Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

May 1988
Vol. 4, No. 5

SID'88 Show Issue

Using displays for market differentiation
Economic display design
SID exhibit preview

LCDs from AEG... any way you look at them, they're clearly superior

Engineers throughout the world have specified AEG custom designed LCDs when their display requirements demanded the best technology available. Our displays are highly engineered to perform under the most stringent environmental conditions.

Reliability and long life is provided by our chip-on-glass technology, eliminating the need for interconnecting to a PCB. The result is an LCD only 3mm in thickness that is completely shock and vibration resistant with an operational temperature range of −55°C to +95°C (w/heater).

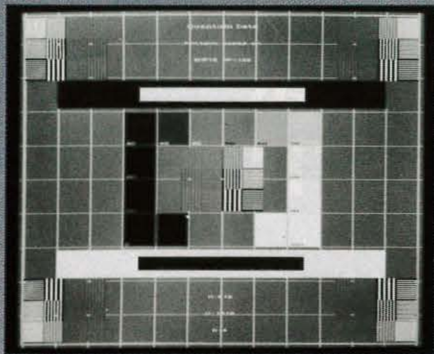
If you are looking for the best in LCDs for automotive, for avionic/military or for public display applications, such as airports and financial centers (stock exchanges)... you should look to AEG where clear viewing, at any angle is superior...

For more information contact:
AEG Corporation, Route 22 — Orr Drive
PO Box 3800, Somerville, NJ 08876-1269
(201) 231-8300

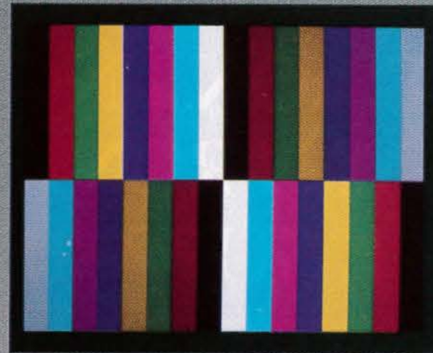
AEG

*Instrument panel in first column, courtesy of Borg Instruments

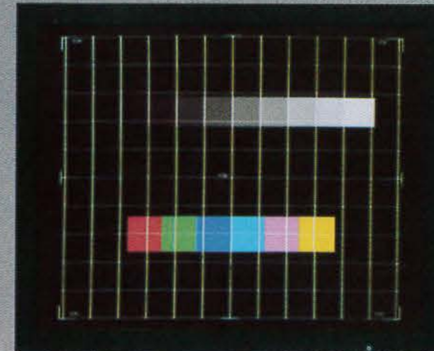
Circle no. 36



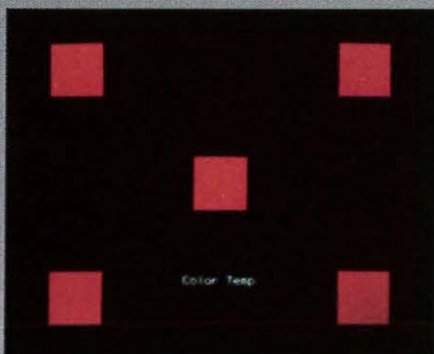
SMPTE RP-133



Color Bars

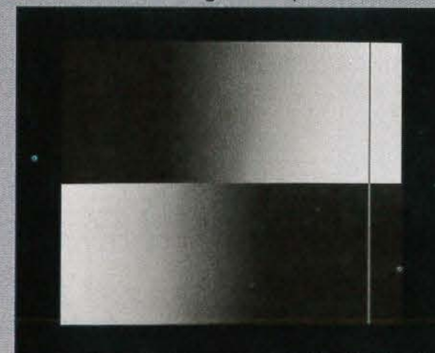


Signal Setup

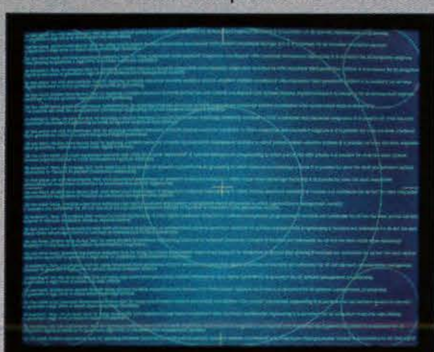


Color Temperature

Cross Talk

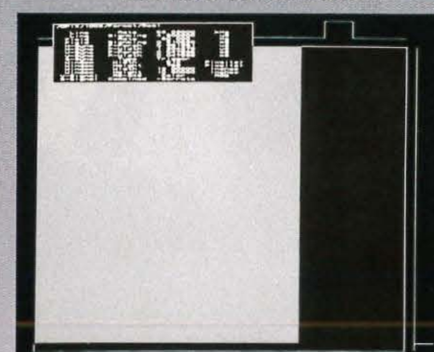


256 Level Gamma Pattern



Text with Circle

RGB Delay



Timing

THESE PROBLEM SOLVING PATTERNS ARE YOURS AT THE TOUCH OF A BUTTON.

The OPIX™ Imager carries 56 built-in Instant-Expert™ test patterns that allow anyone to perform sophisticated diagnostic and correlation tests from day one. It's the only signal generator on the market that offers this capability. And you can design your own tests. Or build off the Instant-Expert patterns by copying a test pattern on disk and modifying it.

The possibilities are endless. The results as exacting as your video parameters require. Do "what if" experiments. Precision test your monitor specifications when hardware logic is still weeks away. Store and recall design specifications that have been out of production for years. You can do it all with the OPIX Imager. Why settle for less? Get the OPIX Imager and bring your video testing to a point of performance you can trust.

For technical data, or a hands-on demonstration contact: QUANTUM DATA, 2111 Big Timber Road, Elgin, IL 60123. Phone: (312) 888-0450 FAX: (312) 888-2802 Telex 206725

Circle no. 37

QUANTUM DATA®

Cover: Different flat-panel displays optimize laptop computers for different market segments. Clockwise from top: transflective backlit LCD, 640 × 200 transmissive backlit LCD, plasma, 640 × 400 transmissive backlit LCD, and electroluminescent. (page 20)

Photo: GRiD Systems Corporation

Next Month in Information Display

CRT Technology Issue

- Computer modeling of guns and yokes
- Bulb design
- Automated CRT testing

Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

MAY 1988
VOL. 4, NO. 5

Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

Editor: Kenneth I. Werner
Managing Editor: Hildegarde Hammond
Contributing Editor: Ronald Cohen
Departments Editor: Lynne A. Henderson
Art Director: Hildegarde Hammond
Advertising Manager: Jay Morreale
District Sales Managers: Ted Lucas (West), Stephen Steeves (Midwest), Becky Akers (East)

INFORMATION DISPLAY (ISSN 0362-0972) is published monthly for the Society for Information Display by Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014; David Slater, Chief Executive Officer; Leonard H. Klein, President; Harold R. Summer, Vice President; Hildegarde Hammond, Secretary; Laura Mangone, Treasurer.

EDITORIAL AND BUSINESS OFFICES: Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014; telephone 212/620-3371. Send manuscripts to the attention of the Editor, ID.

DISTRICT SALES OFFICES: WEST—Ted Lucas, P.O. Box 852, Cedar Glen, CA 92321; telephone 714/337-6627. MIDWEST—Stephen Steeves, The Pattis Group, 4761 West Touhy Avenue, Lincolnwood, IL 60646; telephone 312/679-1100. EAST—Becky Akers, The Pattis Group, 310 Madison Avenue, Suite 1804, New York, NY 10017; telephone 212/953-2121.

SID HEADQUARTERS, for correspondence on subscriptions and membership: Society for Information Display, 8055 West Manchester Avenue, Suite 615, Playa del Rey, CA 90293; telephone 213/305-1502.

SUBSCRIPTIONS: Information Display is distributed without charge to those qualified and to SID members as a benefit of membership (annual dues $35.00). Subscriptions to others: U.S. & Canada: $36.00 one year, $64.00 two years, $90.00 three years, $3.00 single copy; elsewhere: $72.00 one year, $128.00 two years, $180.00 three years, $6.00 single copy.

PRINTED by Sheridan Printing Company, 1425 Third Avenue, Alpha, NJ 08865. Third-class postage paid at Alpha, NJ.

POSTMASTER: Send address changes to Society for Information Display, 8055 West Manchester Avenue, Suite 615, Playa del Rey, CA 90293.

editorial

Nearly four decades ago, Albert Rose laid the foundations of image science at what were then the RCA Laboratories. Since then, the David Sarnoff Research Center, now a part of SRI, has been a leading developer of this expanding science and its applications. An indication of the degree of expansion is the establishment of an Image Science Institute at New York City's Polytechnic University (formerly Brooklyn Polytechnic Institute), under the direction of Arnost Reiser, and another at the Rochester Institute of Technology, under the direction of Rodney Shaw.

In this issue, Curt Carlson, director of Sarnoff's Information Systems Research Laboratory, presents some particularly applicable results of image science and a convenient graphic tool for using them in display design.

In a technical marketing case study, Lee Watkins tells how different segments of the laptop computer market can be targeted by putting different display panels on what is essentially the same computer. A sidebar shares the experience of using a plasma display laptop.

This issue also features *Information Display*'s first software review. The applications program is for designing multilayer interference filters, which sometimes appear on displays as antiglare coatings or for other purposes. The reviewer is Warren Smith, author of the now classic textbook, *Modern Optical Engineering*.

And, to preview the rapidly approaching International Symposium, Seminar, and Exhibition of the Society for Information Display (to be held May 23–27 in Anaheim, California), we highlight some of the products to be displayed at the largest SID exhibit in the society's 26-year history.

Finally, we'd like to rectify an editorial omission and make an editorial note. The omission was of three worthy companies from the large table in "The Flowering of Liquid-Crystal Technology" (February *ID*). We should have included UCE of Norwalk, Connecticut, Crystaloid Electronics of Hudson, Ohio, and Litton Data Images of Ottawa, Canada, all manufacturers of avionic displays. And EDS, which *was* listed, has changed its name to Hercules Aerospace Display Systems and is now located in Hatfield, Pennsylvania.

