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INFORMATION DISPLAY

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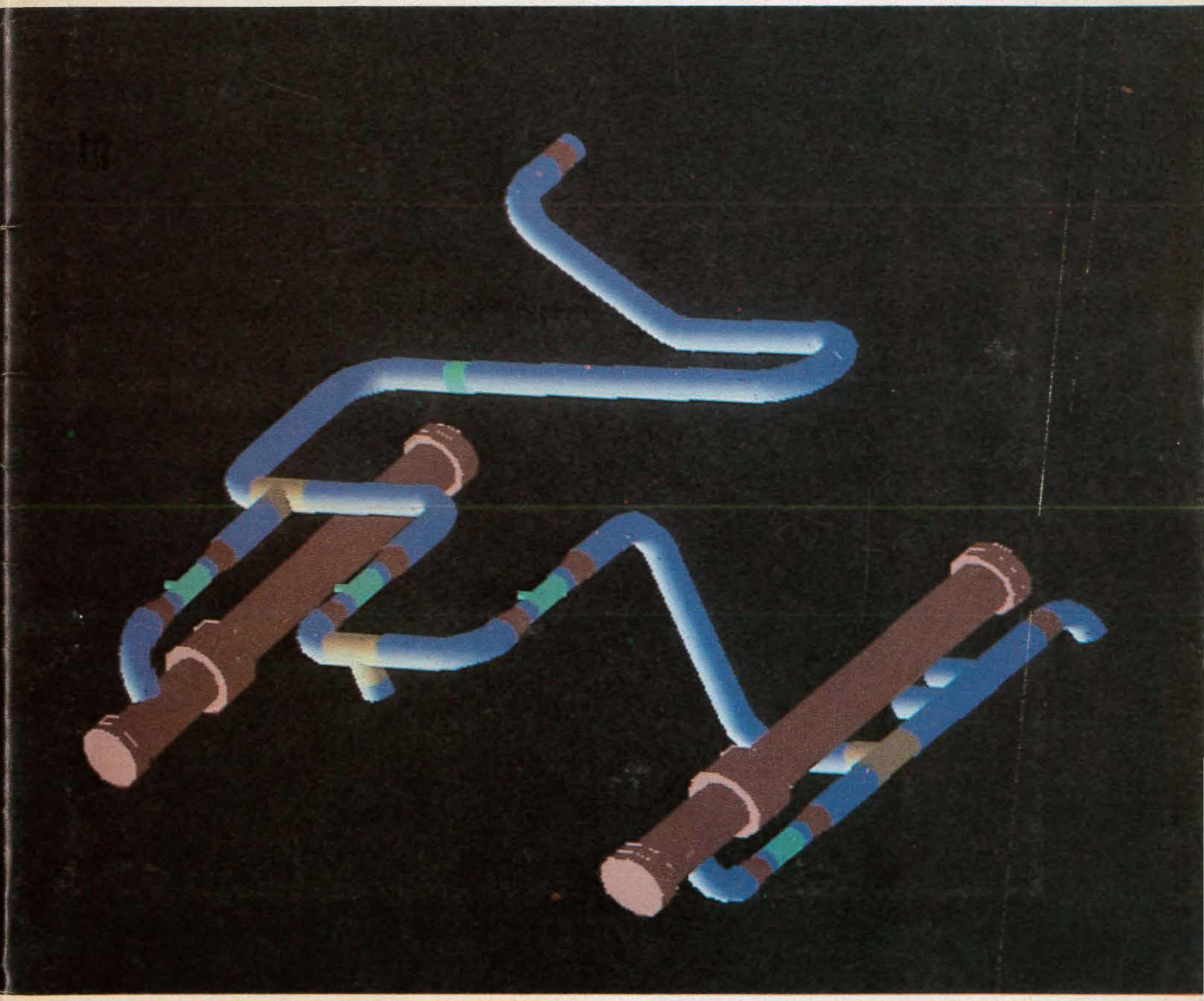

3D human factors
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Display evaluation

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INFORMATION DISPLAY

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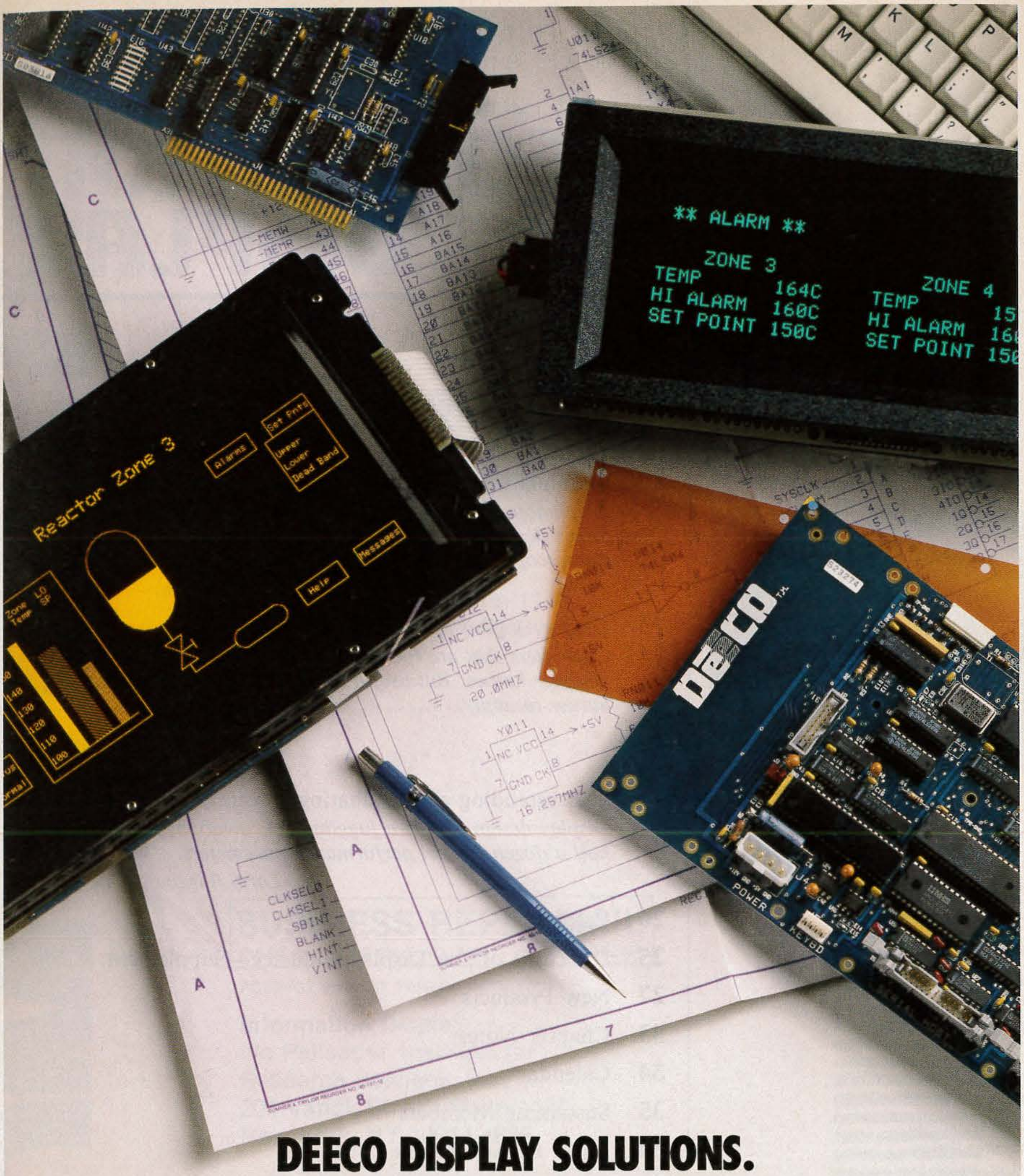
Cover: We are witnessing the birth of a new display technology—computer-generated 3D graphics that can be manipulated in real time. Stereoscopic image is from the screen of the Tektronix SGS 530. (page 10)

Next Month in Information Display

- High-performance CRT deflection amplifiers
- High-resolution monitor design
- Displaying the high seas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TEMP 164C
HI ALARM 160C
SET POINT 150C
ZONE 4
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SET POINT
Reactor Zone 3
Alarms
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Upper
Lower
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Help
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POWER

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INFORMATION DISPLAY

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editorial

The three-dimensional illusion in stereoscopic displays, the evaluation of CRT displays, a handy design aid for determining legible character sizes, and an admission of fallibility are the featured subjects in this last *Information Display* issue of 1987.

Phil Tolin, Dick Sawyer and Tom Talley, and Larry Virgin take three very different approaches to their common subject of display appearance, but their articles each provide practical information to designers and users of displays and of the graphics that appear on them.

The admission of fallibility is ours. The first annual Directory of the Display Industry that appeared in *ID's* September issue has proved popular with our readers. Because, I imagine, readers are spending so much time referring to the directory, you are quickly bringing our omissions and organizational deficiencies to light. We are making some amends for our lack of perfection in the short directory addendum that appears in this issue.

We did not expect the directory to be flawless in its premier performance, and Howard Funk's efforts have exceeded our most optimistic expectations. To attain the degree of authority and completeness we ultimately expect the directory to have, we need your continuing corrections and suggestions.

And now a brief personal note. It is a deep pleasure for me to be returning as editor of *Information Display* after an absence of seven months. I look forward to presiding over a period of substantial editorial and circulation growth, and to meeting many of you at display and computer-graphics-oriented conferences around the country. In an era that is seeing *ID's* readers engineer an exciting rapid growth in display and graphics technology, growth of the publication that covers that technology should be easy.

Please accept my wishes and those of *ID's* editorial and production staff for a joyful holiday and a happy, prosperous, and fulfilling new year.

—Kenneth I. Werner

Micro Display opens European support center

Micro Display Systems, Inc., Hastings, MN, is opening a support center in the Netherlands to service European customers. Grand opening of the center, located in the Hague, is scheduled for January 1988.

Stereolithography provides fast plastic models

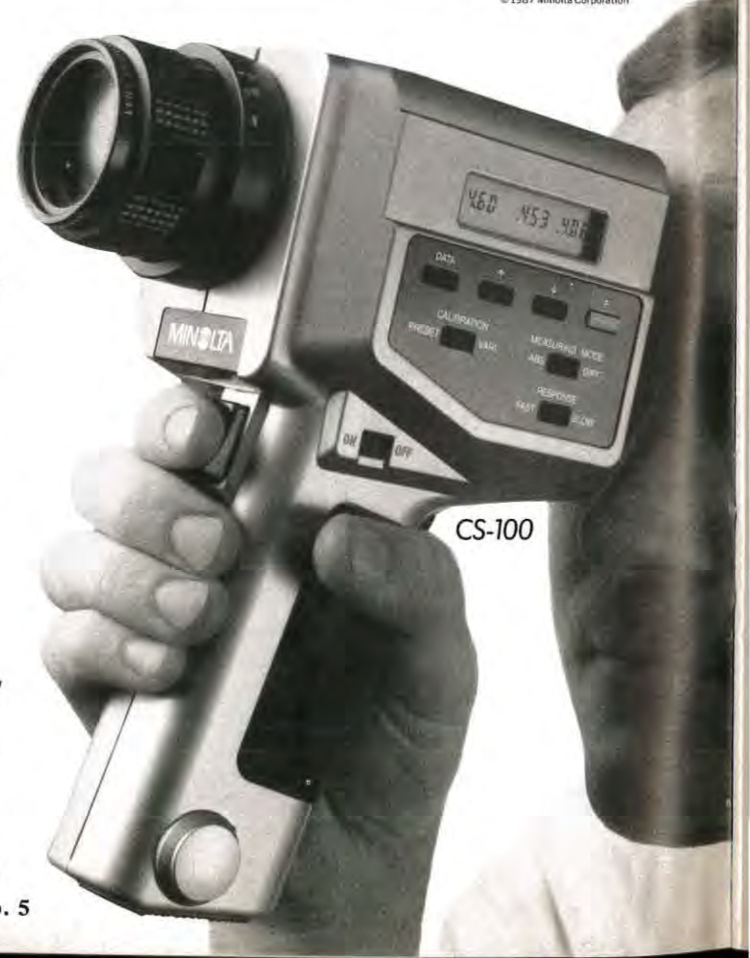
Aries Technology, Inc., Lowell, MA, and 3D Systems, Sylmar, CA, have signed a distribution agreement that allows Aries to sell 3D's stereolithography apparatus to Aries customers through Aries' direct sales channels. Stereolithography allows engineers to produce 3D plastic models from a solid-model data base within hours, eliminating the long and costly tooling methods now employed.

Stereolithography is a three-dimensional printing technology that automatically forms a complex part in plastic. A solid model is first created on the Aries desktop ConceptStation. The solid-model data base is then sectioned by software developed by Aries and 3D Systems. Successive cross-sections are then printed on photocurable materials using a computer-driven scanner and an ultraviolet laser. As each layer is printed, the part is grown to the scale specified by the operator. Larry McArthur, president of Aries, says, "Stereolithography will have a major impact on prototyping as well as on American manufacturing; we are very excited to be involved in this technological breakthrough."

For further information contact Aries Technology, Inc., 650 Suffolk St., Lowell, MA 01854. 617/453-5310.

NCR to acquire Anacomp division

NCR Corp. has signed an agreement to acquire the printer unit of Datagraphix, San Diego, CA. NCR will acquire Datagraphix' printer maintenance business, marketing rights to non-impact printers, and engineering rights to software and hardware features developed by Datagraphix. In addition, NCR will acquire an extensive inventory of spare parts and printer supplies. The printer unit will be integrated into the Customer Services Division of NCR's United States Data Processing Group. ■



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president's message

There seems to be no end to the list of potential health hazards related directly or indirectly to aspects of technology in our modern society. Quite recently a study by New York health authorities raised the possibility that weak alternating magnetic fields are linked to cancer in children.

