and Ceramic Matrix Composites—Short Course. Technology Training Corp. Dept. M and CMC/ANMC, P.O. Box 3608, 3420 Kashiwa St., Torrance, CA 90510-3608. 213/543-3922.
May 21-22 Huntsville, AL

CG Int'l '87: Conference on Computer Graphics in Japan. Prof. Tosiyasu L. Kunii, Kunii Laboratory of Computer Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-Hu, Tokyo 113, Japan. (03) 812-2111.
May 25-28 Karuizawa, Japan

West Coast Desktop Publishing Roundtable. NCGA, 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031. 703/698-9600.
May 27 San Francisco, CA

June

Advanced Non-Metallic Composites—Short Course. Technology Training Corp. Dept. M and CMC/ANMC, P.O. Box 3608, 3420 Kashiwa St., Torrance, CA 90510-3608. 213/534-3922.
June 1-2 Orlando, FL

COMDEX/Spring. The Interface Group, Inc., 300 First Ave., Needham, MA 02194. 617/449-6600.
June 1-4 Atlanta, GA

Designing Modern Software/User Interfaces—Short Course. Nicolette Worley, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213/417-8888.
June 2-5 San Diego, CA
June 9-12 Washington, DC

Integrated Voice/Data Communications and ISDN—Short Course. Marilyn Martin, Integrated Computer Systems, 5800 Hannum Avenue, P.O. Box 3614, Culver City, CA 90231-3614. 800/421-8166.
June 2-5 Toronto, Canada

Images on CD-ROM—Short Course. Institute for Graphic Communication, 375 Commonwealth Ave., Boston, MA 02115. 617/267-9425.
June 3-5 Amsterdam, Netherlands

Metal and Ceramic Matrix Composites—Short Course. Technology Training Corp. Dept. M and CMC/ANMC, P.O. Box 3608, 3420 Kashiwa St., Torrance, CA 90510-3608. 213/534-3922.
June 4-5 Orlando, FL

Special Applications for Electrostatic Imaging—Short Course. Diamond Research Corp., P.O. Box 128, Oak View, CA 93022. 805/649-2209.
June 7-9 Santa Barbara, CA

International Conference on Computer Vision. Azriel Rosenfeld, Univ. of Maryland, Center for Automation Research, College Park, MD 20742. 301/454-4526.
June 8-11 London, England

Second Annual Conference on Optical Storage for Large Systems. Judith Hanson, Technology Opportunity Conference, P.O. Box 14817, San Francisco, CA 94114-0817. 415/626-1133.
June 9-11 New York, NY

Electronic Imaging Industries—Short Course. Institute for Graphic Communication, 375 Commonwealth Ave., Boston, MA 02115. 617/267-9425.
June 14–16 Monterey, CA

National Computer Conference. Marketing Department, AFIPS, 1899 Preston White Dr., Reston, VA 22091. 1-800/NCC-1987.
June 15–18 Chicago, IL

Flat Panel Displays 1987 International Conference. International Planning Information and Stanford Resources, Inc. (IPI), Nordre Ringvej 201, DK-2600 Glostrup, Denmark. 45 2 63 2044.
June 17–18 Copenhagen, Denmark

MARSIM '87: Fourth International Conference on Marine Simulation. Marsim '87, c/o SMS, Ladehammerv 6, 7000 Trondheim, Norway. 47-7-51-14-11.
June 22–24 Trondheim, Norway

45th Annual Device Research Conference. Jerry Woodall, IBM Corp., P.O. Box 218, Yorktown Heights, NY 10598. 914/945-1568.
June 22–24 Santa Barbara, CA

Munich Laser Show. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
June 22–26 Munich, West Germany

Fiber Optic Communications—Short Course. Marilyn Martin, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 800/421-8166.
June 23–26 Boston, MA
June 23–26 Palo Alto, CA

Structured Design and Programming—Short Course. Nicolette Worley, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213/417-8888.
June 23–26 Washington, DC

PC-Based Tools for Software Analysis and Design—Short Course. Nicolette Worley, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213/417-8888.
June 23–26 Los Angeles, CA

Symposium on Marketing Trends in Photoelectronic Imaging. Conference Manager, SPSE, 7003 Kilworth La., Springfield, VA 22151. 703/642-9090.
June 24–25 New York, NY

Color Hard Copy—Short Course. Institute for Graphic Communication, 375 Commonwealth Ave., Boston, MA 02115. 617/267-9425.
June 28–30 Bedford, MA

Advanced Non-Metallic Composites—Short Course. Technology Training Corp. Dept. M and CMC/ANMC, P.O. Box 3608, 3420 Kashiwa St., Torrance, CA 90510-3608. 213/534-3922.
June 29–30 Washington, DC

July

Fiber Optic Communications—Short Course. Marilyn Martin, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 800/421-8166.
July 7–10 Washington, DC
July 14–17 Anaheim, CA

European Simulation Multiconference '87. European Simulation Office, c/o Philippe Geril, Univ. of Ghent, Coupure Links 652 B-9000, Ghent, Belgium. 0032-91-236961 ext. 233.
July 8–10 Vienna, Austria

PC-Based Tools for Software Analysis and Design—Short Course. Nicolette Worley, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213/417-8888.
July 14–17 Boston, MA
July 21–24 Washington, DC