Editorially, we note that Howard Funk's popular columns on patents and publications will be appearing irregularly for the next few months because of space limitations. We're well aware how highly *ID*'s readers value Howard's contributions, and we will restore them as regular departments as soon as page allocations permit.

The editorial and advertising staff of *Information Display* looks forward to meeting as many of our readers as possible in Anaheim.

—Kenneth I. Werner

Delta or Aorta? Which is Which?

No problem here because both of these images were processed on Raytheon's new TDU-850 Thermal Display Unit.

The TDU-850 is the only thermal recorder to display true grey levels (not mere halftone representations) at such high speeds and resolutions. Utilizing 203 dots per inch, the unit offers 64 grey levels and can provide 256 grey levels through the use of super pixels. The TDU-850 is your assurance of high quality images. Standard units about $5,000. (Slightly higher overseas). RS-170 video and IEEE-488 computer interfaces are available.

When you must know what you're looking at, look for equipment that knows what to look for. For details call or write **Marketing Manager, Recorder Products, Raytheon Company, Submarine Signal Division, 1847 West Main Road, Portsmouth, RI 02871-1087. Phone: (401) 847-8000.**

Raytheon

A. Satellite view of river delta. **B.** Arterial angiogram.

Note: These began as continuous tone images which were processed in black and grey by a TDU-850. The TDU-850 images, however, had to be converted to conventional halftones in order to be shown in this magazine. Thus the high quality of the original TDU-850 images have been obscured. For true results ask to see a demonstration.

Circle no. 45

Society for Information Display
8055 W. Manchester Ave., Suite 615
Playa Del Rey, CA 90293
213/305-1502

president's message

Just prior to SID '88 my term as president of SID will come to an end and Larry Tannas will be taking over. As I step down I realize how fortunate I have been to serve with the strong support and dedication of so many SID colleagues who have helped to make our society strong and vital and have caused it to grow steadily. I can only hope that each of you will give Larry the same enthusiastic support, including the benefit of your ideas and constructive criticisms, that you have given me.

The past two years have brought numerous positive changes and accomplishments, almost all of them made possible by the extra efforts of SID's officers and committee chairmen. Our membership has continued to grow steadily, as has the number of sustaining members. And, as a result of a lot of hard work, the new membership directory was recently mailed to all our members.

The new SID chapters in Dayton and Detroit were formed, while the Canada Chapter, which began two years ago, has now joined the ranks of our other strong active chapters. Regrettably, the Midwest Chapter was deactivated since it was unable to maintain regular activities; we certainly hope that this chapter will return to active status in the future, as seems likely soon for the Washington, D.C., Chapter.

We have continued to wrestle with the high costs of our publications, both for the *Proceedings* and the *Information Display* journal. I believe that publications and conferences represent SID's primary obligations to its membership and we must continue to look for ways to reduce these costs without sacrificing the quality of our service.

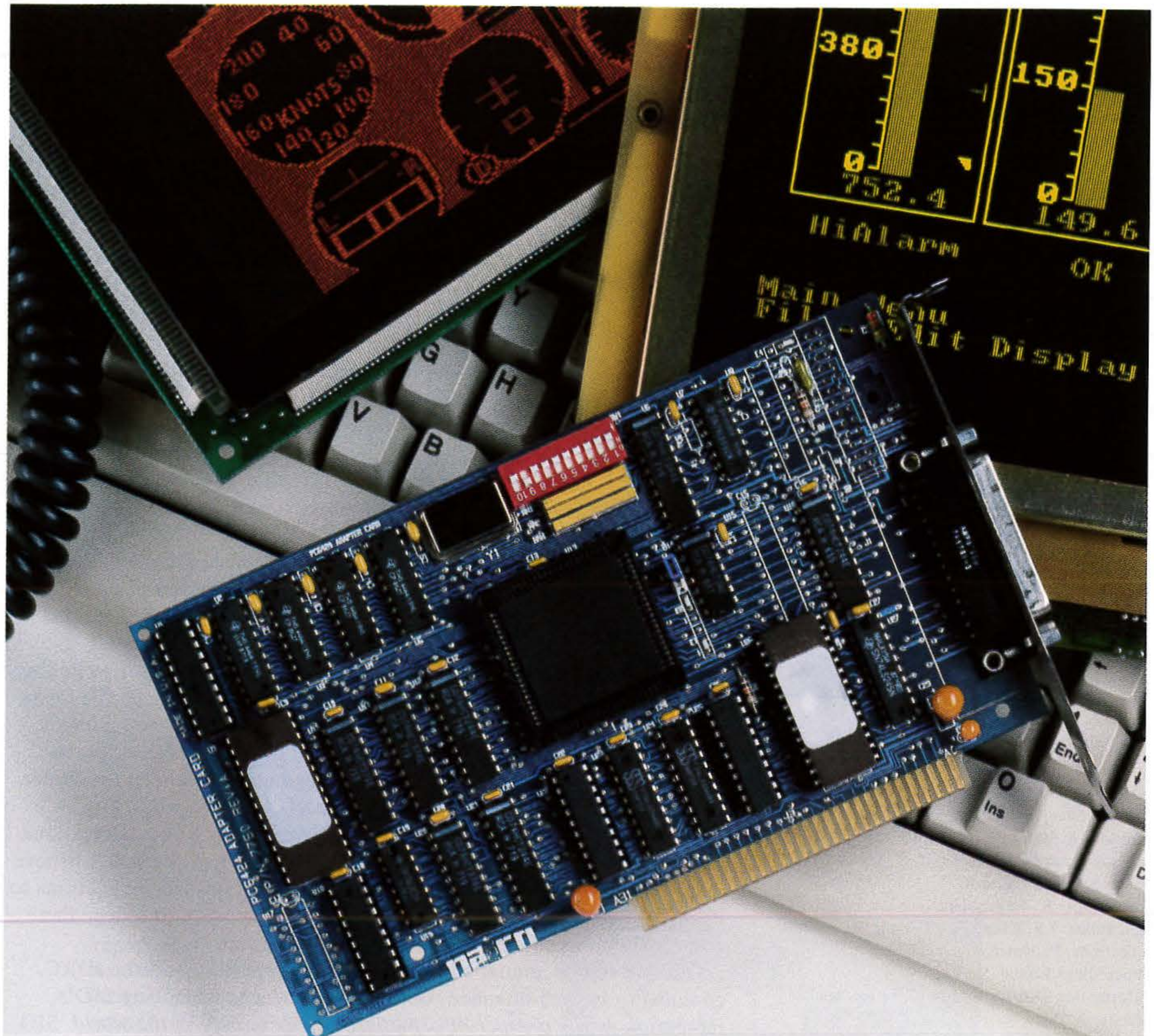
Our two major annual conferences, the Symposium and the IDRC, continue to be well-attended, both confirming and enhancing SID's reputation as *the premier information display society in the world.* SID '88 promises to set new records in almost all categories as, increasingly, our conferences are used as role models for other societies' conferences.

Two new prizes, the Karl Ferdinand Braun Prize and the Johann Gutenberg Prize, were established, replacing the society's earlier F. R. Darne Award. These prizes, each consisting of a medal and an industry-supported $2000 award, annually reaffirm SID's support for excellence and innovation in displays and hard-copy technology.

I believe our society is strong and I feel privileged to have served while we passed our quarter-century milestone. The society must continue to evolve and change with the times. We have had many serious constructive debates about our future course and the pace of change; this is healthy and must continue.

In conclusion, I would like to acknowledge and thank all the volunteers who have helped me so generously, as well as Bettye Burdett for her dedication in managing the SID headquarters office, and all my friends at Palisades Institute for Research Services, Inc., for taking care so ably of many of the society's administrative matters; you have made my term as SID president a truly enjoyable one. I wish Larry Tannas and the new board and committee chairmen the best of luck as they chart our future.

—John A. van Raalte



Circle no. 46

Celco *Micro* Color Film Recorder

35mm Slide Production

The CELCO *Micro* Color Film Recorder is the 35mm workhorse of the computer graphics industry.

- **Business Graphics**
- **Rugged design**
- **24 hr./day continuous operation**
- **Low cost**
- **Compact size**
- **Fast film recording speed:**
  —Less than 1 minute for a complex 35mm slide
- **Excellent image quality**
- **Precise addressability: 8192 x 8192**
- **Full tonal imagery: 68 billion addressable colors**
- **Optional CELCO Control Software**

CELCO introduces the 35mm workhorse to meet the rigorous demands of volume producers of high-quality business graphics.

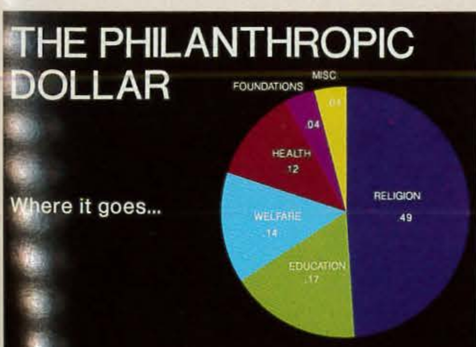
The CELCO *Micro* 35mm Color Film Recorder features fast film recording and excellent quality graphics. Colors are bright and rich.

Also featuring low cost, compact size and rugged design, the CELCO *Micro* is built to yield unprecedented reliability.

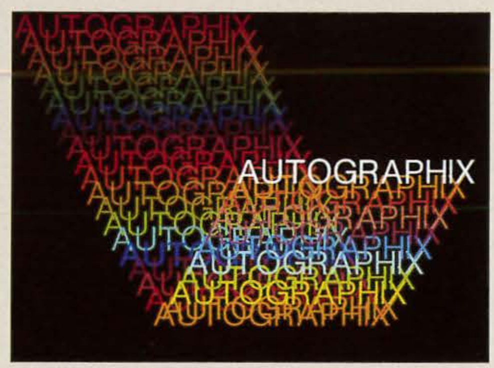
CELCO *Micro* saves time and makes money for producers of 35mm slides.