It is always difficult to accept surprising results that appear to conflict with personal experiences or intuition. Thus when psychophysicists and some lawmakers concluded some years ago that yellow-orange-colored monitors caused less fatigue than black-and-white ones, I carried out a one-man preference test. I remain unconvinced today since I personally prefer my black-and-white screen in the office. Moreover, I know many children who experience less fatigue from watching television for eight hours a day than from washing a few dishes or making their beds.

More recently the possibility that harmful radiation emanated from CRTs was raised in Sweden; this remains a controversial subject today especially because the "radiation" cannot be easily measured and any negative consequences usually have long incubation periods and are only detectable by large-number statistics. On the other hand, it is known that electromagnetic fields can be used to promote healing in the human body, e.g., to accelerate bone growth, and the connection to undesirable cell growth is therefore not inconceivable. Conclusive studies linking radiation intensity to specific health problems, however, are not yet available.

The New York study linking alternating magnetic fields to cancer, however, strengthens the argument for further careful study. When we discussed the CRT concerns at an evening panel at the 1986 SID Symposium we found it difficult to assemble a panel of experts to discuss the facts and scientific evidence. Very often people have preconceived inflexible points of view, thus making rational discussion and open-minded studies very difficult.

Already some lawmakers are arguing that power lines must come down near urban communities and several states are passing new legislation and setting new standards. A multimillion-dollar award was made recently to a Texas school district located near power lines—but it was overturned by a higher court. Now is not the time for hasty reactionary decisions to be made, but rather for open-minded scientific investigations to focus on the facts and evidence.

By the time this issue of *Information Display* reaches you, the holiday season will be upon us. I wish you all joyful holidays and a new year filled with challenges, accomplishments, and good health.

—John A. van Raalte

letters

Compliments on the directory issue

My compliments on the September issue of *Information Display!* Its format and contents are exciting and well-presented. My compliments, also, to Howard Funk. His efforts are contributing greatly to our magazine. Keep up the good work, and I look forward to our next issue.

—Larry E. Tannas, Jr.
Tannas Electronics
Orange, California

Excellent issue. Found the product guide very useful.

—Neville Milward
Ginsbury Electronics
Kent, England

Some firms were conspicuously absent

The Industry Directory seemed to contain only advertisers or firms published in the *Proceedings* or *Digest*. A few firms were conspicuously absent. The directory should also have been easily removed for reference.

—Brian Deamlow
Magnavox Electronic Systems
Fort Wayne, Indiana

A good start but more categories needed

I would like to make some observations about the Directory of the Display Industry in the September issue. The main thrust of the directory appears to be in the direction of CRT and flat-panel displays. There are other display types in the market. In fact, in the field of liquid-crystal displays, the greatest volume of displays is in digital displays and not dot-matrix flat-panel displays. For whatever reason (lack of company response or lack of information on which companies to contact), there are a number of companies that are suppliers to the display industry that are not listed.

First off, I would recommend a general category for materials with sub-group listings of material types in the products and services section. Flat-panel materials, glass products, and optical coatings were listed but not liquid-crystal and polarizer materials, for example.

Companies that should be included in the next directory are: Glaverbel (Belgium), a major supplier of soda-lime glass; Balzers (Lichtenstein) and Donnelly Mirrors (Michigan), suppliers of transparent conductive coatings; BDH, Ltd. (England), F. Hoffmann-LaRoche (Switzerland), and E. Merck (Germany), suppliers of liquid-crystal materials; and Nitto, Sanritsu, and Arisawa (Japan), all suppliers of polarizer materials. Another company that is not a supplier but makes precision glass scribers is Villa Precision in Arizona. Villa Precision's scribers permitted a breakthrough in array and laminate array processing of liquid-crystal displays.

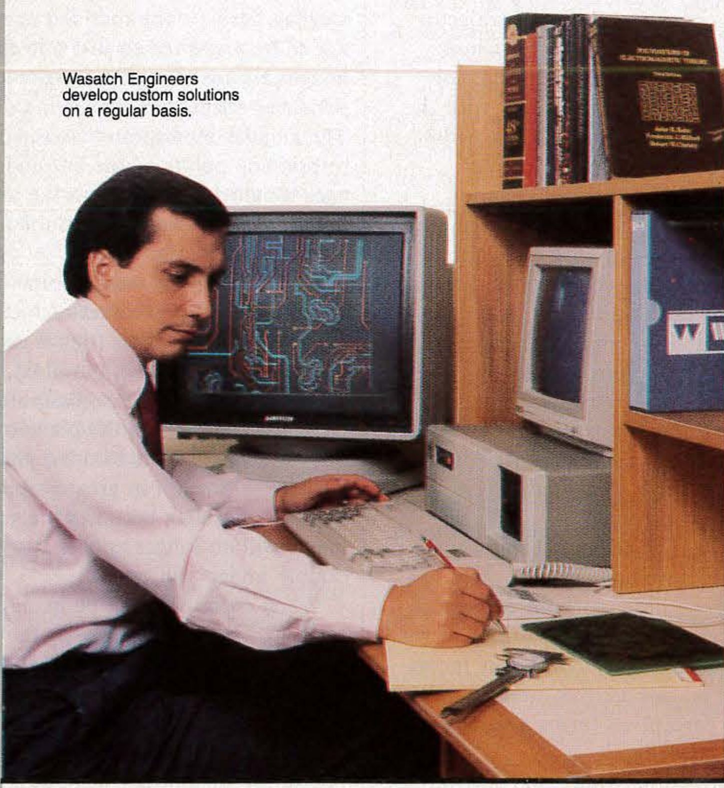
You can also include our company. We are one of the world's highest volume manufacturers of liquid-crystal displays.

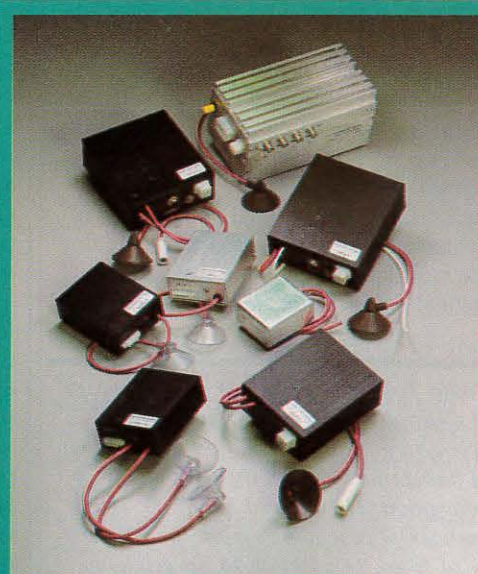
This first directory is a good start. I am sure other individuals will be writing in with advice and recommendations for improvement.

—Jerry Garies
Engineering Manager
Conic Semiconductor Ltd.
Hong Kong

Editor's Note: Most mail about the directory issue fell into one of two categories: enthusiastic praise for the directory or complaints about why this or that (or "my") company was not included. We have tried to remedy some of these omissions with the directory supplement in this issue, and we welcome names of appropriate companies to contact for next year's directory.

Although it's good to know that we're on the right track, what we need more of is thoughtful critiques such as that provided by Jerry Garies. Only input from you, the directory's users, can help make next year's directory a better document and a more useful one.





Maintaining the three-dimensional illusion

BY PHILIP TOLIN

WE ARE WITNESSING the birth of a dramatic new display technology—dynamic stereoscopic graphics—that permits real-time manipulation of computer-generated three-dimensional scenes. The Tektronix SGS 530 announced in April and displayed at SID '87 in New Orleans is one of the first examples of this new generation.

Stereoscopic imagery is not new.[1] Parlor stereoscopes for viewing static scenes were popular in the nineteenth century, and techniques similar to those that entertained the Victorians have been used in aerial reconnaissance photography for decades.

Entertainment systems for viewing dynamic scenes became popular with the 3D movie craze of the 1950s. There is currently a mild resurgence of cinematic interest, but the avionics, industrial, medical, and educational applications of dynamic stereoscopic systems are exciting the most interest. It is the developing technology for computer generation and real-time interactive manipulation of the 3D image that is new and that is creating new applications and new markets.

Philip Tolin is a professor of psychology at Central Washington University, Ellensburg, Washington, and specializes in human factors and the psychology of perception. He received his Ph.D. in experimental psychology from the University of Iowa. In addition to his academic pursuits, Dr. Tolin did precertification workload studies for Boeing on the 757 and 767 airliners, and has more recently done research for Boeing on stereo display generation. He is a member of the editorial board of the journal Human Factors.

Stereo display techniques promise to become increasingly important in applications where the perception of depth is critical and the depth cues available in conventional 2D computer graphics systems—texture gradients, perspective, interposition, relative size, and shading—are inadequate. Stereo patterns are also useful for conveying time and trajectory information in an intuitively obvious manner. The increased perceptual correspondence of display imagery with the external environment that 3D provides can result in a reduction of mental workload and an enhanced situation awareness. Similarly, stereo imagery can enhance stimulus-response compatibility and generate increased response speed and accuracy. It can improve target recognition in visual noise and can be useful in decluttering a complex display by separating display elements through differences in apparent depth. These advantages become especially important under conditions of high workload, stress, or severe time constraints.

A great deal of effort is being devoted to hardware development, but there has been relatively little work on perceptual issues associated with applications of real-time stereo display systems. But incomplete as it is, our current understanding of 3D perception forms a valuable body of knowledge.[2]

Sophisticated hardware and software developers can exploit certain display parameters to enhance the stereoscopic effect, and can avoid some of the perceptual pitfalls. Not taking advantage of the available knowledge can destroy the 3D illusion produced by even the best hardware.

The scene within the screen

If one looks directly at a stereoscopic display, the image appears to be double; the two images simulate the distinct perspective views of the left and right eyes. When seen through an appropriate viewing device—one that shows each image to be presented to just one eye—the images are fused, and the observer experiences a single image having depth. The angular separation between corresponding points of the left and right images is called *parallax*, and the amount of parallax is the critical determinant of stereoscopic depth.

If corresponding image points are separated so that the axes of the left and right eyes do not cross (this is called *positive*, or *uncrossed*, parallax), the image points will appear to be more distant from the viewer than the plane of the display screen. Within limits, greater parallax will result in greater apparent depth. If parallax becomes too great, the image will no longer appear fused, and a double image will result.

When corresponding points are separated so that the axes of the two eyes are crossed, the image is said to have *negative*, or *crossed*, parallax. Objects with negative parallax are perceived as being in front of the plane of the screen. Increases in the amount of negative parallax will, within limits of binocular fusion, result in greater apparent separation from the screen plane, and the image will appear to move nearer to the viewer. Finally, when the parallax value is zero, the image will appear to lie in the plane of the screen.

The inherent contradiction

Ordinarily, visual accommodation, or focus, and the convergence of the two eyes are coordinated. For example, as an object approaches the viewer, the focus changes accordingly and the eyes turn inward to fixate the object. With stereoscopic imagery, however, the relationship between accommodation and convergence is disrupted. For both positive and negative parallax, the viewer's eyes will converge as though the images are behind or in front of the plane of the screen, respectively, while the eyes will focus at the plane of the screen. Only in the case of zero parallax, when the image appears at the screen plane, will the usual accommodation/convergence relationship hold.

Accommodation/convergence discrepancies may result in viewer discomfort, confusion, and loss of *stereopsis*, the visual three-dimensional effect. Care should be taken to minimize these discrepancies. Toward that end, the following guidelines are suggested. First, use the smallest possible amounts of parallax so that the accommodation/convergence discrepancy will be minimized. Second, when possible, objects at the center of attention or objects requiring prolonged fixation should be placed at or near the plane of the screen (at about zero parallax).

Because stereo depth looks impressive, there may be a tendency to assume that more is better. This temptation generally should be avoided, and parallax values should be kept in the low-to-moderate range. The sense of depth can greatly be enhanced by the addition of monocular depth cues, particularly perspective. The addition of strong monocular cues to the parallax cue can make the image look especially deep.

Cue conflict

Apparent overlap of display elements can lead to conflicting depth cues when the elements are distributed among different apparent planes. For example, an image that has negative parallax appears to be in front of the screen. But if it touches the edge of the screen, it may also appear to be cut off by the surround, suggesting that it is behind the plane of the screen. This conflict will be most troublesome in cases of stationary or slowly moving images. If possible, then, the image should be composed so that objects with negative parallax do not touch the boundaries of the screen, and objects that enter or leave the screen should do so as rapidly as possible.

Similar cue conflicts can also occur among different elements of the image. When display elements are not all in the same apparent plane, the viewer should experience no ambiguity concerning which lines or surfaces lie in front of or behind others. Contradictory cues may result in discomfort, confusion, or blurring of the image.

3D or not 3D

It has been estimated that from 2 to 10% of the general population fail to experience stereopsis and that perhaps another 10% experience the effect only to a limited extent. Even among "normal" individuals there are large differences in stereoscopic vision. To complicate the matter even further, stereoacuity is not constant—it can be improved greatly with practice.

These data have several implications. First, display users should be checked for stereo blindness and deficiency. This is easily done with one of the simple stereoacuity tests that are commercially available at low cost.[3] Second, experienced observers of stereo imagery will probably perceive the display differently than inexperienced ones. Therefore, during the development phase, preliminary evaluations of candidate display formats should be conducted using inexperienced subjects rather than people routinely involved in display development. Third, because of the large differences in stereoacuity among people, comparisons of stereoscopic and planar imagery should use an experimental design that tests each subject on both types of display.

An observer's ability to discriminate *relative* depth is considerably better than his or her ability to make *absolute* judgments of depth. Under ideal conditions, an average observer can sense parallax differences as small as 1 sec of visual arc. If depth is used to encode information, as size and color often are (to show relative importance for example), then a small number of discrete depth planes should be employed. When absolute depth judgments are required, the number of discrete depth planes should be limited to, perhaps, four.