Structured Design and Programming—Short Course. Nicolette Worley, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213/417-8888.
July 14–17 Los Angeles, CA
July 28–31 Boston, MA

Designing Modern Software/User Interfaces—Short Course. Nicolette Worley, Integrated Computer Systems, 5800 Han-

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MODEL	OUTPUTS	VOLTAGE	OUTPUT CURRENT	REGULATION		RIPPLE	INPUT POWER	FEATURES	SIZE (INCHES)
				LINE	LOAD				
	Anode	25KV	1.2MA	0.050%	0.050%	1V PK-PK		Mil-Spec	
	Focus	7 to 9 KV	25uA	0.050%	0.100%	1V PK-PK		Mil-E-5400	
102	Dynamic Focus	0 to 500V					27V to 30V DC	Temp: - 54° C to +60° C	7.25 x 8.50 x 1.78
	G2	625V	20uA	0.100%	0.500%	0.2V PK-PK		Dynamic Focus	
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num Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213/417-8888.
July 21-24 Anaheim, CA

1987 Summer Computer Simulation Conference. The Society for Computer Simulation, P.O. Box 17900, San Diego, CA 92117. 619/277-3888.
July 27-30 Montreal, Canada

SIGGRAPH '87. Ellen Frisbie, SIGGRAPH '87, Conference Management Office, 111 E. Wacker Dr., Chicago, IL 60601. 312/644-6610.
July 27-31 Anaheim, CA

Call for Papers

129th SMPTE Technical Conference and Equipment Exhibit. Oct. 30–Nov. 4, Los Angeles, CA. Papers are sought on motion picture and TV technology. Topic headings have not been determined, but past sessions have focused on laboratory practices; film and video post-production; film and electronic production; computer applications for TV; digital applications for TV; and enhanced TV systems. Send name, address, paper title, and a 100-word abstract to Dollie Hamlin, Society of Motion Picture and Television Engineers, 595 W. Hartsdale Ave., White Plains, NY 10607. 914/761-1100.
Deadline for abstracts: June 15

1988 SCS Multiconference. Feb. 3–5, San Diego, CA. Papers are solicited in the following areas of interest: modeling and simulation on microcomputers, power plant simulation, aerospace simulation, distributed simulation, and simulation and artificial intelligence. Send an original, unpublished paper proposal of 300 words, specifying area of interest, to: Society for Computer Simulation, P.O. Box 17900, San Diego, CA, 92117. 619/277-3888.
Deadline for abstracts: June 1 ■

Greater Dayton Chapter

We are pleased to announce the formation of the newest SID chapter, the Greater Dayton Chapter, Dayton, OH. All SID members extend a hearty welcome, and wish the newest chapter the best of success.

At the March 26 meeting, the following officers were elected: Chairman, **Walter Watkins;** Vice-Chairman, **Joe Mays;** Secretary, **Lena Welch;** Assistant Secretary, **Tom Liberio;** Treasurer, **Jim Byrd;** Assistant Treasurer, **John Cunningham.** The first official meeting, at which the officers were installed, was held on April 23 at **Electronic Image Systems and Cooperative Facility,** Xenia, OH. Electronic Image Systems' president **Richard E. Holmes** spoke on "A Large Screen Color Projection System with Digital Correction."

Los Angeles Chapter

Larry Tannas of **Tannas Electronics** was the guest speaker at the March 19 Chapter meeting in Santa Ana. Attendees at the jointly-sponsored IEEE-SID meeting heard Mr. Tannas' interesting presentation "3-Dimensional Displays Have Finally Arrived." The presentation covered the stereoscope, the psychophysics of stereopsis, and applications to computer-aided design, modeling, medical analysis, and complex data analysis. An excellent presentation of 3-D images on a color monitor was provided by **Sat Narayanan** of **Tektronix, Inc.,** using the liquid-crystal stereo switch to provide a multiplexed stereoscopic display. This Tektronix development will be the subject of a future article in *Information Display.*

Mid-Atlantic Chapter

"Laser Beam Imaging" was the topic of the March 3 Mid-Atlantic Chapter meeting. The speaker was **Leo Beiser,** president and research director of **Leo Beiser Inc.** Mr. Beiser, a SID Fellow and charter member, is well known for his pioneering work in the laser field. Mr. Beiser explained and evaluated factors that determine resolution of any laser scanning system, and discussed future developments in the laser field, focusing on the development of holographic scanning techniques.

San Diego Chapter

On February 17 the San Diego Chapter met at the **Reuben H. Fleet Space Theater. John Lipscombe** presided over two Omnimax film presentations: "On the Wing," dealing with the history of flight, and "Nomads of the Deep," focusing on the humpbacked whale.

The Chapter met March 10 and heard **Richard Austin** and **Robert Ruff** of **EG&G Gamma Scientific** speak on EG&G's "CRT Automatic Convergence Measuring System." Mr. Austin discussed the three detector/filter channels that are used to quantify the spatial relationships and profiles of the three primary components of a white line. Measurements are taken simultaneously of the three detector channels, which eliminates the errors inherent in systems that measure the three primary components sequentially. This new technology will improve accuracy and time involved in convergence measuring systems.

Robert Ruff, sales manager for EG&G Gamma Scientific (left) with Chairman John Lipscombe.

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