OPTIONAL CELCO CONTROL SOFTWARE

—Plotting control
—File handling
—Complete diagnostic and calibration routines
—Job Control Block (JCB) for animation files handling

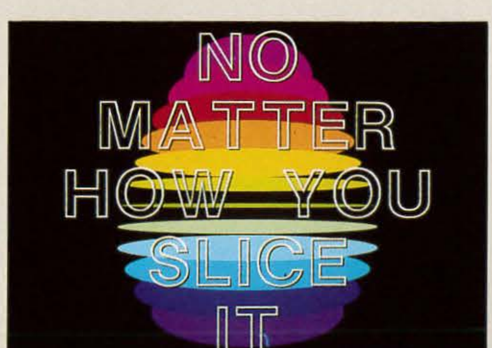


Service bureau business graphics.
Data courtesy MAGI/MAGICorp.



CELCO *Micro* saves time and money for volume producers of high quality business graphics. Data courtesy Autographix.

"Sexy Robot"
Data courtesy Ketchum Advertising for Abel Image Research, Hollywood, CA.



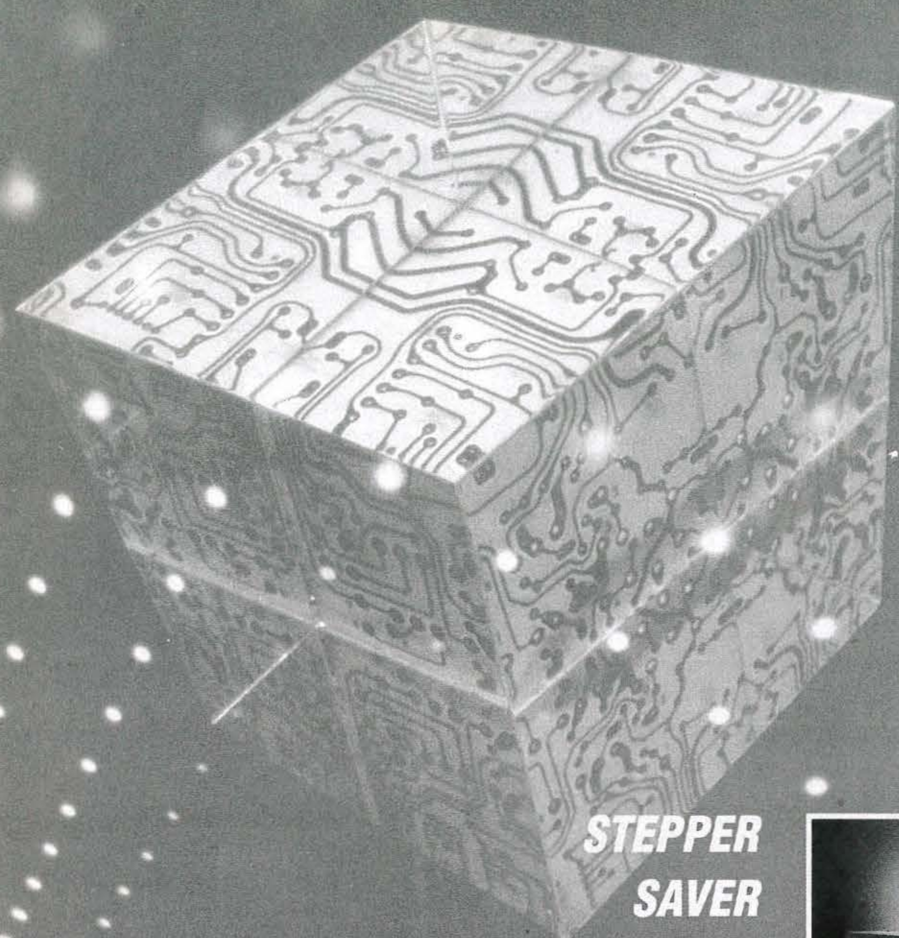
"No matter how you slice it," you never get a lemon.
Data courtesy Management Graphics

For more information, call CELCO today.

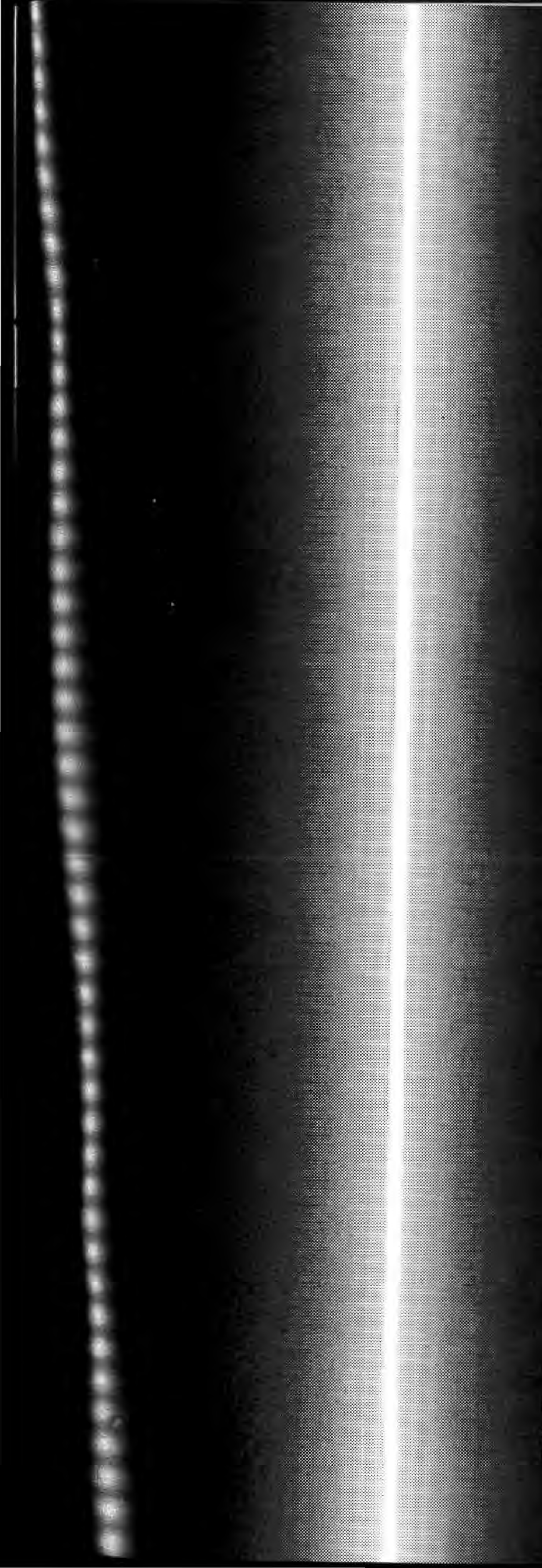
CELCO-Constantine Engineering Labs, Co.
70 Constantine Drive, Mahwah, NJ 07430
201-327-1123

CELCO, Pacific
1150 E. Eighth Street, Upland, CA 91786
714-985-9868

Circle no. 47



OPTI·BEAM 7106



Economic display design

BY CURTIS R. CARLSON

THE FINAL TEST of an imaging system comes when a viewer looks at it and says, "That's a good picture." This judgment is easily made and requires no understanding of the complex visual processing performed by the eye and brain. But that processing defied understanding until the 1950s, when Otto Schade made a major contribution by looking at the eye as part of an overall optical system and characterizing its performance using the techniques of linear systems analysis.

Schade quantified human visual sensitivity by using gratings with sinusoidal luminance profiles—the same inputs he had used for studying optical and electro-optical systems.[1] By measuring the minimum contrast necessary for detection at different spatial frequencies [Fig. 1], Schade derived the contrast-sensitivity function (CSF), which is closely related to the modulation-transfer function (MTF) familiar to engineers.

The CSF is a natural quantity to measure if the visual system is viewed as containing a single broadly tuned linear filter followed by a detector stage having

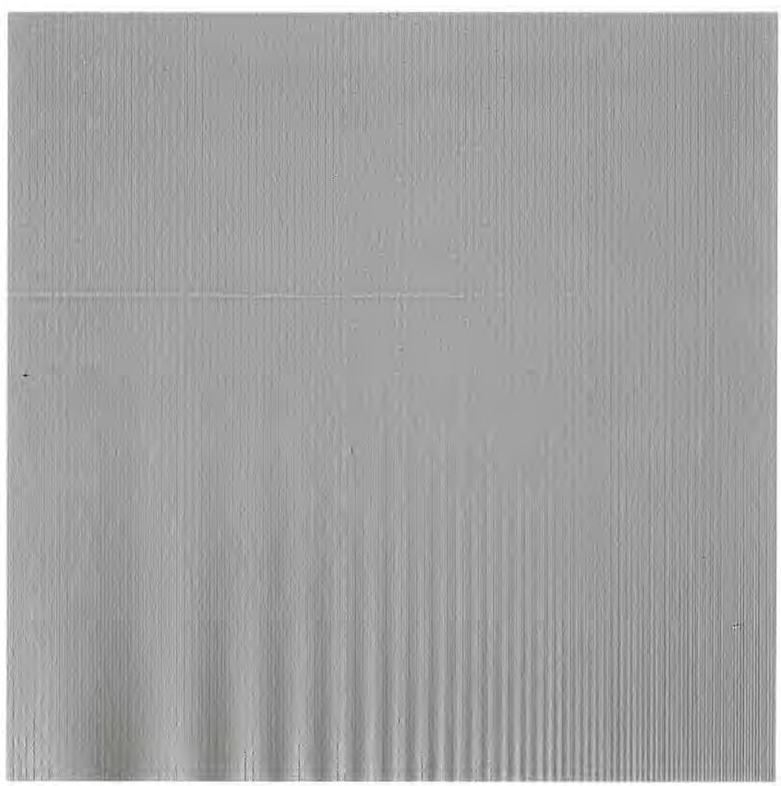


Fig. 1: This is a sinusoidal grating whose frequency is swept logarithmically along the horizontal axis and whose contrast is swept logarithmically along the vertical axis. You should see your own contrast-sensitivity function (CSF) in the form of an inverted U-shaped envelope beneath which the gratings are visible. The envelope is not in the picture, but is part of your perception of the grating. Move the page either closer to or farther from you, and the peak will shift.