Pitfalls for display designers

- *Unequal illumination* of the left and right eye fields may cause discomfort or strain that increases over time. Another consequence of unequal illumination is a phenomenon known as the Pulfrich effect, in which a displayed object that is moving laterally will also seem to be moving in depth. The effect is easily demonstrated: suspend a weight at the end of a string and set it in motion as a pendulum. View this movement binocularly, but with one eye looking through a neutral density filter such as a sunglass lens. Although the pendulum is moving laterally across the field of view, the movement will appear to describe an ellipse. The illusion of depth is a compelling one. Further, the apparent direction of this ellipse is determined by the eye over which the filter is placed. It follows that a point-by-point comparison should be made of corresponding image points in the left and right eye fields. Ideally, illumination differences should not exceed 10%. While this is generally not a problem with CRT displays, some monitors exhibit differences near the edges of the display when operating at a 120-Hz refresh rate.
- *If the timing* of left and right images is not synchronized, the resultant image of moving objects may appear to be surrounded by a rippling effect. An object that is moving laterally may also seem to change its depth—a characteristic known as the Mach-Dvorak effect. Temporal asynchrony effects have not been reported with time-multiplexing systems, but may be a problem with space-multiplexing technologies.
- *Image width correspondence.* When a bar pattern seen by one eye is slightly wider than the pattern seen by the other eye, the fused image appears to be rotated in depth about the vertical axis because of the parallax caused by differential bar width.
- *Small vertical misalignments* of the images seen by each eye may degrade stereopsis and cause double vision and viewing discomfort. Tolerance for vertical misalignment is small—less than 5 min of visual angle.
- *Differences in the geometry* of the images presented to the two eyes may result in double vision, discomfort, fatigue, headaches, intolerance to light, tension, and motion sickness. Size differences as small as 1% can result in physical and perceptual effects, and humans are more sensitive to differences in the vertical dimension than to differences in the

horizontal dimension. Image size differences are not likely to be produced by display hardware, but may occur if the observer wears lenses greatly differing in refractive power.

- *Ghost images* may result when each eye does not see only the image intended for it. Display deficiencies are a likely cause. While ghosts do not necessarily destroy the stereoscopic effect, they may be a source of discomfort. To minimize ghost images, displays should utilize normal persistence phosphors. The color green should be used as little as possible, since ghosting is more likely even with normal persistence phosphors of that color. Other strategies for minimizing the effect are to avoid excessive contrast and keep parallax values small.
- *Size/distance relationship.* Of two objects having the same retinal size, the one that appears farther away will appear larger. As stereo depth is added to a scene, one possible consequence is that perceived image size may not be the same as actual image size. Developers can compensate for distortions in apparent size when they prepare imagery.
- *Illumination level.* Stereoacuity increases with increasing levels of illumination up to a maximum of about 3 cd/m^2. If an application requires a viewer to detect differences in depth at very low illumination levels, allowance should be made for reduced stereoacuity.
- *Retinal location.* Stereoacuity is maximum at the fovea, and rapidly decreases as the image moves toward the periphery of the retina. This should not ordinarily pose a major problem because the observer will be scanning the display. But it does suggest that software developers should not use stereo depth to draw attention to objects toward the periphery of the visual field. There, color and motion will attract attention more effectively.

Depth as a coding dimension

Designers may be able to present a great deal of information to users via the depth cue, either by using it alone or together with parameters such as color, size, and shape. But stereopsis should be used judiciously and, probably, sparingly. The wisdom of allowing coding dimensions to proliferate is questionable and, as is true with any stimulus dimension, depth can increase clutter, mental workload, and confusion if used inappropriately.

Other major hardware and software issues also suggest the need for careful application. Display and graphics-generator-resolution standards, monitor screen size, and image refresh rate are hardware characteristics that can affect stereo-display capability. The software routines required for dual-image generation are time consuming, and if scene content is complex, generating acceptable real-time interactive displays may not be practical without simplifying the image.

Three-dimensional interactive displays are such a striking development that developers and users may be tempted to use the new technology inappropriately. The solution to ever-increasing operator information loads may more appropriately lie in display integration and simplification. Stereo imagery should be introduced only where it seems to simplify the operator's task, and its utility should then be evaluated empirically.

Notes

[1]"True Three-dimensional CRT-based Displays," by Larry Hodges and David F. McAllister, a survey of viable 3D display techniques, appeared in the May 1987 issue of *Information Display.*

[2]A good undergraduate-level textbook is *Perception* by Robert Sekuler and Randolph Blake (Alfred A. Knopf, 1985). An excellent and entertaining book on stereoscopy is Lenny Lipton's *Foundations of the Stereoscopic Cinema* (Van Nostrand Reinhold, 1982), which contains a great deal on stereoscopic perception and hardware as well as historical anecdotes.

[3]Two of the most popular stereo vision acuity tests on the market are the Randot Stereotest and the Verhoef Stereopter. Both are available from Western Optical Company, 1200 Mercer St., Seattle, WA 98109, and other ophthalmic supply houses.

Acknowledgments

This report was partially supported by faculty research funds of Central Washington University. ■

Display legibility guidelines: a design aid

BY DICK SAWYER AND WALTER T. TALLEY

IT IS SO BASIC a consideration in designing legible information displays, it is often overlooked. But lack of character legibility can betray even the best display design in which such concerns as contrast modulation, resolution, and gray-scale levels have been given full and proper attention.

Most designers are familiar with the various ratios that typify easily read characters. They are aware, for example, that for dark characters on a light background common width-to-height ratios are 1:1 to 3:5 for symbols and 1:6 to 1:8 for individual strokes. On the other hand, all of these ratios stem from the most basic of measurements, character height, which is critical for legibility and readability from different viewing distances and under varying viewing conditions.

The issue of symbol height and legibility would seem straightforward. Substantial research findings exist in this area, and these provide an empirical basis for human factors guidelines.[1] Many of these guidelines, however, do not lend themselves to accurate and efficient application because they include only partial data. In fact, further derivations may be necessary to apply them in a specific situation. Another deficiency is that many of these guidelines, developed by psychologists, use terminology unfamiliar to display designers. Finally, the information is often presented in essay form, which has limited appeal to designers, who generally find tabular data more useful.

***Dick Sawyer** is a senior staff scientist at the Alexandria, Virginia, office of the Essex Corporation. His current focus is human factors in the electronic delivery of maintenance information. He received his Ph.D. in experimental psychology from the University of New Mexico. **Walter T. Talley** is a program manager for the Essex Corporation human engineering department in Alexandria. He received his M.S. in applied psychology in 1977 from the Stevens Institute of Technology. He is currently providing technical and management direction for defense C2 projects, especially with respect to CRT color applications.*

Useful data in useful form

When developing guidelines for designers, the human factors practitioner often fails to consider both the design problem and the process. Even the straightforward design of labels, for example, demands that the designer balance the often conflicting requirements for symbol size, viewing distance, amount of information presented, and space available for presentation. Computer display design usually adds additional cost and design constraints imposed by the available hardware and software alternatives. In the case of the highly complex C^3I systems, the human factors challenge can become formidable, and designers may have to defend or change their recommendations at a moment's notice.

A tool for making such quick precise tradeoffs is needed, but available guidelines often consist of only a recommended visual arc subtended on the retina or a few desired character heights at specified viewing distances. This is informative but not sufficient for rapid decision making. The greater danger is not simply that of inaccurate extrapolation from limited data. Since many designers have little basic knowledge of human factors to begin with, minimal information may trivialize the issue. Add to this the effort necessary to expand the data for tradeoff analyses, and the designer's response may be an inadequate regard for human factors that compromises the effectiveness of the final system.

Composite case study

Designer Mike Abrams is responsible for all informational aspects of console operation: CRTs, LEDs, legend buttons, and panel labels. Although viewing distances normally will be short, a lot of information must be crowded into very little space. In addition, substantial glare and contrast variability are anticipated. Mike's instructions are to minimize costs and to go with minimal, rather than optimal, symbol sizes. Also, there are minimum information requirements per CRT screen (24 lines × 80 spaces), and there may not be the luxury of increasing display size to accommodate increased character height. Finally, design recommendations will contribute to decisions about viewing distances. Thus, Mike must be prepared to answer rapid-fire questions about the effect of alternative viewing distances upon legibility and, conversely, the constraints placed upon viewing distance by any tentative symbol size. If larger characters are proposed, a larger screen will be needed, and Mike will probably be asked both to defend his recommendations and to respond to other unanticipated questions—for example, What are the minimum character heights at a 0.5-m viewing distance? This is not an unusual case. Designers often work with worst case, minimal legibility situations, and need readily available, clear, comprehensive, and detailed information for their recommendations to retain credibility at design review meetings.

A guideline to guidelines

Human factors guidelines for workstation symbol legibility are often in the following form. (These examples are hypothetical.)

Example 1: Recommended symbol heights are from 0.20 to 0.40 cm, respectively, for viewing distances of from 45 to 90 cm.

Example 2: Symbols should subtend the retina at 15 min of visual arc (VA). The visual arc formula is as follows: $VA = (57.3)(60)h/d$ (h is the symbol height and d is the viewing distance).

The first example gives the designer no guidance about *how* to measure symbol height. Should upper- or lower-case letters be used as the standard? If lower case, should they be measured with or without ascenders and descenders? Unfortunately, this guideline assumes the "all-caps and smallest character" conventions derived from label design. Second, the measurements are in metric units only. Despite the International System of Units (SI), many American designers still use the English system. Third, is the "recommended" height the *only* reasonable choice? The recommendation provides no flexibility for making informed tradeoffs. Fourth, what does the designer do if asked about heights or distances not coinciding with those shown? There is not enough information to try out different combinations of height, distance, and visual arc without making a large number of calculations.

In the second example (recommended visual arc), the means of developing a recommended symbol height for any viewing distance are provided; that is, given the time and initiative, a designer could develop the data the guidelines should include. But a proper standard for measuring symbol height is not given, and, as in the first example, a single recommended value restricts flexibility.

Solving the problem

The designer's problem can best be addressed by a more complete guideline that includes the following information:

1. values for symbol size by viewing distance (as determined by recommended visual arc);
2. dimensions in both SI and English units;
3. an adequate range of values; and
4. conventions for symbol measurement.

Table 1 presents data meeting all criteria except (4), which is discussed later in the text.

Using the table, designers can select any combination of symbol height, viewing distance, and visual arc (within the defined limits), and can use either English or metric measurements.

Using the table

Most tools come with instructions and background information. Here are some considerations for using the table.

1. Because of differences between characters, height should be geared to the smallest letters, not to capitals. Lower-case letters should be measured by *x height*, excluding ascenders and descenders [Fig. 1].

2. For graphics applications, it is important not to confuse point size, as used in typography, with character or symbol height. Type is measured in points (1 pt. = 0.0138 in.) from top to bottom of the metal slug that contains the type. The height of the alphabet, from the tops of the ascenders to the bottoms of the descenders, is the point size. Upper-case letters are less than full point size, and lower-case letters are even smaller. Point size is not even a reliable guide to type size, since typefaces vary widely in design and in the apparent size of the letters [Fig. 1].

3. Any of the three values in the table (height, distance, or visual arc) can be determined by the following equation, given the other two values and assuming a visual arc $\leq$ 60 min:

$$\text{Visual arc (VA)} = (57.3)(60)h/d = 3438h/d,$$

where h is the vertical character height and d is the viewing distance.

4. Always measure characters directly.

The formula given above for visual arc is the general form and we recommend it. There are others in the literature that apply to specific cases or are more difficult to use. The graphics issue is raised to warn against selecting a character or symbol set using a point size to match a specified height only to find that the characters are undersized. Finally, implicit in the statements above is the need to measure characters directly and to account for the height of the smallest character.

Translating character height into raster dimensions

The translation of desired character height into hardware and software specifications requires some deliberation. Character height drives stroke (line) width, which in turn drives the number of pixels representing that dimension (once the display surface specifications have been established). For example, if the designer determines that the appropriate character

Fig. 1: Point size is a poor indication of character size, as these three samples of 60-pt. type illustrate (left to right: Garamond, Century Expanded, and News Gothic). When specifying character size for a display, it is best to measure characters directly using the smallest character. For upper- and lower-case alphabets, measure the x height, the height of a lower-case letter not including ascenders or descenders. (Illustration is reprinted with permission of R. R. Bowker Company from Editing by Design *by Jan V. White. Copyright © 1982 by Jan V. White.)*

Table 1: Application Aid— Recommended Character Heights and Viewing Distances for a Given Visual Angle

Viewing Distance in inches (centimeters) — Visual Angle in minutes of arc

Character Height in. (cm)	18.0 (45.7)	20.0 (50.8)	22.0 (55.9)	24.0 (61.0)	26.0 (66.0)	28.0 (71.1)	30.0 (76.2)	32.0 (81.3)	34.0 (86.4)	36.0 (91.4)
0.04 (0.10)	7.6	6.9	6.3	5.7	5.3	4.9	4.6	4.3	4.0	3.8
0.06 (0.15)	**11.5**	**10.3**	**9.4**	8.6	7.9	7.4	6.9	6.4	6.1	5.7
0.08 (0.20)	**15.3**	**13.8**	**12.5**	**11.5**	**10.6**	9.8	9.2	8.6	8.1	7.6
0.10 (0.25)	**19.1**	**17.2**	**15.6**	**14.3**	**13.2**	**12.3**	**11.5**	**10.7**	**10.1**	9.6
0.12 (0.30)	**22.9**	**20.6**	**18.8**	**17.2**	**15.9**	**14.7**	**13.8**	**12.9**	**12.1**	**11.5**
0.14 (0.36)	**26.7**	**24.1**	**21.9**	**20.1**	**18.5**	**17.2**	**16.0**	**15.0**	**14.2**	**13.4**
0.16 (0.41)	30.6	**27.5**	**25.0**	**22.9**	**21.2**	**19.6**	**18.3**	**17.2**	**16.2**	**15.3**
0.18 (0.46)	34.4	30.9	**28.1**	**25.8**	**23.8**	**22.1**	**20.6**	**19.3**	**18.2**	**17.2**
0.20 (0.51)	38.2	34.4	31.3	**28.7**	**26.4**	**24.6**	**22.9**	**21.5**	**20.2**	**19.1**
0.22 (0.56)	42.0	37.8	34.4	31.5	**29.1**	**27.0**	**25.2**	**23.6**	**22.2**	**21.0**
0.24 (0.61)	45.8	41.3	37.5	34.4	31.7	**29.5**	**27.5**	**25.8**	**24.3**	**22.9**
0.26 (0.66)	49.7	44.7	40.6	37.2	34.4	31.9	**29.8**	**27.9**	**26.3**	**24.8**
0.28 (0.71)	53.5	48.1	43.8	40.1	37.0	34.4	32.1	30.1	**28.3**	**26.7**
0.30 (0.76)	57.3	51.6	46.9	43.0	39.7	36.8	34.4	32.2	30.3	**28.7**
0.32 (0.81)	61.1	55.0	50.0	45.8	42.3	39.3	36.7	34.4	32.4	30.6

Underlined area is the preferred range of visual angle.
Tinted area is the minimum recommended range.

height is 0.10938 in., the recommended stroke-width to character-height ratios of 1:6 to 1:8 would yield widths between 0.01823 and 0.01370 in. Also assuming a minimum attainable stroke width (given pixel dimensions) of 0.0088 in., a stroke width of 0.01760 in. (2 × 0.0088) becomes the obvious choice since it closely approximates the 0.01823 value for a 1:6 stroke-width to character-height ratio.

It often happens, however, that multiples of minimum stroke width will yield values too wide or narrow, outside the range bounded by the 1:6 to 1:8 ratios. In such cases the designer should select the value closest to one or the other of the widths coinciding with these ratios. In cases where the width is smaller than that dictated by the larger ratio (1:8), the resulting character height should be checked against the legibility guidelines to determine whether or not it is within the recommended range. Finally, the designer may want to consider using characters made of odd numbers of pixels both vertically and horizontally.

Character size in context

Information presented as in Table 1 offers the designer flexibility and immediate answers. When values for two of three dimensions (character height, visual angle, and viewing distance) are selected, the appropriate third value is then established without computations or guesswork. Although legibility problems are often associated with video displays, character size is an even more widespread problem in the design of labeling and printed hard copy, as a quick survey of consumer product labeling reveals. The user here is normally the general public, a population varying greatly in visual acuity. Since there exists little standardization of print size in signage, product labeling, and documentation, people with marginal vision often cannot read critical information (e.g., warnings) even under good viewing conditions. Environmental conditions frequently reduce legibility further (e.g., instructions on the lower rear section of a gas heater located in a poorly lighted basement). Acute viewing angle and poor lighting together can make the reading of even optimally sized characters difficult and the reading of minimally sized characters virtually impossible. Thus, it is apparent that clear and detailed legibility data are needed even for seemingly mundane situations.

The integration of legibility data with other kinds of information can extend its applicability to a variety of design situations. For example, as shown in Fig. 2, increased vertical viewing angles in large-screen displays produce smaller visual arcs. Calculation of symbol top and bottom viewing angles allows for simple determination of visual arc.[2]

Finally, the presentation of complete data can be thought provoking beyond the context of a specific design application. The data in Table 1, for example, might lead some readers to investigate the implicit linear relationship [Fig. 3] between symbol height and viewing distance, especially for longer distances where they have not been fully tested for electronic displays. Likewise, the data might serve as a baseline for testing predictions about the effect of environmental factors upon legibility.[3]

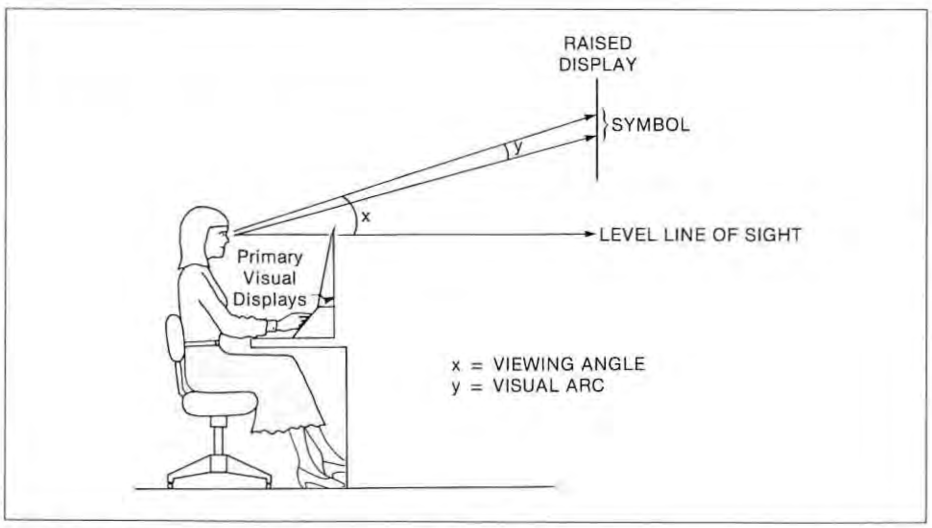


Fig. 2: As viewing angle (x) increases, visual arc (y) decreases for symbols of a fixed size. The effect of viewing angle upon visual arc can easily be calculated.

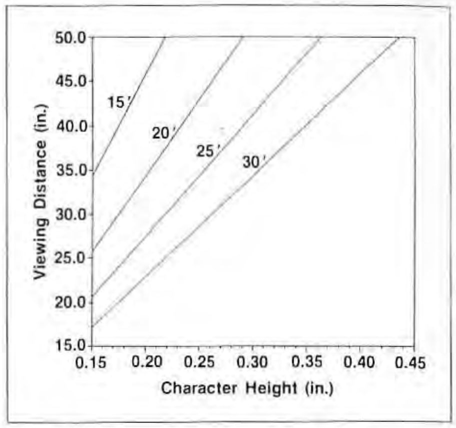


Fig. 3: Character heights and viewing distances for five visual angles.

Other kinds of angular data can also be presented in the same manner as that in Table 1. The authors have found that angular data presented in a tabular format is an effective way of showing designers where to place displays to minimize vertical and horizontal viewing angles for console operators.

In general, presenting human factors data comprehensively will both facilitate its effective use by designers and serve as a stimulus for innovative ideas and approaches. Because they believe this so strongly, the authors are making available complimentary copies of more extensive versions of Table 1 to interested readers.[4]

Notes

[1]S.L. Smith, "Letter Size Legibility." *Human Factors,* Vol. 21, No. 6 (1979).

[2]D. Sawyer, R. Pain and C. Gal, "Long Beach-Los Angeles Rail Transit Project Human Factors Guidelines." Prepared for Southern California Rail Consultants by Essex Corp. in association with Macro Corp. (sponsored by the Los Angeles County Transportation Commission).

[3]E.J. McCormick and M.S. Sanders, *Human Factors in Engineering and Design* (McGraw-Hill, New York, 1976), pp. 91-92.

[4]Complimentary copies of more comprehensive legibility tables, as well as reprints, may be ordered by writing to Walter T. Talley, The Essex Corporation, 333 N. Fairfax St., Alexandria, VA 22314.

Acknowledgements

The authors would like to thank Rick Pain for his encouragement and insightful comments. ■

Understanding and evaluating a computer graphics display

BY LARRY VIRGIN

THE DISPLAY HEAD is the key interface for computer graphics. Therefore, when designing a display, or procuring one either for integration into a system or for end use, one would like to make the best possible technical choices. Unfortunately, but not suprisingly, those choices depend on several performance tradeoffs.

Six performance parameters that are critical to the display user are: addressability, resolution, convergence, viewability, picture stability, and power consumption. These parameters, and their importance, apply to any kind of display, but I will focus on CRTs because they are the highest quality and most commonly used graphics displays today.

A common mistake

Addressability and resolution are two parameters that are often confused and incorrectly defined. Resolution is a function of the CRT's design, while addressability is primarily determined by a particular display's electronic driving circuitry [Fig. 1].

Resolution is a measure of the trace width or spot size of the electron beam on the CRT's phosphor coating. It is usually quantified by the number of just-merged lines displayed per inch or centimeter. Addressability, on the other hand, is an indicator of the minimum line-to-line or pixel-to-pixel spacing of a display. If resolution is less than addressability—that is, if spot size is greater than the line-to-line spacing—the lines will overlap. Resolution greater than addressability—spot size less than line-to-line spacing—results in individual pixels and lines being visible. Equal resolution and addressability yield a uniform display with no visible line structure.

The interaction between these two parameters causes some interesting effects [Fig. 2]. Resolution greater than or equal to addressability causes the often seen "jaggies," where a diagonal line is jagged instead of smooth. There is another less appreciated effect. Increasing addressability without improving resolution causes the display's brightness to increase when adjacent traces begin to overlap [Fig. 3]. One negative effect of this overscan is that filled areas are brighter than lines which, in turn, are brighter than single pixels. At a resolution-to-addressability ratio of 0.5,

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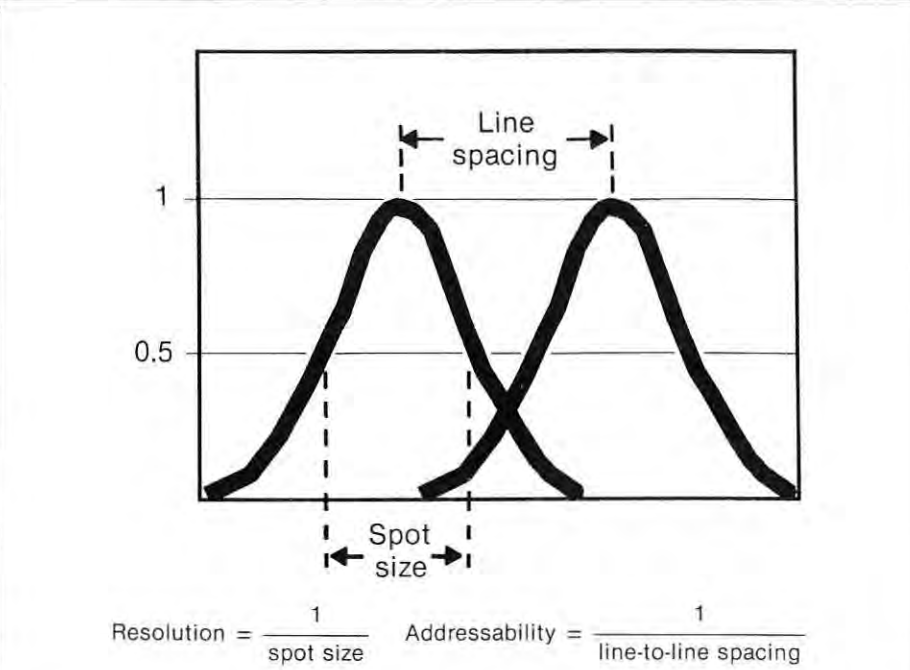

Fig. 1: Resolution and addressability are often confused. Resolution is a measure of the spot size produced by a CRT's electron beam. Addressability is the minimum line-to-line spacing in a display.

a line is twice as bright as a pixel and a filled area is twice as bright as a line.

Failing to converge

Ideally, the three electron beams of a color display should strike the same area on the CRT's phosphor layer. When this occurs, a line that is supposed to be made up of appropriate amounts of each of the three primary colors and appear, for example, uniformly white, will indeed be white, and the beams are said to be converged.

But misconvergence to some degree is quite common [Fig. 4]. A total misconvergence of two linewidths causes supposedly white alphanumeric characters to be displayed as three parallel bands of primary colors. The characters would be unreadable. Misconvergence of one linewidth results in four parallel color bands where a white line is intended, but the bands are only half a linewidth wide. The misconvergence is less, but alphanumerics would still be hard to read.

A total misconvergence of half a linewidth does yield a center portion of the line that is actually white, as desired, but only for about half a linewidth. Alphanumerics would be readable.

The view must please

How easy it is for users to view a display is a crucial consideration, but display viewability is not a simple parameter. Viewability is composed of three major factors—brightness, contrast ratio, and minimization of glare from the CRT's front surface.

Brightness is a function of the resolution-to-addressability ratio (see above), video rise and fall times, and video dynamic range. Rise and fall times become a factor when they are greater than one half of the pixel time—time allocated to write a single picture element—because vertical lines and single pixels will not have a chance to reach the full intended brightness. They will therefore be noticeably dimmer than horizontal lines.

Video drive affects viewability in two ways. If the video stage offers insufficient dynamic range, the display will not generate adequate brightness. If, on the other hand, excessive drive is available and used, the resulting high beam current can cause localized heating of the shadow mask. This can result in doming of the shadow mask and a consequent loss of color purity. Overdriving can also shorten cathode and CRT life.