Curtis R. Carlson is director of the Information Systems Research Laboratory of the David Sarnoff Research Center, Princeton, New Jersey, where he is responsible for programs in advanced image processing, artificial intelligence, computers and communications, and user interface design. He received his B.S. degree in physics from Worcester Polytechnic Institute in 1967 and his M.S. and Ph.D. degrees from Rutgers University in 1969 and 1973, respectively.

a fixed threshold. But the system is more complicated than that, and more complicated measurements are needed to model the eye effectively. The current view, pioneered by Campbell and Robson and others around 1968, is that the visual system contains a bank of spatial-frequency-tuned filters, which function more or less independently of each other.[2] In this model, the overall CSF of the eye is the sum of the CSFs of the individual filters [Fig. 2].

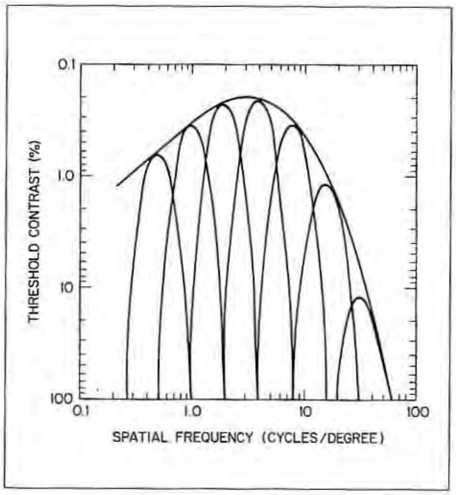


Fig. 2: The human visual system's contrast-sensitivity function can be represented as the outer envelope of a bank of spatial-frequency filters having different center frequencies.

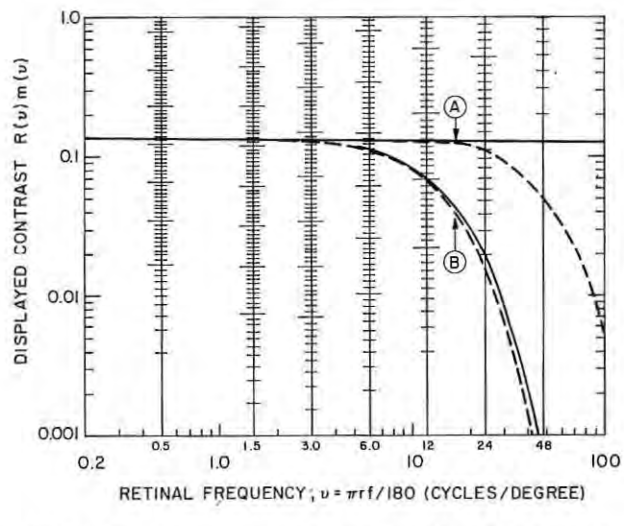
No more than meets the eye

Economic display design requires a display's performance—the resolution of future high-definition television (HDTV) systems, for example—to just match the perceptual requirements of the observer. The puzzle has been to determine what those requirements are in terms that are useful to display designers.

The JND diagram—a powerful tool for display design

The JND diagram is a simple graphical tool for converting changes in a display's modulation transfer function to just-noticeable-differences (JNDs) of perceived quality. The diagram presents displayed contrast on the vertical axis vs. retinal frequency ν—the spatial frequency of the image on the viewer's retina in cycles/degree—on the horizontal axis. (ν is obtained from the display frequency f, expressed in cycles/in., by using the equation $\nu = \pi rf/180$, where r is the viewing distance in in.) The quantity $R(\nu)$ on the vertical axis represents the display MTF; $m(\nu)$ characterizes the scene being viewed. In what follows, we will deal only with a 100% contrast edge transition [where $m(\nu) = 0.14$], so differences between curves are due only to differences between display MTFs.

The vertical lines in the JND diagram are located at the key frequencies of 0.5, 3.0, 6.0, 12, 24, and 48 cycles/degree, which are the center frequencies of the filters in the human visual system. On each vertical line the distance between adjacent tic marks indicates the change in $m(\nu)R(\nu)$ needed for an observer to perceive a 1-JND change. When JND changes occur over more than one filter, the total perceived change can be aproximated by adding the JNDs in the individual filters.



Now for an application. Curve A (the dotted line) represents the MTF of an extremely good display. There exists only one full JND, at 24 cycles/degree, between this display and a perfect one [represented by the solid horizontal line, $R(\nu) = 1$]. If the bandwidth of this display were increased infinitely, an improvement of only 1 JND would result.

This means that a potential HDTV system, for example, with a cut-off frequency of roughly 24 cycles/degree would look "perfect." This contradicts the commonly stated view that the design objective for HDTV systems should be 60 cycles/degree because that is the limiting frequency response of the visual system. For the sake of affordable HDTV, it is fortunate that such high bandwidths are not required.

Dotted curve B is typical of current television displays viewed at normal distances. Here, the increase in display bandwidth, at $R(\nu) = 0.5$, needed for a 1-JND improvement in image sharpness is only about 0.7 cycles/degree. Thus, for typical displays, perceivable increases in image sharpness can result from relatively small changes in display MTF.

—C. R. C.

(a)

(b)

(c)

Fig. 3: Analysis of just-noticeable-differences (JNDs) is a useful way of determining the perceptual effect of changes in a display system. Viewed from a distance of 18 in., there is a 3-JND degradation in image sharpness between (a) and (b). Three-JND differences are perceived by viewers 99% of the time. At 18 in., the degradation between (a) and (c) is 10 JNDs—a significant change.

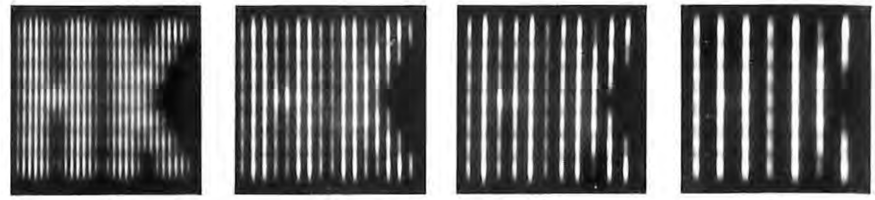


Fig. 4: The model described in this article can predict the number of samples needed to produce good renderings of alphanumeric characters. Here, a simulated HK without sampling (a) is sampled at twice the Nyquist frequency (b), at 1.5 times the Nyquist frequency (c), and at the Nyquist frequency itself (d). Viewed from a distance of 15 ft., these images correspond to the calculated predictions of Fig. 6 and compare well with them.

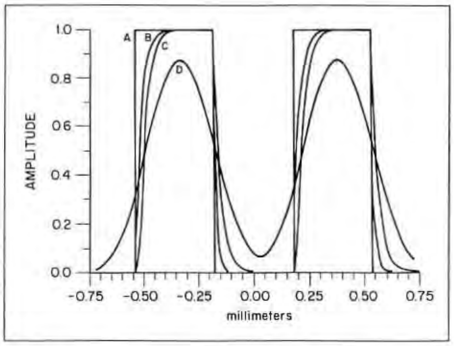


Fig. 5: The on-off-on input test image for alphanumerics (A) suffers the effects of receiver filtering (B), tube nonlinearity or gamma (C), and smoothing by a Gaussian electron spot (D).

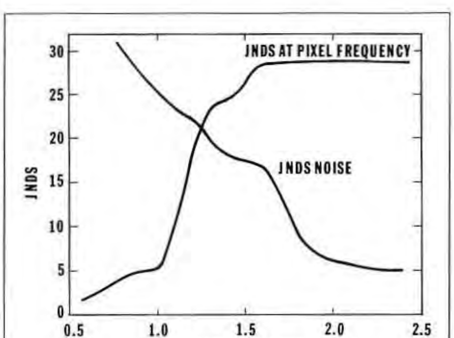


Fig. 6: The predicted number of JNDs at pixel frequency and number of JNDs of pixel noise are plotted against the number of samples, normalized to the Nyquist sampling rate. In this example the Nyquist rate is one sample per pixel. The results compare well with the simulated results of Fig. 4.

Thanks to Schade, researchers now know that the overall spatial-frequency response of a display determines its perceived image sharpness. A measure of that frequency response is given by the MTF: the ratio of the displayed contrast of sine-wave gratings to their input contrast. But when do changes in display MTF result in perceivable changes in displayed image sharpness? This question is answered by just-noticeable-difference (JND) analysis.

One JND is the amount of change a viewer will perceive 75% of the time. It's a small unit. But a 3-JND change can be seen 99% of the time, and 10-JND changes represent significant perceptual effects [Fig. 3].

Whether a change in MTF will be seen depends on what is displayed. In pictorial scenes, for example, observers are very sensitive to small changes in MTF when they look at edges. Once a scene has been selected, a model we've developed at the David Sarnoff Research Center can be used to predict visible changes in MTF. The operation of the model is straightforward—it simply converts the MTF changes within each visual filter to the appropriate number of perceived JNDs. (In addition to image sharpness, the model handles such display parameters as brightness and signal-to-noise ratio.) The model's predictions correspond nicely to experimental results.[3]

We've simplified the application of the model with a graphical representation called a JND diagram. [See accompanying article, "The JND diagram—a powerful tool for display design."]

Seeing letters and numbers

The model can also predict the number of image samples required to reproduce alphanumeric information—a determination required for all sampled imaging systems. These systems include CCDs, LCDs, and conventional tube displays (in which the sampling arises from the red, green, and blue phosphor stripes).