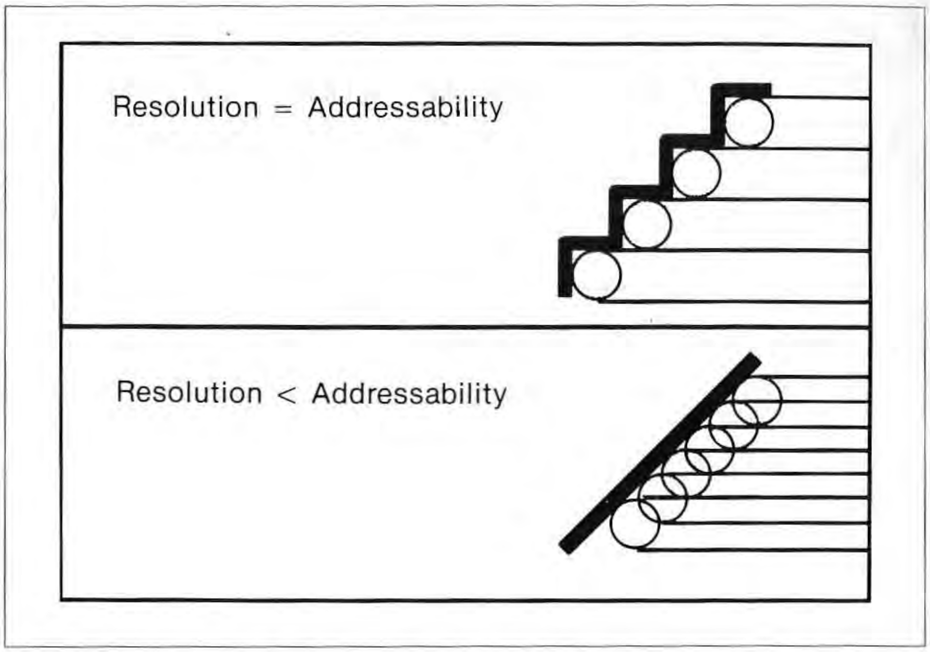

Fig. 2: Resolution equal to or greater than addressability contributes to the infamous "jaggies," which smooth out when resolution is less than addressability.

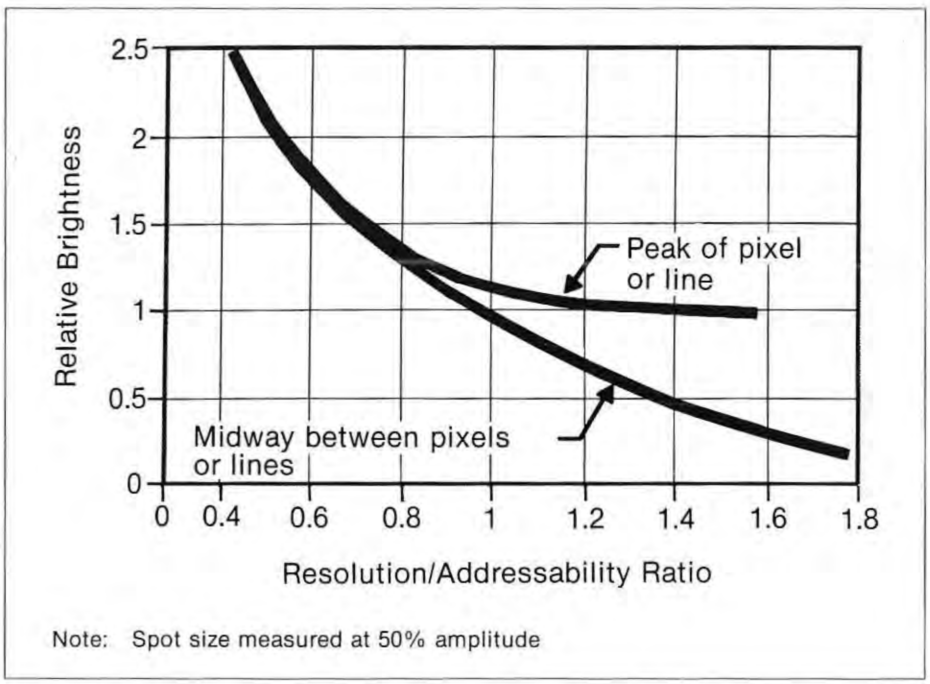

Fig. 3: When resolution is less than addressability, the resulting overscanning increases the brightness of the display, but affects single pixels, lines, and filled areas by widely differing amounts (see text).

Light—transmitted and reflected

The second factor in viewability is contrast ratio, the brightness ratio between a region of the display with information displayed and a region without information displayed. The following equation for contrast ratio (CR) is more complicated than many people would at first suspect:

$$CR = \frac{(B \times T) + (A \times T^2 \times R)}{(A \times T^2 \times R)},$$

where B is the brightness of the display, T is the optical transmission of the display's contrast-enhancement filter in fractional percent ($0 \leq T \leq 1$), A is the ambient illumination, and R is the reflectivity of the

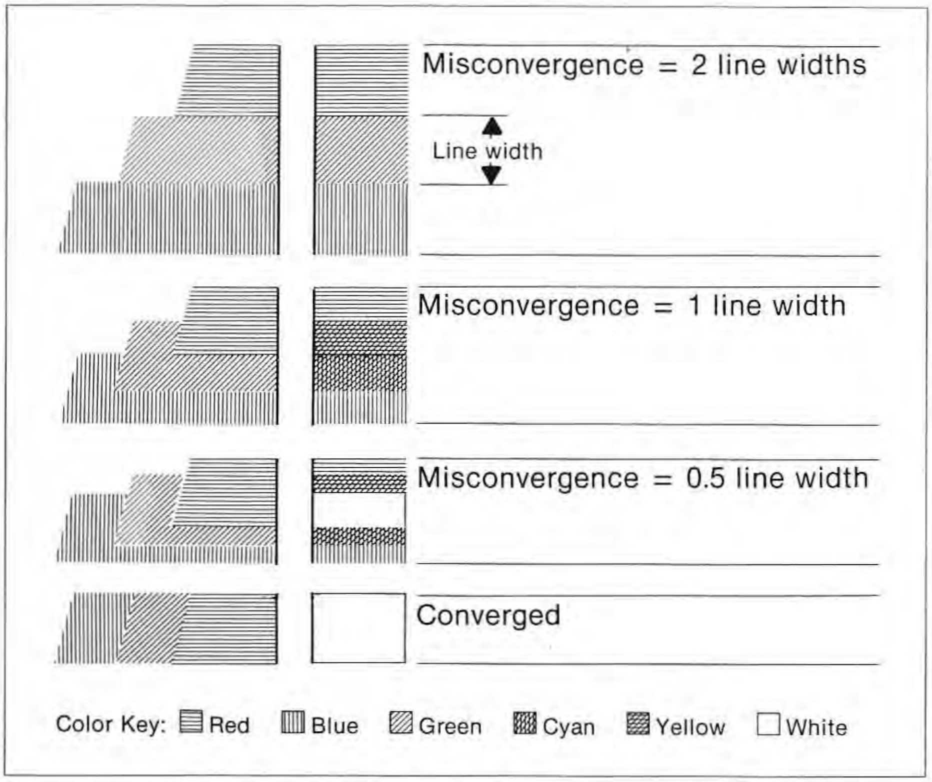

Fig. 4: Misconvergence of a color display's three electron beams can cause a supposedly white line to appear as parallel colored bands.

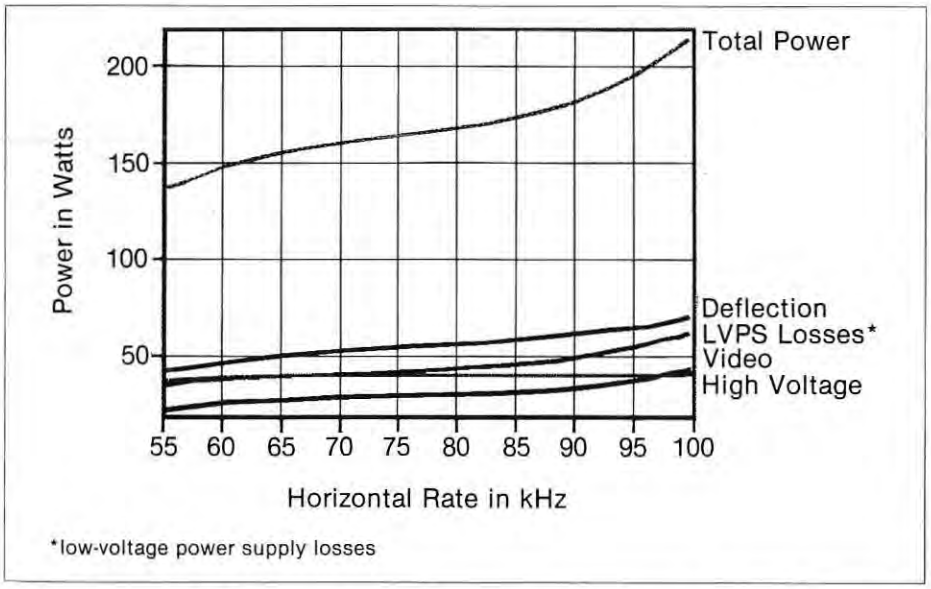

Fig. 5: Increases in horizontal scan rate require increased power to the display, and the current trend to higher addressability requires increasing scan rates.

faceplate in fractional percent ($0 \leq R \leq 1$).

If transmission is reduced and all other parameters remain fixed, the contrast ratio will increase. Transmission reduction is frequently implemented by placing a contrast-enhancement filter in front of the CRT faceplate. Such filters normally have transmissions ranging from 50 to 80%.

A major problem in display viewability is glare—reflections from the CRT's front surface. Glare can be reduced by depositing an anti-glare coating on the face of the CRT (or the contrast-enhancement filter), or by etching the front surface. Front-surface anti-glare coatings are effective but expensive. Etching is relatively inexpensive but it reduces the perceived sharpness of displayed lines.

Stability is a virtue

Even when a display is "viewable," there are separate parameters that affect the readability and pleasantness of the image. Among these is picture stability.

An unstable display delivers an image of reduced width in regions of the screen containing high information density, though the image is of normal width where the information density is low. The culprit is poor regulation of the high voltage with changes in average beam current. Displays of good quality have well-regulated high-voltage supplies.

Addressability burns power

Displays are tending toward higher power consumption, and are now reaching power levels that may require forced air cooling. Educated users will consider whether the fan noise and heat from such displays are likely to be a problem in their environments.

But the increased power can buy something of value: addressability. The greater the addressability of a CRT system, usually measured in number of horizontal lines, the higher the scan rate required. A 1000-line CRT system requires a horizontal scan rate of 64 kHz, which typically results in a power consumption of about 150 W [Fig. 5]. A 1500-line system, which runs at 93 kHz, would be pushing 200 W (and might well require forced-air cooling of key components).

Recommendations

In designing or selecting a graphics or high-density information display, I advise the following:

- *The addressability/resolution ratio should be less than 2* to avoid variations in feature brightness. But the ratio should be greater than 1 to avoid visible separation of adjacent lines or pixels.
- *Misconvergence should be less than 0.5 linewidth* for good full-color rendition of lines and alphanumeric characters.
- *The display should offer good viewability:* high brightness (at least 45 cd/m^2); good contrast (a CR of 3:1 or higher), and subjectively low front surface glare.
- *The display's viewing area should not change size* significantly with information density. The recommended change is less than 0.5% of the picture width for general applications and less than 0.25% of picture width for some critical ones. ■

Compiled by HOWARD L. FUNK
IBM CORP.

U.S. Pat. No. 4,683,481; Issued 7/28/87

Thermal Ink-Jet Common-Slotted Ink-Feed Printhead

Inventor: SAMUEL A. JOHNSON
Assigned to: HEWLETT-PACKARD CO.

A thin-film-resistor substrate for a thermal ink-jet printhead is described having an elongated ink-feed slot for supplying ink to a plurality of heater resistors on the substrate. Ink flows from this slot vertically through the substrate and then laterally along predetermined ink flow paths in an orifice plate and barrier layer members to ink reservoirs above the heater resistors. In this manner ink-flow pressure drops to all of the reservoirs are equal and thereby enhance ink pressure control for all of the reserviors.

U.S. Pat. No. 4,683,477; Issued 7/28/87

Ink-Jet Printhead

Inventors: HILARION BRAUN, FLETCHER BRAY
Assigned to: EASTMAN KODAK CO.

An ink-jet printhead is described having an elongated rectangular printhead body that is vibrated at its resonant frequency to stimulate formation of ink drops, is provided with a rigid ink supply tube connected to the printhead body at a nodal point, and is mounted by the rigid supply tube.

U.S. Pat. No. 4,682,881; Issued 7/28/87

Apparatus for Producing an Electrophotographic Print

Inventors: YUKIO HATABE, TOORU HORIKAWA, SHOJI KOMATSUBARA, HAJIME MURAKAMI, SADAO MURASAWA
Assigned to: DAINIPPON SCREEN SEIZO K. K., ISHIHARA SANGYO KAISHA LTD.

An apparatus is described for producing an electrophotographic print on a photosensitive receptor that is movable through a plurality of predetermined stations so as to produce an electrostatic latent image on the photosensitive receptor. The apparatus includes a rotary drum having a peripheral surface which defines an image-forming section and a non-image-forming section; the photosensitive sheet is placed on the image forming section of the drum surface. A developing unit has at least one developing section for supplying a developer to the photosensitive sheet on the drum, thereby making the electrostatic latent image visible, and a device for collecting the used developer from the photosensitive sheet, the collecting device being provided axially of the drum in the non-image forming section of the peripheral surface.

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U.S. Pat. No. 4,693,562; Issued 9/15/87

Liquid-Crystal Display Device

Inventors: SHINJI HASEGAWA, YASUHIKO KANDO, TAMIHITO NAKAGOMI
Assigned to: HITACHI LTD.

An LCD device is described wherein a nematic liquid cyrstal having a positive dielectric anisotropy and added with a chiral material is sealed between a pair of upper and lower substrates so as to constitute a helical structure twisted within a range between 96° and 108° along a direction of thickness thereof. Absorption axes of a pair of polarizing plates disposed on the upper and lower substrates constitute an angle between 63° and 73°, and a product $\Delta N \times D$ of a thickness D (μm) and an optical anisotropy ΔN of a liquid-crystal layer falls within a range of from 0.69 to 0.79 μm.