The problem we wish to solve arises when we sample the letter combination HK, for instance, at rates ranging from 1-2 times the Nyquist frequency [Fig. 4]. The visibility of the letters is a very strong function of the sampling rate.

In order to apply the model we must again select a test image for m(ν). Here, we select an on-off-on profile as a one-dimensional test image characterizing the information needed to replicate the letters [Fig. 5]. This image also shows how other aspects of the display system—such as receiver filtering, tube nonlinearities or gamma, and tube electron spot profiles—can be incorporated into the model. Sampling the image of Fig. 5 produces images similar to those of Fig. 4b, c, and d.

We can characterize the result of sampling by the number of JNDs of signal that can be seen, along with the JNDs of "noise" introduced by the visibility of the sampling structure. Plotting the calculations of these quantities against the number of samples produces an interesting result [Fig. 6]. The number of samples has been normalized to the Nyquist sampling rate, which, in this example, is one sample per pixel.[4] (That is, the on-off-on pattern of Fig. 5 requires three samples.) The Nyquist rate is the sampling rate at which all the information in the displayed image can theoretically be recovered. However, Fig. 4 makes it clear that the Nyquist rate is not sufficient for the visual system to see all the displayed information, a result that can be traced back to the filter bandwidths in the human visual system.

In summary, the JND model predicts:

Sampling Frequency (multiples of Nyquist frequency)	JNDs of Information	JNDs of Sampling Noise
1.0	5	26
1.5	25	18
2.0	27	6

The JND analysis indicates very poor performance at the Nyquist frequency. The visibility of the signal is low and the visible sampling noise is high [Fig. 4d]. However, nearly the full information visibility has been achieved at 1.5 times

the Nyquist frequency, although significant levels of sampling noise still remain. Finally, at 2.0 times Nyquist, in this instance, we can achieve both high levels of information visibility and low levels of sampling noise.

From knowledge, power

We now have sufficient understanding of the human visual system to quantitatively model a number of important display characteristics. Models have been developed and applied to a variety of imaging problems, such as predicting the required signal-to-noise ratio of different displays and establishing the convergence requirements for color television. They have also been used to quickly and economically design advanced display systems, such as the recent David Sarnoff Research Center proposal for advanced compatible television (ACTV), an extended-definition system with increased aspect ratio that is backward compatible with the current NTSC system.

Notes

[1]O. H. Schade, Sr., "Optical and Photoelectric Analog of the Eye," *Journal of the Optical Society of America*, Vol. 46 (1956), p. 721.

[2]F. W. Campbell and J. G. Robson, "Application of Fourier Analysis to the Visibility of Gratings," *Journal of Physiology* (London), Vol. 197 (1968), p. 551.

[3]C. R. Carlson and R. W. Cohen, "A Simple Psychophysical Model for Predicting the Visibility of Displayed Information," *Proceedings of the SID*, Vol. 21, No. 3 (1980), p. 229.

[4]Strictly, the Nyquist criterion applies only to bandlimited signals. The images described only approximately satisfy this criterion. For details, see "Application of Psychophysics to Display Evaluation" by C. R. Carlson, *Proceedings of the 1982 International Display Research Conference* (October, 1982). ■

Technical marketing case study

using displays for market differentiation

By Lee Watkins

The criteria that customers use when choosing personal computers are generally straightforward, unambiguous, and predictable. Few users, for example, would willingly buy a system that housed the slower of two microprocessors, the smaller of two disc drives, or the more awkward of two keyboards. Users tend to want the same things from most important computer components and, all else being equal, they will do their best to get them.

Of course, all else is rarely equal. Price is usually a factor in computer purchases, and a customer's desire for speed, capacity, and ergonomics is invariably tempered by budgetary realities. But with the price constraint removed, most customers have similar "wish lists." And that is a happy circumstance for computer manufacturers, who can design products with a reasonable degree of certainty about their reception in the marketplace.

The myth of the "ideal" display

But there is one important feature of computers, especially laptop computers, on which customer agreement vanishes—the screen display. Certainly, all laptop users want easy readability from their screens, but both backlit LCDs and plasma displays—the two major screen technologies in regular commercial use today—achieve this goal handily.

There are a number of other attributes of screen displays—none of them related to price—that make one or the other of these technologies better suited to a particular group of users. Knowledgeable laptop customers choose their screens based on the specific applications they have for their systems. (The lingering perception that plasma screens are inherently and always superior to LCD screens rarely persists when customers have a chance to see one of the current generation of good LCDs.)

We at GRiD have moved both to serve this fragmented market and to benefit from it by offering laptop computers with more different display technologies than any other manufacturer. (In addition to backlit LCD and plasma screens, we also sell electroluminescent (EL) screens—though mostly to government customers.)

What, then, is the most appropriate screen for a given laptop user? Six major display characteristics lead to a (usually) unambiguous answer.

Price

We will not discuss price, except to note that plasma panels are typically 3–4 times more expensive than backlit LCD modules.

Power consumption

Because laptop computers operate from batteries whenever they are "on the road," a display's power requirement is a serious concern. Here, plasma screens are at a considerable disadvantage.

A plasma screen uses 10 W of power; an LCD uses 200 mW, and its backlight uses 2 W. That fivefold difference has a substantial impact: an average LCD system will run 4 hours on a single charge; change to a plasma screen, and that time period plummets to under 2 hours. We've compensated for this to some extent in GRiD computers by providing rechargeable lightweight batteries that are easily slipped into and removed from a pocket accessible from the computer's exterior. But, compact as they are, the number of batteries a typical user would happily carry around is likely to be limited.

Portability

Plasma displays, by themselves, weigh 2 lbs. while backlit LCDs weigh 1.3 lbs. In a typical 12-lb. portable computer, the display is one of the heaviest components. And because plasma screens need more power, the power supply is usually larger, adding even more weight to the overall system. Users who spend a lot of time carrying their machines, or who actually use their laptops on their laps, are likely to find the weight difference is an important factor.

Optical response

Each pixel that makes up a screen display is "refreshed" by hardware many times a second. The amount of time it takes a newly activated pixel to become visible (or a newly deactivated one to extinguish) is the optical response time. Here, the difference between the leading technologies is dramatic: the optical response time of plasma is about 2 μsec; for LCD units, the figure is almost 50,000 times slower—about 0.8 sec. It takes many refresh cycles after an LCD pixel is changed before the change becomes visible.

Lee Watkins is director of hardware development at GRiD Systems Corporation, Fremont, California.

For the majority of computer displays, which are relatively static exhibitions of text and numbers, the LCD's slow response is not a problem. But animated displays can suffer considerably: what was intended by a programmer or an artist to be a crisp display of moving lines could turn into an undiscernible blur. Whether this should affect a purchase decision depends, of course, on the types of software the user plans on running.

Brightness and contrast

In these two related parameters, plasma systems are considered superior. In fact, it is the razor-sharp lines of plasma displays that attract most buyers to them in the first place. But, though LCD screens have less brightness and contrast than their plasma counterparts, they have enough to make them easily viewable under most indoor conditions.

But viewability indoors is not sufficient for those laptop customers who need to take their systems outdoors and use them in broad daylight. Here, both plasma and backlit LCD come up short, as both of them are washed out by sunlight. The answer for this application is a regular LCD screen, which uses reflected light and is all the brighter in the sun.

Viewing angle

Imagine a line extending outward perpendicularly from the middle of a screen. When the user's eyes are directly on this line, virtually any computer screen can be seen clearly. But when the eyes move off this line, viewability is reduced. For LCD systems, viewing angles exceeding 30° diminish viewability substantially. This is not the case with plasma, which presents no problem with viewing angle other than the foreshortening that the principles of geometry inflict on any display.

The narrow viewing angle of LCDs is usually not a concern for single users, who can adjust the screen to ensure viewability; but it is a serious liability when more than one person is looking at the system, as often happens when a laptop is used for presentations. In such cases, a viewer who is very far off axis will scarcely be able to tell whether or not the machine is turned on.

What?. . . and for whom?

With an understanding of the different laptop display technologies, we can map their individual characteristics onto the real-world applications for which users buy them.

When auditors, for instance, rely on laptops, they are usually on site and working with their machines all day—keyboard sessions of 8 hours or more are not uncommon. They are, therefore, highly concerned with issues such as eye fatigue and they are likely to prefer the crisp images of plasma devices. Plasma is also preferred by traveling sales personnel who give computer presentations to groups of prospective customers, all of whom must be able to see what is on the screen. (Another advantage plasma screens have in sales situations is the frequent perception that they are more "professional" than LCD panels, which results in a better impression.)

Field-service workers typically travel with their computers from job site to job site, which causes several concerns. Since these workers are frequently away from power supplies, they need to use their machines for long periods between rechargeings. Because they are constantly lugging their systems around with them, they want them to be as light as possible. Backlit LCD screens are usually the best answer in these cases.

Corporate managers usually work indoors in well-lit areas, and use their machines for relatively brief stretches of time—to compose a memo or examine a spreadsheet, for example. A backlit LCD, which has the added advantage of convenient portability, is often the best match.

Who supplies the display?

GRiD relies on several well-known Japanese suppliers for display screens. At present, NEC is the source for plasma displays, Hitachi for LCDs. (No North American company currently manufactures competitive modules.)

All panels are manufactured to our size specifications but are otherwise off-the-shelf units with unmodified operating specifications, though we do have close relationships with our suppliers and have often suggested features that later appeared in new panels.

Using a plasma display

Most of *Information Display's* readers are not strangers to plasma displays. But despite their rapidly increasing use, personal computers with plasma displays are not yet ubiquitous, and it is likely that most readers have not had a chance to use these machines for extended periods. To provide some sense of what it is like to use computers with these displays, GRiD Systems was kind enough to lend *ID* a GRiDCase 3 Plus laptop computer for a "test drive."