U.S. Pat. No. 4,684,936; Issued 8/4/87

Displays Having Different Resolutions for Alphanumeric and Graphics Data

Inventors: MARK W. BROWN, ROBERT E. DUBKE
Assigned to: IBM CORP.

A display terminal presents alphanumeric and graphic data at different resolutions simultaneously. The durations of the individual alphanumeric and graphic dots have a fixed but nonintegral ratio to each other, and are mixed together asynchronously to form a combined video signal to a CRT.

U.S. Pat. No. 4,685,095; Issued 8/4/87

Optical Storage and Retrieval Device

Inventors: GARY S. ANDERSON, PAUL CARY, ARTHUR A. ROTH, MICHAEL RUDY
Assigned to: FILENET CORP.

A system is described for storing and retrieving cartridges, a plurality of which are placed in plural slots of diverse location and orientation. A rotatable carriage contains a first and second gripping mechanism, either of which extends to engage and slidably retract a cartridge from a first storage slot into the carriage. The carriage can rotate the cartridge to the orientation of a second slot. A vertical and horizontal transport mechanism moves the carriage to the second slot whereupon the position and orientation of the carriage with respect to the second slot is verified. The gripping mechanism then retractably extends and releases the cartridge into the second slot, whereupon the gripping mechanism retracts into the carriage. The use of a first and second gripping mechanism allows expedited manipulation and transportation of the cartridges. Sensors verify the alignment of the carriage with respect to the various slots.

U.S. Pat. No. 4,684,206; Issued 8/4/87

Light Waveguide with a Submicron Aperture, Method for Manufacturing the Waveguide, and Application of the Waveguide in an Optical Memory

Inventors: JOHANNES G. BEDNORZ, WINFRIED DENK, MARTIN LANZ, WOLFGANG D. POHL
Assigned to: IBM CORP.

A light waveguide is described consisting of an optically transparent body cut at one end to a sharp tip and polished optically flat at the other end. A metallization layer on its surface is thick enough to be opaque. By pressing the waveguide against a rigid plate the metallization is plastically deformed so as to expose a tiny aperture at the tip of the body through which light can pass. By carefully controlling the deformation of the metallization the diameter of the aperture can be kept between 10 and 500 nm. The waveguide can be incorporated into a semiconductor laser of a read/write head used in an optical storage device.

U.S. Pat. No. 4,686,520; Issued 8/11/87

Digital Color Encoder

Inventor: SHIGEMITSU YAMAOKA
Assigned to: NIPPON GAKKI SEIZO K. K.

A digital color encoder for producing a color TV signal comprised of primary color image signal sources, a sampling signal generator, coefficient memories, multipliers and an adder is described. The primary color image signal sources provide digitized color image signals of red, green, and blue. The sampling signal generator generates a sampling clock having a frequency three times as high as that of the chrominence subcarrier and provides three phase sampling signals for 0°, 120°, and 240° having a frequency the same as that of the chrominence subcarrier. The coefficient memories provide coefficients for 0°, 120°, and 240° for the respective colors of red, green, and blue according to the formula of NTSC color picture signals. The respective color image signals are sampled at the sampling clock frequency and respectively multiplied with the respective coefficients in the multipliers, and then added together in the adder. This composite color video signal is synthesized without the use of ordinary subcarrier modulators for B-Y and R-Y.

U.S. Pat. No. 4,684,956; Issued 8/4/87

Method for Applying a Hot Melt Ink to a Substrate

Inventor: JEFFREY M. BALL
Assigned to: WILLETT INTERNATIONAL LTD.

The present invention provides a process for applying a thermoplastic image-forming composition as a series of discrete droplets from a non-contact ink-jet printing apparatus to form separate drops on a substrate moving relative to the apparatus, characterized in that the molten composition is thermally stable at the temperature of application and is applied at a temperature in excess of 100°C. The invention can be used to apply the molten composition to a variety of substrates using on-demand or continuous non-contact ink-jet application techniques. However, the invention is of special use in the application of thermoplastic inks to nonporous substrates using an on-demand ink-jet printer.

U.S. Pat. No. 4,688,048; Issued 8/18/87

Drop-on-Demand Ink-Jet Printing Apparatus

Inventors: HIROMICHI FUKUCHI, RYOSUKE UEMATSU, TOYOJI USHIODA
Assigned to: NEC CORP.

A drop-on-demand ink-jet printing head having an ink chamber filled with ink from an ink supply reservoir is described. The ink chamber has a deflectable upper elastic surface, a deflection of which increases ink fluid pressure. A deflection of the surface excites a plurality of resonant pressure vibration modes within the chamber. A pressure increase within the chamber causes an ink droplet to be projected out of a nozzle at one end of the chamber. A piezoelectric transducer is fixed on the elastic surface to deflect it and excite resonant vibration with a plurality of nodes and loops or antinodes. The transducer is positioned on the elastic surface at one of the loops or antinodes of a preselected pressure vibration mode, which excites the pressure modes with a short time constant (high frequency), enabling a very fine droplet of small volume to be projected. This can be done without reducing the cross sectional area of the nozzle or the velocity of the droplet.

U.S. Pat. No. 4,686,164; Issued 8/11/87

Electrophotosensitive Member with Multiple Layers of Amorphous Silicon

Inventors: ISAO DOI, TOSHIYA NATSUHARA, IZUMI OSAWA
Assigned to: MINOLTA CAMERA K. K.

This invention relates to a photosensitive member containing an a-Si:Ge layer with an a-Si intermediate layer. A photosensitive member containing a-Si:Ge has an excellent sensitivity to long-wave light so that it is suitable for an electrophotographic system equipped with a laser beam printer. However, the sensitivity of the member had not been improved because of its weak dark resistance and lower carrier mobility in general. In the present invention a photosensitive member having an a-Si:Ge layer with excellent sensitivity to long wavelengths by controlling the balance between the Ge content and the thickness of the a-Si:Ge layer and the concentration of oxygen or oxygen and carbon in the electroconductive layer is provided.

U.S. Pat. No. 4,685,968; Issued 8/11/87

Process for Preparing Ink Compositions for Ink-Jet Printers

Inventor: DONALD J. PALMER
Assigned to: HEWLETT-PACKARD CO.

A process for preparing an aqueous-based ink composition for use in ink-jet printers is described. The process entails (a) forming a solution of a dye having at least one negatively charged functional group per molecule; (b) acidifying the solution; (c) cycling the solution through a reverse osmosis membrane to form a concentrate and a permeate (the concentrate includes a cation of the compound associated with at least one functional group on the dye and the permeate including a cation formerly associated with at least one functional group); (d) adding water as necessary; (e) concentrating the dye by reverse osmosis; and (f) admixing the concentrated dye with at least one glycol ether. The pH of the ink composition is maintained below about 7.

U.S. Pat. No. 4,686,163; Issued 8/11/87

Electrophotographic Color Imaging Method

Inventors: LAWRENCE E. CONTOIS, JOHN D. MITCHELL, SEUNG NG YEE, JAMES D. WALLING
Assigned to: EASTMAN KODAK CO.

An electrophotographic imaging method is described that uses an element comprised of a photoconductive layer on an electrically conducting substrate capable of transmitting actinic radiation to which the photoconductive layer is responsive, and a dielectric support, releasably adhered to the substrate, comprising the photoconductive layer or an overcoat thereof forming a surface of the element capable of holding an applied electrostatic charge. To use the element, the surface of the dielectric support is charged, and the photocon ductive layer is imagewise exposed to actinic radiation, thereby forming a developable electrostatic image on the dielectric surface. The electrostatic image, in turn, is developed with toner to form a first-color image. A composite color image is formed on the element by repeating the sequence one or more times with imagewise exposure of the photoconductive layer to actinic radiation transmitted through the substrate, and developing over each preceding image with a different color toner. The composite toner image is transferred with the dielectric support to a receiving element to form a color copy such as a three-color filter array or a color proof closely simulating the color print expected from a full press run.

U.S. Pat. No. 4,688,049; Issued 8/18/87

Continuous Ink-Jet Printing

Inventors: JAMES J. DOYLE, AMMAR LECHEHEB
Assigned to: DOMINO PRINTING SCIENCES

In a continuous ink-jet printing method for printing mulitple lines of print, a raster of drops is produced in which the differential charge between drops printed on opposite sides of an interline gap is increased in comparison with that between adjacent drops to be printed within a line. At the same time the number of guard drops is maintained or reduced between the printable drops immediately adjacent to the interline gap, so that the distance between printed drops immediately adjacent to the interline gap is increased without increasing the number of drops in the raster.

U.S. Pat. No. 4,686,636; Issued 8/18/87

Liquid Development System

Inventor: CHE C. CHOW
Assigned to: XEROX CORP.

An electrophotographic printing machine is described in which an electrostatic latent image recorded on a photoconductive member is developed with a liquid developer material having at least a liquid carrier with marking particles dispersed therein. The liquid developer material is advanced on a roll from a supply thereof to the latent image at a development zone. Marking particles are moved through the liquid carrier onto the surface of the roll and a resilient blade removes excessive liquid developer material from the roll prior to the development zone.

U.S. Pat. No. 4,687,319; Issued 8/18/87
Liquid Carrier Reclaiming Apparatus
Inventor: SATCHIDANAND MISHRA
Assigned to: XEROX CORP.

An apparatus is described in which a developing liquid used in an electrophotographic printing machine to develop an electrostatic latent image on a photoconductive surface is reclaimed. The developing liquid is vaporized to dry the wet copy sheet. The developing liquid vapor enters the chamber of a housing where it is thermoelectrically cooled. In this way, the developing liquid vapor in the chamber of the housing liquefies. A Peltier heat pump is employed to cool the chamber of the housing so as to liquefy the developing liquid vapor.

U.S. Pat. No. 4,687,298; Issued 8/18/87
Forming an Opaque Metal Layer in a Liquid-Crystal Display
Inventors: SHIGEO AOKI, KATSUMI MIYAKE, KOTARO OKAMOTO, YASUHIRO UGAI
Assigned to: HOSIDEN ELECTRONICS LTD.

An LCD device is described, comprised of first and second transparent substrates facing each other; a liquid crystal sealed between the transparent substrates; a plurality of display electrodes formed on the inner surface of the first transparent substrate; thin-film transistors also formed on the first transparent substrate inner surface, each connected to each display electrode; and a transparent common electrode formed on the inner surface of the second transparent substrate, in which the thin film transistors are selectively controlled to selectively drive the display electrodes for display. The resistance of the semiconductor layers of the thin-film transistors is reduced by external light resulting in deterioration of the display contrast. An opaque metal layer is formed between each thin-film transistor and the first transparent substrate, and an insulating film is placed between the opaque metal layer and the thin-film transistor. Source buses on the same material as and connected to the opaque metal layers are formed on the first transparent substrate.

U.S. Pat. No. 4,688,104; Issued 8/18/87
Apparatus for Producing a Full Resolution Color Photographic Copy of a Color Video Signal
Inventor: DANA W. WOLCOTT
Assigned to: EASTMAN KODAK CO.

A color video printer for producing a color photographic copy from a color video signal is described. The printer includes a monochrome CRT and an exposure station located along an optical path from the CRT. The printer includes a rotatable filter wheel having red, green, and blue filters sequentially movable into the optical path in synchronism with the field frequency of the color video signal to filter monochrome images produced by the CRT. A video signal circuit provides a color video signal including three concurrent red, green, and blue component video signals repeated at broadcast field frequency. A gate is electrically connected between the video signal circuit and the CRT to selectively apply, when actuated, one of the three concurrent color component video signals to the CRT. An unexposed self-processing photographic element positioned at the exposure station is exposed to a sequence of six color field images constituting a full frame of a color video signal having odd and even fields of each of the red, green, and blue colors.

U.S. Pat. No. 4,688,204; Issued 8/18/87
Pulsed Optical Data Detection System
Inventors: GEORGE I. NOYES, JR., PRABODH L. SHAH
Assigned to: STORAGE TECHNOLOGY PARTNERS II

Disclosed is a data detection system and method for accurately detecting data transition marks recorded on a recording surface. A data transition pulse, generated by a data head as recorded data transition marks pass thereby, is presented to consecutive delay circuits in order to generate first and second delay pulses. The second delay pulse and the data transition pulse are subtracted from the first delay pulse, thereby creating a narrow output pulse that indicates the occurrence of a data transition. This narrow output pulse is used to toggle a flip-flop or equivalent logic circuit, the flip-flop output thereby representing a recreation of the data as recorded on the recording surface. The system is best suited for use with an optical storage system wherein data transitions are recorded on an optical disk as spots of substantially uniform size, although the detection system does not require that the spots be of uniform size.

U.S. Pat. No. 4,688,175; Issued 8/18/87
Image Processor with Automatic Setting of Window Width and Level for Individual Blocks of the Image
Inventors: HIROSHI ASAHINA, MAKOTO KANEKO, ICHIRO OGURA, HIROSHI YASUHARA
Assigned to: TOSHIBA CORP.

An image-processing apparatus including frame memories for storing information of an image to be displayed is described. A block memory

patents

for dividing the information stored in the frame memories into a given number of information blocks stores the divided information blocks. A microcomputer circuit automatically determines a desired value of each level and width according to the given contents of the divided information blocks. An image emphasis circuit window processes information of the image to be displayed according to the determined value of each level and width.

U.S. Pat. No. 4,691,353; Issued 9/1/87
Scrambling Systems for CATV
Inventor: JAMES O. FARMER
Assigned to: SCIENTIFIC-ATLANTA INC.