The GRiDCase 3 Plus is an IBM PC compatible personal computer with an 80C86 microprocessor and a 640×200 bit-mapped gas plasma display that measures 9.5 in. diagonally and presents 80 characters × 25 lines. The unit we received was equipped with an internal 10-Mbyte hard disc, which brought the weight of the unit, in its solid-feeling magnesium case, to 12 lbs.

The display's appearance lives up to plasma's favorable reputation. The display is admirably crisp and, to my eyes, flicker free, though plasma specialists inform me that there can be some flicker on this kind of plasma display. The soft orange color is pleasing and easy on the eyes, even over extended periods of time. The display's glass faceplate becomes warm to the touch, but not unpleasantly so.

The GRiDCase's display, as GRiD drives it, produces well-formed alphanumeric characters, most of whose strokes are more than 1 pixel wide. Although a slide switch at the lower right corner of the panel allows three levels of brightness through changing the sustain frequency, there is no provision for selectively brightening certain characters. Therefore, the kind of highlighting usually done on CRTs by brightening characters is done on the GRiDCase's screen by displaying the characters with strokes just 1 pixel wide—"lightface" rather than "boldface."

The display washes out readily in the early afternoon sunlight that shines through my office's south-facing windows. The amber CRT sitting next to the plasma display does quite a bit better on its maximum brightness—it is readable with great difficulty instead of being completely unreadable.

The plasma display's power consumption is not helped by the internal hard disc. A fully charged battery lasts about 1 hour during my straightforward word-processing sessions. GRiD has taken measures to deal with the battery's final Ampere-seconds: a red light goes on in the lower right corner of the display's frame. If you see it, and if you're fast, you have time to save what you're working on, exit from your applications program to the operating system, and turn off the machine. You can then replace the battery in a matter of seconds or substitute the ac power supply, which is the same size as the battery and slips into the same easily accessible pocket.

—K.I.W.

Engineers know best, but the customer is always right

Even when skilled application engineers carefully discuss anticipated uses with customers and explain to them the relevant characteristics of each display, more than a few consumers end up buying systems that are "wrong" for them—and many of these customers remain pleased with their purchases. When that occurs, a manufacturer has no choice but to assume that customers do, in fact, know best, and that they should be left to their own (display) devices. ■

In memoriam

Dave Glaser, display scientist for Cherry Display Products Corp., died on March 29. He was 61 years old. Dave held numerous patents and authored several papers in the information-display field while he worked for Burroughs, Zenith, Lucitron, and Cherry. He co-founded Panel Technology, Inc., and worked for many years as a consultant for both display manufacturers and users. His technical contributions and his unique personality will be sadly missed by friends and colleagues.

Multilayer Interference Program

by Sound Decisions, 6646 Clearhaven Circle, Dallas, TX 75252. $135 plus $4 shipping.

Reviewed by WARREN J. SMITH

The Multilayer Interference Program (MIP) is a computer program that calculates the reflection and transmission of thin-film coatings. It will handle absorbing or nonabsorbing coatings and will calculate their characteristics at normal or oblique incidence. In addition to reflection and transmission values, the program will calculate the ellipsometric principal azimuth angle and phase angle.

This is a basic program that simply calculates the characteristics of a given film structure. It does not have optimization ("automatic design") capability, so that, unless the user is reasonably expert in thin-film design, it will not be very useful as a design tool.

MIP does, however, have a number of convenient features. One may choose almost any numerical aspect of the calculation as a variable and have the program print or plot a performance characteristic (e.g., transmission or reflection) as a function of that variable. Thus, plots of transmission vs. angle of incidence, or wavelength, or the thickness of a given layer, for example, are easy and convenient to obtain.

The program does this sort of thing "one at a time" so that one can get reflection *or* transmission, but not both, in one pass. To get both, one repeats the output sequence.

With a certain amount of design savvy, one could design a thin-film system by manually optimizing the value of one variable, accepting only a fraction of the optimum change, and then going on to the next variable, and so on, until all the variables had been adjusted. Several iterations of this procedure could result in a design comparable to that produced by an automatic optimization program, although the amount of labor involved would be more than a little overwhelming.

Manipulation of the program by a menu screen is reasonably convenient once one gets used to it. However, as with most "user friendly" interfaces, one sometimes wonders if the alleged friendship is worth the trouble.

I compared the results of several calculations on MIP with Genesee Computer Center's THIN FILMS program (one of the larger comprehensive programs, which includes automatic optimization and many "deluxe" features). Given the same input data, the two programs produced the same results. On my 8087-equipped IBM PC they did it in what seemed at first blush to be almost the same time. For example, MIP took about 17 sec to output the reflection of a 7-layer stack for wavelengths from 0.4–0.7 μm in 0.01-μm steps. The GCC THIN FILMS program took 13 sec. *But*, it also printed out transmission, YR, and YI and made a printer plot of the reflection at the same time.

The MIP program will not accept dispersive index data, so that if there is a significant change of index in the spectral bandpass of interest, the user must change it manually and rerun the data through the program for each segment of the bandpass.

MIP, at a price of $134 plus $4 shipping, is the lowest-priced thin-film program that I know of. Its capabilities are limited to the basic calculations, without any frills. It is accurate and reasonably fast. Thus, if one has a need for an occasional interference-film calculation, MIP should fill that need and it is certainly well worth the price.

MIP requires an IBM PC, PC-XT, PC-AT, or compatible computer with MS-DOS or PC-DOS version 2.0 or later; 160K RAM; disc drive (hard or double-sided floppy); and an 80-character display. An IBM, Compaq, or Hercules graphic option will allow one to see the graphics produced on the monitor. An 8087 coprocessor is optional. ■

Warren J. Smith is chief scientist at Kaiser Electro-Optics, Inc., Carlsbad, California. He has worked in lens design, optical engineering, and optical manufacturing for many years. His book Modern Optical Engineering *is widely used as a text and is considered by many to be the current definitive work on the development of optical systems.*

◄ Circle no. 53

Circle no. 54

products on display

AD-VANCE MAGNETICS, INC.
Rochester, IN 219/223-3158
Booths 128, 130

Protection for flexible discs

Infogard is a magnetically shielded enclosure that protects flexible computer discs from distortion, erasure, or degradation of valuable recorded data. Damage to recorded data could occur from a variety of causes: local severe thunderstorms, power generating equipment, electromagnetic pulse, airline transport, and ambient magnetic pollution. Infogard provides inexpensive protection against these hazards while discs are being stored or transported. Laboratory tests indicate a shielding effectiveness in excess of 35 dB through an applied frequency range of 1–25 Os. Available for 5 1/4- or 8-in. flexible discs.

Circle no. 1

ASAHI GLASS CO., LTD.
Tokyo, Japan 03-218-5426
Booths 415, 417

Full-color 9-in. LCD

Optrex Corp., a joint venture by Asahi Glass and Mitsubishi Electric, reports that it has produced the largest full-color LCD ever made with simple matrix technology. The display has a viewing area of 180 × 140 mm, equal to a 9-in. TV screen. The number of pixels is 320 (RGB) × 240 and the size is 0.57 mm square. With a backlight, it produces very high contrast of 22:1 (maximum).

Circle no. 2

BREWER SCIENCE, INC.
Rolla, MO 314/364-0300
Booth 404

Polyimide color filter materials

Brewer Science, Inc., introduces PIC®, polyimide color filter materials developed for the production of high-quality multicolor displays, color camera chips, and color copiers. PIC offers outstanding colors, which are uniform and reproducible. These filters can be patterned on one level using standard positive photoresist equipment and processes. The simple photolithographic process gives high yields even with very large substrates. Excellent light and heat stability make PIC perfect for harsh environments. A special technology transfer program allows your lab to produce three-color devices successfully in three days or less.

Circle no. 3

CELCO (Constantine Engineering Labs. Co.)
Upland, CA 714/985-9868
Booths 427, 429

Crosshatch/dot generator

The model CHD359B crosshatch/dot generator from CELCO provides crosshatch and dot patterns for CRT system evaluation. A unique vector design provides extremely accurate and stable crosshatch and dot patterns suitable for testing even the highest-resolution CRTs. The CHD359B provides 9–81 dots or crosshatch scan lines in three discrete ranges. Its 12-bit accuracy makes it ideal for evaluating important CRT parameters such as resolution, linearity, and pincushion distortion.

Circle no. 4

CITRONIX, INC.
Orangevale, CA 916/961-1398
Booth 325

Raster/calligraphic deflection amp

The CD-100-6RS combines the best of two CRT beam-deflection techniques—energy-free resonance retrace and linear feedback control for line trace or calligraphic-mode presentation—all in one frame. This deflection amplifier can retrace a beam in less than 2 μsec with a 30-μH yoke at 30 APP. After retrace you can continue in the raster mode with precision geometrically corrected raster lines or switch to the calligraphic mode and stroke write high-resolution images with a closed loop bandwidth of up to 2 MHz.

Circle no. 5

CONNECTOR CORP.
Chicago, IL 312/539-3108
Booth 216

CRT sockets

Connector Corp. will exhibit its expanding line of sockets for CRTs. Socket families are available for most JEDEC-base configurations and those not so designated. Most sockets feature the new rugged tube-neck retaining clamp that secures the socket to the tube base to withstand shock and vibration during instrument operation and shipping. Most sockets also feature protective spark gaps, wrap-around contacts with tapered entries, and optional integral circuit components. They are available with flying wire leads, printed-circuit pins, or solder tail terminals.

Circle no. 6

CORNING GLASS WORKS
Corning, NY 607/974-4308
Booths 116, 118

High-temperature alkali-free glass

Corning Japan KK now supplies a new non-alkali boroaluminosilicate-glass substrate: Corning Code 1733. This new glass substrate has a high strain point, 640°C, and a coefficient of thermal expansion of 36 × 10^{-7}/°C, which is close to that of silicon. This new substrate was developed in response to requests by display manufacturers for a commercial glass meeting the high-temperature requirements of advanced electroluminescent and polysilicon displays. The glass is manufactured in the United States and finished in Japan. Current production capacity is 300,000 m^2/year. Corning 1733 is available in thicknesses of 0.5, 0.7, 0.9, and 1.1 mm. Maximum product size is 900 × 800 mm.

Circle no. 7

CR TECHNOLOGY, INC.
Laguna Hills, CA 714/859-4011
Booth 307

Automated CRT test system

The new CRT-480 test system uses machine vision to automate the CRT production line or incoming test station. CRT inspection, adjustment, and calibration tasks are conducted in a programmed sequence of test steps. All measurements, calculations, and controls are performed by the CR Technology PC-AT 80386-based Vision Test Controller, with interactive prompts for operator response. The test sequence includes tests for brightness, rotation/tilt, vertical/horizontal size, centering, and linearity. For color monitors, purity, focus, and convergence tests are optional.

Circle no. 8

CRAFT DATA, INC.
Mission Viejo, CA 714/582-8284
Booth 531

Gas plasma panel assemblies

Craft Data, Inc., now offers Dixy Corp. gas plasma panels with or without IR touch panel and RS232C, EGA, or composite video interface as an assembled, tested module complete with filter, bezel, cables, and software to get started. Finished dimensions using a 12-in. display and touch panel are 13 in. (L) × 8 1/2 in. (H) × 3 in. (W). The power supply is left unmounted.

Circle no. 9

MAKE FAST, COMPREHENSIVE, AUTOMATIC CRT MEASUREMENTS WITH THE SUPERSPOT 100 FROM MICROVISION

CRT MEASUREMENT SYSTEM FROM MICROVISION

The **SUPERSPOT 100** System coupled with the **SPOTSEEKER II** Positioning System (with Automatic Focus) allows fully automatic characterization of Color and Monochrome CRT Displays without operator intervention.

Measures:

- Luminance (Footlamberts & Nits) • Line Width, Including Color Line Width (Gaussian Fit) (1 Second)
- Color Misconvergence (2 Seconds) • Linearity, Pincushion and Focus • Line Jitter, Swim and Drift
- Contour Maps of Spots, Lines or Characters (10 Seconds) • Beam Landing & Crowding
- FFT for Discrete Frequency Spectra (1024 points in one second) • High Voltage Regulation Tests
- Real Time Display of Beam Intensity Profile (20 Frames/Second Display) • Disk Data Logging • MTF

Provides:

- Pattern Generation for Tests • Adjustable Cursors for Feature Analysis

MICROVISION • 591 West Hamilton Avenue, Suite 250, Campbell, CA 95008 • Tel: 408/374-3158 • FAX: 408/374-9394

Circle no. 55

Draw from a full line

Corning now offers more than 120 types of small special-purpose CRT bulbs, ranging in size from .5" to 17", in round, rectangular, and fiber optic designs.

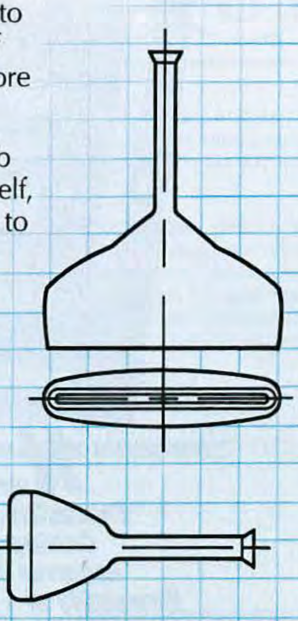
Non-browning bulbs are also available for optimum performance displays in high-voltage applications.

And the superior light transmission of Corning bulbs offers the brightness required for military applications, such as cockpit displays.

We can also deliver small bulbs with precision tolerances for high-resolution applications. Neck diameters are consistently held to within 0.005", and alignment of centerface to neck varies no more than 0.040".

Call on Corning for all your bulb needs. You can order off-the-shelf, or we can custom design bulbs to your specs.

To get free technical information about Corning's CRT bulbs, circle the reader service number.



The solutions people

Materials Business
Corning Glass Works
MP 21-3-4
Corning, NY 14831
(607) 974-4305

CORNING

Circle no. 56

Circle no. 57

Circle no. 58

products on display

DAVID SARNOFF RESEARCH CENTER
Princeton, NJ 609/734-3017
Booth 426

CRT design, analysis, simulation

The David Sarnoff Research Center provides client-confidential contract services in the design, analysis, and simulation of nonconsumer CRT systems, electron guns, and deflection yokes. Using its state-of-the-art 3D electron-optics software, The Sarnoff Center can optimize bipotential or multilens gun designs or saddle, toroidal, or stator-wound yokes with or without permeable pieces. Computer programs determine the part dimension and alignment tolerances necessary to maintain performance. Services include prototype construction and the measurement of yoke fields, spot contours, and convergence.

Circle no. 10

DIGITAL ELECTRONICS CORP.
Hayward, CA 415/471-4700
Booths 229, 231

Industrial touch-screen terminal

The new SealTouch Terminal from DeeCO is an extremely thin compact VT-220 compatible NEMA 4 & 12 rated touch-screen terminal that withstands harsh industrial environments. The electroluminescent 9-in.-diagonal flat-panel display with IR touch interaction is completely sealed in cast aluminum. There are no fans or filters, so contaminants don't get in or out. The small—10 1/2 in. (W) × 11 1/2 in. (H) × 3 in. (D)—lightweight unit can be mounted conveniently on walls, benches, desks, or equipment. VT-220, VT-100, and VT-52 emulations are standard.

Circle no. 11

DIXY CORP.
Yokokama, Japan 045-962-1717
Booths 524, 526

Plasma panel with gray scale

Dixy Corp. has developed a 640 × 480 pixel flat-panel plasma display capable of 16 levels of gray scale. Pixel pitch is 0.39 × 0.39 mm. Viewing angle is 115° up/down and viewing area is 256 × 195 mm. Input signal required is 4-bit parallel TTL. This display uses a unique capacitive coupled trigger, developed by Dixy, which allows the nondisplay areas to remain black for maximum contrast ratio.

Circle no. 12

DONTECH, INC.
Doylestown, PA 215/348-5010
Booth 205

EMI/TEMPEST windows

Dontech, Inc., manufactures EMI/TEMPEST windows and optical filters for CRTs, LEDs, EL, plasma, and touch-panel displays. Dontech also makes shielded structural windows to 5 × 12 ft., fleximeric shielding, narrow bandpass filters (P43, night-vision-compatible, etc.), and antireflection contrast-enhancement panels.

Circle no. 13

EG&G GAMMA SCIENTIFIC
San Diego, CA 619/279-8034
Booths 300, 401

Convergence measurements

EG&G Gamma Scientific's C-11CNV system was developed to quickly and accurately measure the spatial convergence of up to three different spectral components of stroke and raster color displays. For the first time, accurate and repeatable convergence measurements can be made without external connections to the monitor deflection amplifier circuits. The computer-controlled system is ideal for use in the manufacturing of color CRT displays, particularly those used in CAD/CAM and graphic art applications.

Circle no. 14

ELFORM, INC.
Reno, NV 702/356-1734
Booth 125

Anisotropic conductive tape

Anisotropic conductive tape, as a film or as part of a heat seal connector, makes it easy to attach flexible circuitry to rigid substrates without solder. Heat and pressure is all that's required. Gold particles up to 30 μm in size are distributed in a 10-μm layer of hot-melt thermoset resin with 30–40 particles/mm^2. As long as spaces are 0.002 in. or greater, this material will not create electrical shorts. The conductivity is then in the Z-axis only. Allow for about 5 Ω of contact resistance and 0.05 $\Omega/\square$ trace resistance. Elform also manufactures a vacuum-deposited anisotropic type of heat seal connector having a pitch of 0.20 mm.

Circle no. 15

FINLUX, INC.
Cupertino, CA 408/725-1972
Booth 214

High-resolution EL matrix display

The Finlux MD640.350 is a new high-resolution electroluminescent (EL) matrix display designed for high-end personal computers, instruments, factory terminals, and process controllers that will benefit from added resolution. The display is EGA-compatible and supports both high-quality text—from 25 lines of 80 characters—and detailed high-resolution graphics. Crisp stable flicker-free images in a pleasing yellow color are Produced by means of a-sub-wavelength thin light-emitting EL phosphor layer. The display has a resolution of 13.8 mils (V) and 11 mils (H). Power consumption is typically less than 16 W. The EL panel and an electronic board containing the drive and controlling electronics are assembled into a package less than 0.5 in. thick.

Circle no. 17

products on display

GTE PRODUCTS CORP.
Greenland, NH 603/436-8900
Booth 518

Lightweight compact EL display

The Sylvania GTE DM512256-01 is a flat lightweight ac thin-film electroluminescent (EL) display module. Engineered to weigh 16 oz. and be only 0.530 in. thick, this display module can be the solution to many space-limited design problems. Its pleasing light-emitting yellow-orange color, flicker-free performance, 512 × 256 resolution, and individually addressed pixels all contribute to a less-tiring more-efficient work environment. In addition, the greater than 140° viewing angle allows more than one person to use the display at the same time.

Circle no. 18

HOYA ELECTRONICS CORP.
Woodcliff Lake, NJ 201/307-0003
Booth 330

Materials for flat-panel production

Hoya Electronics employs special substrate preparation, film-deposition techniques, and patterning methods to provide not only superior quality materials for flat panels but also products required to fabricate the panels. Products and materials to be exhibited include: large blanks, large masks, quartz wafers with thin-film ITO-on-glass plates, patterned ITO display panels, antireflection coatings on glass, a wide variety of electroconductive metal films on glass for electrocircuit application (Al, AlCu, Ti, Ta, W, MoSi, Cr), patterned electroconductive metal films, and display color filter information.