A TV signal-scrambling system for use in a CATV network wherein premium programs are transmitted over cable, by broadcast transmission and the like with the sync pulses of the color TV signals suppressed, is described. A processor is provided which processes the color components separately from the luminance and sync components so as to remove coherency (constant phase relationship) between the color subcarrier and the sync pulses. The separately processed components with the coherency removed are recombined to provide the composite TV signal which is scrambled and transmitted to the subcribers. Subscribers having television receivers of the type which recover sync signals by countdown techniques from the color subcarrier, such as those using some integrated circuits (chip sets), are then made unable to recover the sync pulses unless equipped with an authorized descrambler. Unauthorized subscribers who are equipped with digital television receivers therefore obtain a scrambled TV picture which rolls horizontally across the screen.

U.S. Pat. No. 4,684,929; Issued 8/4/87
Liquid-Crystal Display Device
Inventors: PETER STREIT
Assigned to: U.S. PHILIPS CORP.

An LCD device having two linear polarizers and a nematic liquid crystal with positive dielectric anisotropy is described. The liquid crystal is illuminated by a light source which is arranged in a fixed spatial relationship to the display. Behind the display, a diffusely scattering metallic reflector is provided. The angle of incidence of the light relative to the perpendicular on the surface of the front carrier plate is in the range from 50° to 90°, preferably between 70° and 80°. The operating voltage of the display device according to the invention is less than 2.0 times the Freedericksz threshold voltage of the liquid crystal. In this way, optimum contrast is achieved, coupled with a very large range of viewing angle. With this display device, very high multiplex rates (up to 1:120) can be reached.

U.S. Pat. No. 4,694,404; Issued 9/15/87
High-Speed Image Generation of Complex Solid Objects Using Octree Encoding
Inventor: DONALD J. MEAGHER
Assigned to: KEY BANK N.A.

To generate two-dimensional images of three-dimensional solid objects at high speed, an object is defined within a three-dimensional universe hierarchically subdivided into a plurality of discrete volumes of uniform size and similar orientation. The three-dimensional universe is represented by an octree structure having a plurality of nodes, one for every volume in the three-dimensional universe that is at least partially occupied by the object. An arbitrary point of view is selected. Nodes in the tree structure representing the three-dimensional universe are visited in a sequence determined by the selected point of view so that nodes corresponding to volumes which are unobstructed by other volumes are visited first. Each visited node contained by the object is projected onto a subdivided view plane organized into a hierarchy of discrete areas. Areas of the view plane enclosed by the projection are painted onto a display screen. View plane areas which intersect but are not enclosed by the projection are further subdivided. To create sectional views, a user may define a region of the three-dimensional universe, and volumes outside of that region are not projected. Real-time image generation wherein calculations necessary to create the image are performed by hard-wired digital logic elements to increase speed performance is possible.

U.S. Pat. No. 4,694,310; Issued 9/15/87
Method and Apparatus of Electrophotography
Inventors: TUTOMU SAITO, HITOSHI YONEDA
Assigned to: TOSHIBA CORP.

A method and apparatus of electrophotography used for a printer or a copying machine are described, wherein a toner having no photoconductivity is applied on a surface of a photoconductive layer of a photoreceptor consisting of a transparent conductive layer and the photoconductive layer, which are sequentially formed on a transparent substrate. The photoconductive layer is exposed from a side of the transparent substrate. Toner particles on an exposed region of the photoconductive layer are transferred to toner-receiving paper opposite the photoconductive layer so as to form a toner image. A process for developing a latent image can be omitted. In addition, a special toner such as a photoconductive toner having low sensitivity is not used, thereby forming a high-quality image. ■

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CONVERTERS
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CRT DISPLAYS

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Computing Devices Co.
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Hitachi America, Ltd.
HMW Enterprises, Inc.

CRTs, flat
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CRTs, miniature
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CRTs, multibeam
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CRT monitors, full color
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CalComp
CalComp, Display Products Div.
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Mitsubishi Electronics America

CRT monitors, monochrome
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AZTEK
CalComp
CalComp, Display Products Div.
David Sarnoff Research Center

CRTs, electron guns and deflection yokes for
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David Sarnoff Research Center

CRTs, other
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Schott America

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FILTERS AND POLARIZERS

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Polarizers
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David Sarnoff Research Center

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Axonix Corp.
Conic Semiconductor Ltd.
David Sarnoff Research Center
Hitachi America, Ltd.
LXD, Inc.
Taliq Corp.

Liquid-crystal displays, active matrix
David Sarnoff Research Center
Hitachi America, Ltd.

Matrix addressing
Computing Devices Co.
David Sarnoff Research Center
Hitachi America, Ltd.
LXD, Inc.

Vacuum fluorescent displays
ISE Electronics Corp.

Flat panel displays, other
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FLAT-PANEL MATERIALS
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IMAGE TUBES, CCD IMAGERS
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David Sarnoff Research Center
Hitachi America, Ltd.

LARGE-SCREEN DISPLAYS

Large-screen plasma displays
Hitachi America, Ltd.

Large-screen text displays
Taliq Corp.

Liquid-crystal light-valve projectors
David Sarnoff Research Center
Taliq Corp.

Message boards
LXD, Inc.
Schott America
Taliq Corp.

Projection CRTs
Hitachi America, Ltd.

Large-screen displays, other
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Hitachi America, Ltd.
Mitsubishi Electronics America
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Electrophotographic laser printers
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TMC Co.

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Axonix Corp.

Ink-jet printers
TMC Co.

Optical disks/video disks
AZTEK
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Pen plotters
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CalComp

Thermal-transfer printers
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CalComp
Mitsubishi Electronics America
TMC Co.

Videotape
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401/762-3800 Telex: 92-7584
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801/466-9797

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416/231-5535

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Manufacturers of 12- to 37-in. color high-resolution displays, color thermal-transfer printers, and optical disk drives for the computer industry.
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213/515-3993 Fax: 213/324-6466

SCHOTT AMERICA
3 Odell Plaza
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Manufacturers of CRT bulbs for industrial and military displays; x-ray protection panels (CRT); highly transparent B 270 Superwite glass for LCD oscillograph and monitor tube covers; and other glasses such as curved, bent, non-reflective, contrast enhancing, and low-expansion.
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Manufacturers of large-area plastic liquid-crystal displays and light shutters. Products include: auto and architectural light modulating windows and custom color graphic control panels and displays.
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44-61-681-7072 Telex: 851-665326
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High-performance UNIX-based graphics workstations

Tektronix, Inc., introduces eight UNIX-based high-performance 4300 series graphics workstations. Products range from a 3D true-color graphics workstation to a 3D wireframe graphics system, both with optional stereoscopic viewing. They achieve graphics application throughput and drawing speeds of 450,000 2D vectors/sec, 340,000 3D vectors/sec, and 20,000 Gouraud shaded polygons/sec. The workstations feature smooth dynamic motion and produce vivid and accurate shaded solids through simultaneous display of a full palette of 16.7 million colors.

The 4300 series workstations incorporate industry standards, including Motorola's 68020 processor; UTek (Tektronix' implementation of bsd 4.2 UNIX, with System V extensions); X windows; network file system; the Ethernet local area network with TCP/IP protocol; and Tek's PLOT 10 graphics software.

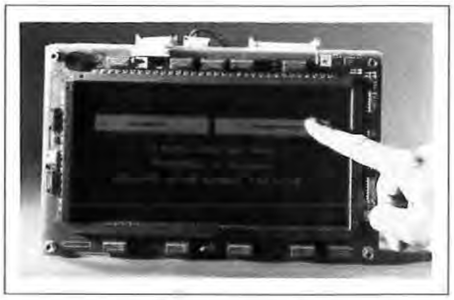
Tektronix' dual compute and graphics engines maximize graphics throughput by allowing graphics processing to take place in the 68020-based graphics engine without drawing on the independent 68020/68881-based 2.5-MIPS compute engine. The dual structure also facilitates independent upgrades to computing and graphics capabilities. Prices for the 3D graphics workstations range from $37,500 to $51,500.

For further information contact Donna Loveland, Tektronix, Inc., P.O. Box 1000, Wilsonville, OR 97070. 503/685-3837.

Circle no. 10

AC plasma display with gray scale

Thomson-CSF announces the TH 7621 AC plasma display panel with gray scale, which offers eight luminance levels on each of its 256 × 512 dots. Data input is



by a digital video interface for easy connection to microprocessor-based systems. Screen dimensions are 208 × 104 mm; dot spacing is 0.406 mm (equivalent to 62.5 lines/in.), which provides a good image definition. The panel also has a wide viewing angle (>160°), high contrast (>10 under 1000 lux, with etched filter), and extremely rugged reliable construction. Accessories for the TH 7621 include: power supply, interface (VT 220 or other), touch input screen, and optical filters.

For further information contact Thomson Electron Tubes and Devices Corp., 550 Mount Pleasant Ave., P.O. Box 6500, Dover NJ 07801. 201/328-1400.

Circle no. 11

Large-character gas-discharge display

Babcock Displays, Inc., announces their SP-432 Plasmaflex 2-in. character displays. The seven-segment format displays numeric information, and includes decimal points and commas in each

position; colons follow the second and fourth digits, and a plus or minus symbol is included in the most significant digit. A 150° viewing angle and 90 fL of brightness make this neon-orange gas-discharge display readable up to 100 ft. (30 m). The SP-432 is horizontally or vertically stackable and comes with single in-line flexible leads. Price is $51.55 in quantities of 100.

For further information contact Carl Cox, Babcock Display Products, Inc., 1051 S. East St., Anaheim, CA 92805-5799. 714/491-5100.

Circle no. 12

Wide-angle LCD

AEG Corp. announces their LCD with a contrast ratio of 30:1 in the transmissive viewing mode. The modified dichroic technology developed for the LCD is

especially effective in large indoor signboard displays such as airport and railway information boards. White characters on a black background offer maximum brightness. The LCD manufacturing process employed by AEG includes a highly concentrated dye mixed with the liquid-crystal fluid. In addition, one rear polarizer is employed to overcome typical bleed-through in transmission.

For further information contact Chris T. Fatta, AEG Corp., Route 22-Orr Dr., P.O. Box 3800, Somerville, NJ 08876-1269. 201/231-8300.

Circle no. 13

Enhanced VGA CMOS chip set

Cirrus Logic announces the availability of their enhanced VGA graphics chip set CL-GD510 and CL-GD520 targeted at board-level suppliers and system OEMs. The new CMOS chip set provides VGA, EGA, CGA, MDA, and Hercules compatibility with all existing and future software; digital and analog monitor support; display resolution up to 600 × 800 with 16 colors; support for 256 colors out of 256K at 320 × 200 resolution; and increased gray scale. Key among the software performance improvements are hardware text and graphics cursors, automatic switching between graphics modes (EGA to CGA, etc.) and fast-host CPU access to video memory. The Cirrus Logic chip set comes in 84-pin PLCC packages for socketed and surface-mount designs and is available now. The kit price is $45 in 1000-piece quantities.

For further information contact Mark Singer, Cirrus Logic, Inc., 1463 Centre Point Dr., Milpitas, CA 95035. 408/945-8300.
Circle no. 14

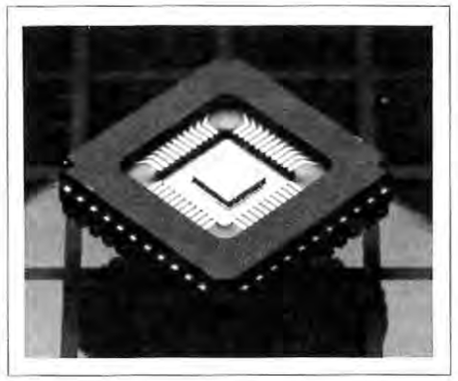
Industrial PC/AT/XT compatible monitors

Xycom, Inc., announces the release of a new line of PC/AT/XT compatible industrial monitors designed specifically for use in harsh environments. The 4100 Series is available in both color and monochrome, and with or without interactive keypads and function keys. The monitor front panels are all sealed to NEMA 4 / NEMA 12 standards, and each CRT is protected by an impact-resistant Lexan shield. Each unit is designed to be either rack or panel mounted. For applications where only a simple monitor is required, Xycom offers the 4103 12-in color monitor with EGA/CGA color graphics or the 4104 12-in. amber monitor with MDA/HGC compatibility. For applications where regular operator interaction or data entry is a requirement, there are the 4105 12-in. EGA/CGA color monitor and the 4106 MDA/HGC amber monitor, both with integral keypads and function keys. All of the 4100 series monitors are designed with a PC/AT/XT compatible keyboard port on the front panel.

For further information contact Ron Howard, Xycom, Inc., 750 N. Maple Rd., Saline, MI 48176. 313/429-4971.
Circle no. 15

Wide-spectrum low-noise CCD imagers

Tektronix, Inc., introduces a family of silicon charge-coupled device (CCD) imagers for applications requiring high-frame-rate output in a room-temperature environment. The new imagers have a large full-well capacity and high signal-to-noise ratio. Single and multiple outputs are available with excellent noise performance at high readout rates. A demonstration board designed for one of the new devices allows changing modes of operation and pixel output rates. Depending on the speed required, the frame transfer rates vary from greater than 500 frames/sec in single (serial) output mode, to greater than 500 frames/sec in parallel output mode. The device's wide dynamic range of 20,000:1 is constant even at high parallel-frame transfer rates.



The imagers range in image size from 64 × 64 pixels to 64 × 128 pixels, and offer both front- or thinned-backside illumination. The unique backside thinning process used in device fabrication gives good quantum efficiency at blue and ultraviolet wavelengths. Charge transfer efficiency is greater than 0.99995 per transfer at 50,000 pixels/sec and 0.9999 per transfer at 5 × 10^6 pixels/sec. All Tektronix CCD imagers will be shipped within four weeks. Prices range from $2,000 to $17,500.

For further information contact Donna Loveland, Tektronix, Inc., P.O. Box 1000, Wilsonville, OR 97070. 503/685-3837.
Circle no. 16

Circle no. 17

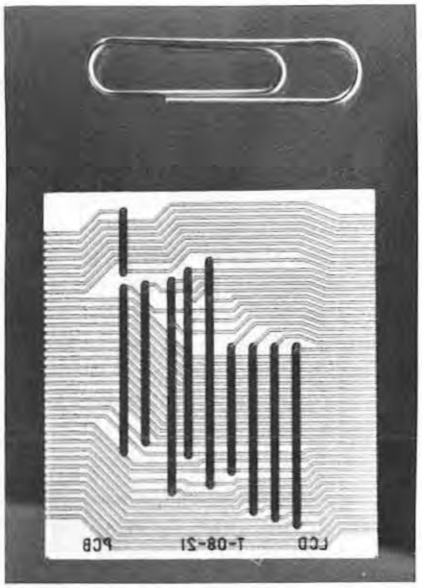
Hand-held interfacer

Two Technologies, Inc., introduces a hand-held terminal that interfaces with computers or industrial equipment. The terminal parameters are completely user programmable and its standard alphanumeric keypad can be custom designed to a wide variety of OEM or industrial production applications. Standard features include five user definable keys; baud rate from 300 to 19,200; 4-line × 16-character LCD; 45-tactile keypad; and nonvolatile parameter storage (EEPROM). The low-profile unit is provided with either RS-232 or RS-422 interface, and a retractable hanger is built into the rear of the unit for storage convenience. An eight-zone touch screen is also available.

For further information contact Michael Schwartz, Two Technologies, Inc., 405 Caredean Dr., Horsham, PA 19044. 215/441-5305.
Circle no. 18

Crossover heat-seal connectors

Elform Co. introduces a variation of the heat-seal connector offering two-sided circuitry that allows for crossovers using via holes. They are commonly used for interfacing LCDs to PCBs. The procedure used is to align the connector, seal with heat, and apply pressure for 10 sec. The base material is polyester, and the traces are copper, silver, or graphite. In all



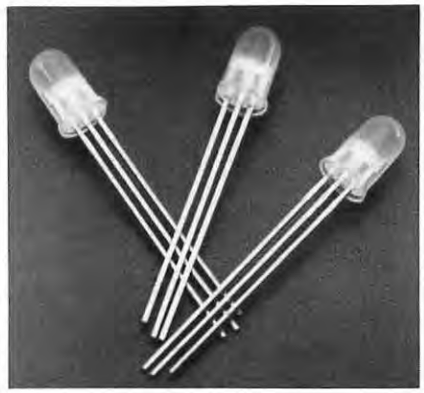
cases, the traces are covered with a protective layer of graphite loaded hot melt adhesive. The connectors are 0.003 in., and prices start at $\$0.10/\text{in}^2$. Custom connectors take five weeks to produce.

For further information contact Roger R. Reinke, Elform, P.O. Box 7362, Reno, NV 89510. 702/356-1734.

Circle no. 20

Bicolor LED lamp

Hewlett-Packard introduces a three-leaded bicolor LED lamp in the industry-standard T-1 3/4 package. The new HLMP-4000 is designed for applications where space is limited and two colors of indication are needed. The HLMP-4000 has a high-efficiency red and a high-



performance green chip on the center lead of the three-leaded T-1 3/4 lamp. Leads are spaced 0.050 in. from each other with the center lead providing the common cathode. The HLMP-4000 has a viewing angle of 65°. Typical luminous intensity

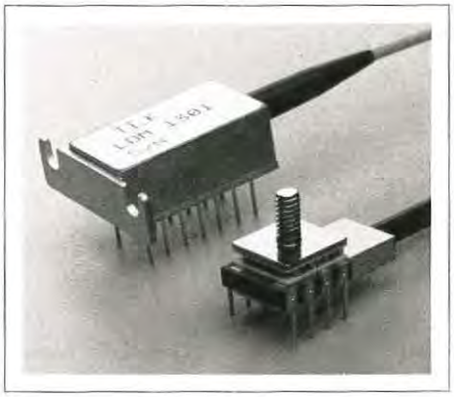
Circle no. 21

at 10 mA is 5.0 mcd for the high-efficiency red and 8.0 mcd for the high-performance green. The HLMP-4000 lamps are priced at $0.46 each in quantities of 10,000 units.

For further information contact the Hewlett-Packard Co. sales office listed in the white pages telephone directory.
Circle no. 22

Polarization retaining laser diode modules

Textronix, Inc., announces the availability of the LDM 1300PR and LDM 1301PR laser diode modules. The LDM 1300PR is a small rugged 8-pin DIP package with complete functionality, including laser, thermistor, and monitor diode. The LDM 1301 PR is a pin-compatible industry standard 14-pin DIP package that offers a

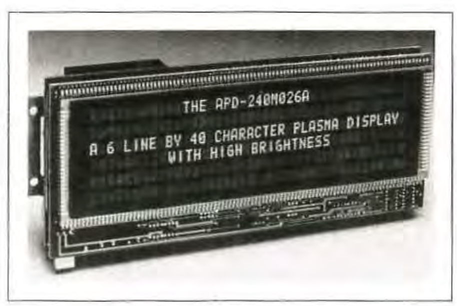


true extended operating temperature range. Both products feature high-output emission coupled into a polarization retaining single-mode fiber. Tektronix' proprietary lensing and alignment process guarantees a continuous fiber output power of 1 mW minimum, with an extinction ratio of 200:1. Both packages are hermetically sealed in an inert environment containing neither epoxies nor organic compounds, assuring reliable and highly stable operating lifetimes. Packages with high fiber positional stability coefficients are capable of maintaining fiber-to-laser alignment with or without a thermoelectric cooler. Devices are operated with a forward bias current of 100 mA for 250 h in a 70°C ambient oven. Production quantities are available in four to six weeks.

For further information contact Sheri Hill-Tanquist, Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077. 503/627-5392.
Circle no. 23

Interfaceable matrix display

A new 240-character dot-matrix plasma display module complete with drive electronics and designed for easy interfacing with CRT controllers is now available from Dale Electronics, Inc. The APD-240M026A displays six lines of 40 characters; each character is 0.14 in. (W) × 0.26 in. (H) in a 5 × 7 dot-matrix format. Overall dimensions are 4.30 in. (H) × 11 in. (L) × 1.21 in. (D). Viewing area is 2.26 in. (H) × 8.33 in. (W). The display provides high brightness (100 fL) and a viewing angle of 150°. It is easily interfaced with CRT controllers, and can be provided with a controller board which has parallel and RS232 ASCII inputs (Model APD 240M026A-1.) Price is $480 each in quantities of 100. Approximate delivery is six to eight weeks.



For further information contact Margaret Nowicki, Dale Electronics, Inc., 2064 12 Ave., Columbus NE 68601. 402/564-3131. ■
Circle no. 24

UK and Ireland Chapter

A team from **Phillips Research Laboratories**, Redhill, UK, won the SID UK & Ireland Chapter premium of £100 for the best oral paper presented at Eurodisplay (the Seventh International Display Research Conference), September 15-17. The award was presented to **M.J. Powell, J.A. Chapman, A.G. Knapp, I.D. French, J.R. Hughes, A.D. Pearson, M. Allinson, M.J. Edwards, R.A. Ford, M.C. Hennings, O.F. Hill, D.H. Nicols,** and **N.K. Wright** for "Active Matrix-Addressed LC Television Using a–Si Thin Film Transistors." The SID UK & Ireland Chapter premium was one of three prizes announced by executive committee chairman Cyril Hilsum. The others were £100 for the best poster presentation to **C.B. McArdle** et al. of **GEC** for "Information Storage and Erasure Processes in Liquid Crystal Polymer Films," and a special award of £50 for originality and innovation to **F. Morin** et al. of **CNET** (France) for "An Image Projector Using an Active Matrix Display."

The September 14 meeting of the SID UK and Ireland Chapter focused on administrative business.

On November 10, the Chapter hosted a CRT Display Symposium in London. Topics included "CRTs for Avionics"; "Jumbotron Giant Screen"; "Penetration CRT Problems"; "Twenty-first Century CRTs"; and "Very High Resolution Monochrome CRTs." The symposium was preceded by the Chapter's annual general meeting.

Upcoming meetings include:

Feb. 1988. London, "Hard Copy"

Mar.-Apr. "UK Manufacturing"

May-June. London, "High-Information Content" (joint meeting with IEE)

July. Bath (tentative), "LCDs for TV and AGM"

Oct.-Nov. Chertsey or Fort Halstead, "Military and Civilian Vehicle Displays"

San Diego Chapter

SID San Diego Chapter members heard a presentation on "The Future of CRTs—Miniature to Projection" by presiding officer **J. Lipscombe** of **Hughes Aircraft Co.** at the September 8 meeting.■

December

1987 Microcomputer Graphics Conference. Susan Werlinich, Expoconsul International, 3 Independent Way, Princeton, NJ 08540. 609/987-9400.
Dec. 16–18 New York, NY

1987 Architects and Engineers Conference. Carol S. Henderson, Expoconsul International, 3 Independence Way, Princeton, NJ 08540. 609/987-9400.
Dec. 16–18 New York, NY

January

1988 Simulation in Education Engineering. Simulation Councils, Inc., P.O. Box 17900, San Diego, CA 92117. 619/277-3888.
Jan. 7–8 San Diego, CA

O-E LASE/'88. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
Jan. 10–15 Los Angeles, CA

Tenth Annual Conference on Computer Graphics. Frost and Sullivan, Inc., Dept. RE-12, 106 Fulton St., New York, NY. 212/233-1080.
Jan. 13–15 San Diego, CA

Conference and Exhibition on Electronic Imaging Devices and Systems '88. SPSE, 7003 Kilworth La., Springfield, VA 22151. 703/642-9090.
Jan. 15–20 Los Angeles, CA

Military Computer Graphics. Bob Cramblitt/Michael Weiner, National Computer Graphics Assn., 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031. 703/698-9600.
Jan. 21 Cape Canaveral, FL

Paper and Film for Copiers, Printers and Plotters. Diamond Research Corp., P.O. Box 128, Oak View, CA 93022. 805/649-2209.
Jan. 31–Feb. 2 Santa Barbara, CA

Second International Conference on Computer Workstations. Patrick Mantey, 335A Applied Science Bldg., Dept. of Computer Engineering, Univ. of Calif. at Santa Cruz, Santa Cruz, CA 95064.
Jan. 31–Feb. 3 Santa Clara, CA

Medical Imaging II. SPIE, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
Jan. 31–Feb. 5 Newport Beach, CA

February

1988 SCS Multiconference. Simulation Councils, Inc., P.O. Box 17900, San Diego, CA 92117-7900. 619/277-3888.
Feb. 3–5 San Diego, CA

The International Conference on Technology Management. Tarek M. Khalil, Chair, Dept. of Industrial Engineering, Univ. of Miami, P.O. Box 248294, Coral Gables, FL 33124. 305/284-2344.
Feb. 17–19 Miami, FL

Fourth Annual Computer Graphics New York. Exhibition Marketing and Management, Inc., 8300 Greensboro Dr., Suite 1110, Mc Lean, VA 22102. 703/893-4545.
Feb. 22–24 New York, NY

Flat Panel and CRT Display Technologies—Short Course. UCLA Extension, P.O. Box 24901, Los Angeles, CA 90024. 213/825-1047.
Feb. 22–26 Los Angeles, CA

The Image Processing Market. Bob Cramblitt/Michael Weiner, National Computer Graphics Assn., 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031. 703/698/9600.
Feb. 24 St. Louis, MO

Call for Papers

Elettronici Graffiti. Bari, Italy, April 13–18. Material is being solicited for the following areas: computer art; small, medium, and large computer graphics systems; computer animation; computer advertising, TV, and cinema. Exhibitions will include: video installation, a gallery, system demonstration and live computer grpahics performances, and a conference. Participants should send the following: a video-tape in 3/4 in. format, either BVU (High band) or u-matic semi-professional or VHS or Betamax; for small systems (Amiga, Atari, Apple, etc.) please include a disk containing the graphic pages to be shown and notes about the software used; a photo (min. format 20 × 30 cm), slide, or print on paper, hard copy in color (please include one of the above for each image); personal data (name, address, age, profession, curriculum vitae of the authors, informative notes about the company); and a signed authorization to use the material during the exhibition period to: Softmedia scrl, via O. Serena, 38-70126 Bari, Italy. 80/233250.
Deadline for material: Dec. 31

International Conference on Consumer Electronics. June 8–10, Rosemont, IL. Papers are being solicited for, but are not restricted to, the following areas: video technology; home information systems; design and manufacturing; audio; components; and emerging technologies. Send ten copies of a 500- 700-word summary and a 35-word abstract to Diane D. Williams, Conference Coordinator, 131 Ledgewood Dr., Rochester, NY 14615, 716/865-2938 (U.S. papers); J. Beriere, Philips Elcoma, BAE-2, Eindhoven, The Netherlands, 31-40-722497 (European papers); Hiroshi Tanimura, Sony Corporation, Atsugi Plant, 4-14-1, Asahi-cho, Atsugi-shi, Kanagawa, 243 Japan, 0462-30-5674 (Far East papers).
Deadline for abstracts: Jan. 11

Visual Communications and Image Processing III. Nov. 6–11, 1988, Cambridge, MA. Papers are being solicited for, but are not restricted to, the following areas: digital image processing; video communications; mathematical morphology and fractals; digital image processing in medicine; and VLSI implementation and system architectures. Send four copies of the following to SPIE: author application, a brief professional biography, and a 200-300-word abstract, typed double-spaced on 8½ × 11 in. white paper. For a detailed copy of the call for papers and an author application, write SPIE Technical Program Committee/Cambridge '88, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290.
Deadline for abstracts: Mar. 28 ■

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- display design, measurement, and evaluation
- optical design
- video image processing

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Circle no. 29