Circle no. 19

HOYA OPTICS, INC.
Fremont, CA 415/490-1880
Booth 328

Q-switch laser for LCD repair

Hoya Optics now offers a 10-mJ Q-switched laser for LCD micromachining. The compact laser head is easily interfaced directly to microscopes. The 1064-nm wavelength output is ideally suited for LCD and mask repair, resistor trimming, thin-film thermal-head trimming, and IC wafer-pattern cutting, including real-time circuit repair and diagnosis. LCD repair can double LCD screen yields leading to significant increases in profits of high-volume LCD devices.

Circle no. 20

Our smallest performer gives a brilliant display.

Among special purpose cathode ray tubes, the Hughes Model H-1401 one-half inch tube for helmet-mounted displays outclasses and outsells any similar tube in the industry. Its high brightness and fine resolution characterize our entire line. Hughes is the leader in the design and production of special purpose CRTs—a leadership position maintained by ongoing research and development that sets industry standards for innovation and refinement in CRT technology.

Hughes special-purpose CRTs range in size from one-half-inch diameter to thirteen inch diagonals. They serve avionics, ground vehicles, manportable displays, helmet-mounted displays and high-performance commercial applications such as phototypesetting and medical research.

Model 1401, actual size.

Hughes has one of the world's finest engineering and technical facilities devoted to CRT production. High manufacturing and testing standards result in the production of tubes of consistent performance, outstanding brightness and resolution factors, low power consumption and high reliability.

For total CRT capability—off the shelf or custom—look to Hughes. You are invited to examine our facilities and discuss your exact requirements. Call (619) 931-3587 or write: Hughes Aircraft Company, 6155 El Camino Real Carlsbad, CA 92009

Circle no. 62

HUGHES
AIRCRAFT COMPANY

Circle no. 63

Circle no. 64

HUGHES AIRCRAFT CO.
Carlsbad, CA 619/931-3000
Booths 408, 410, 509

High-brightness CRT

Significant improvements in brightness and resolution for 1-in. CRTs have been achieved by Hughes Aircraft Company's Industrial Products Division. Through the combined efforts of Hughes and the Armstrong Aerospace Research Laboratory at Wright-Patterson AFB, a new 1-in. tube type for helmet-mounted display has been developed. This new tube, designated the H1426, has twice the light output and one-half the line width of previous models: up to 5000 fL (peak) and 0.8 mils (scanned at 50%).

Circle no. 21

INTERNATIONAL PLANNING INFORMATION/STANFORD RESOURCES
Redwood City, CA 415/364-9040
Booth 510

Enhanced-LCD market study

Stanford Resources, in a new report, forecasts that the worldwide market for enhanced-LCD flat-panel displays will grow from $450 million in 1988 to nearly $2 billion in 1994. This sales growth will be driven by the use of these displays in new product applications. Two of the key uses for flat-panel displays will be pocket color television receivers and portable microcomputers. Other important 1994 market segments include application-specific computer terminals, automotive instruments, electronic typewriters, word processors, and industrial and medical equipment.

Circle no. 22

KELTRON CORP.
Waltham, MA 617/894-8700
Booth 430

Beam-penetration color power supply

Beam-penetration technology offers the CRT designer the ultimate in resolution for large bright high-contrast color displays, made possible by the elimination of the shadow mask. Four colors—red, orange, yellow, and green—selected by anode voltage, can be drawn with the resolution of a monochrome CRT. The Model HC17 power supply can switch through all four colors up to 120 times/sec for flicker-free display.

Circle no. 23

MICROVISION
Cambpell, CA 408/374-3158
Booths 327, 329

Test system for CRT production

Microvision announces their latest product for high-volume production testing of both monochrome and color CRT systems. The PRD-1 will completely characterize a CRT in 10 sec, making simultaneous measurements at up to 16 different locations on the CRT face. The PRD-1 makes high-resolution measurements of pincushion error, raster size and position, line width (focus), intensity, MTFr, and jitter. The PRD-2 makes similar measurements plus convergence. User-friendly displays assist in real-time adjustments of out-of-spec parameters.

Circle no. 24

OPTICAL DEVICES, INC.
Camarillo, CA 805/987-8801
Booth 419

Contrast-enhancement and shielding

Optical Devices, Inc. (ODI) is a full-service contrast-enhancement and shielding filter manufacturer. ODI combines sophisticated coating technologies with bandpass elements and polarizers to provide filters for all display technologies, for both commercial and military applications. ODI's high-temperature polarizers and ANVIS filters are examples of recent announcements.

Circle no. 25

PHOTO RESEARCH SPECTRAMETRICS
Division of Kollmorgen
Chatsworth, CA 818/341-5151
Booths 211, 213, 215

Video photometer

The new PR-900 Video Photometer increases the speed and accuracy of displays analysis. It functions in a wide range of ATE environments, performing spatial, photometric, and colorimetric inspection of color and monochrome CRTs, flat-panel displays, and other image-producing systems. The system measures luminance, luminance profiles in two or three dimensions, display uniformity (including pseudocolor presentation), line width, and character size, at video frame rates. Chromaticity, misconvergence, and MTF measurement modules are optional, as is an autofocus capability for automatic measurement across curved or skewed surfaces. Prices begin at $30,000.

Circle no. 26

PHOTONICS TECHNOLOGY, INC.
Northwood, OH 419/666-0762
Booths 309, 311

1.5-m dot-matrix display

Photonics Technology is the manufacturer of the world's largest (1.5 m) nonprojected fully populated dot-matrix display. Photonics produces ac plasma gas-discharge display terminals ranging in size from 256 × 256 (10 cm) to 2048 × 2048 (1.5 m).

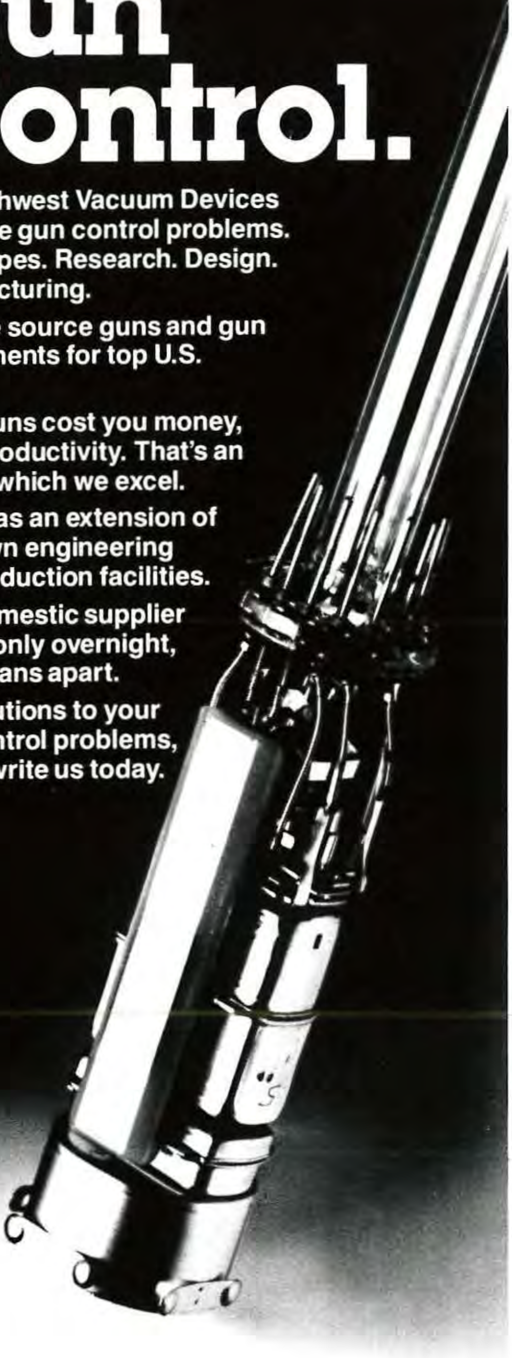
Circle no. 27

PTK/RANTEK DIVISION
Emerson Electric Co.
Los Osos, CA 805/528-5858
Booths 306, 308

High-voltage power supplies

The LCC series commercial high-voltage power supplies (HVPS) for monochrome displays provide multiple outputs, tight regulation, low ripple, overvoltage protection, compact packaging, and reliable operation with MTBF in excess of 100,000 hours. The CDC series commercial HVPS for color and very-high-resolution monochrome displays provide anode, focus, grids, and B+ outputs with DF input capability. Features include overvoltage protection, remote ON/OFF, low ripple, and tight regulation. High-volume manufacturing allows PTK to offer these HVPS at extremely low prices. The new LCM series HV lead assemblies and connectors are LGH-compatible, MIL-qualified, and low cost.

Circle no. 28



RANK BRIMAR, LTD.
Manchester, U.K. 061-681-7072
Booths 127, 129

Shadow-mask color tube for avionics

A new rugged shadow-mask color CRT specifically designed for military cockpit display is available from Rank Brimar. This 127-mm square flat-faced tube is the first of a range of color tubes being developed. The tube has a stretch mask, 0.2-mm resolution (dot triad pitch), and the high brightness needed for cockpit displays. The tube is fully encapsulated, with all coils, in a mumetal shield and is fitted with flying leads. A special optical filter with antireflective coating is optional.

Circle no. 29

SCHOTT AMERICA
Yonkers, NY 914/968-8900
Booths 317, 319

Contrast-enhancement filters

Schott Glass Technologies, Inc., has developed a high-contrast-enhancement filter for use in full-color displays: the S-8806 high-transmittance triple-notch contrast-enhancement filter. A 2.5-mm thickness has the following characteristics:

Wavelength (nm)	Transmittance
445	82.5 ±2.5%
555	69.5 ±2.5%
580	0.25±0.25%
618	80.0 ±2.5%

Circle no. 30

SONY CORP. OF AMERICA
San Diego, CA 619/487-8500
Booths 200, 201, 301

High-resolution color raster display

The DDM2801C from Sony Corp. is the largest super-high-resolution color raster display currently available. It provides 2048×2048 resolution at a 60-Hz noninterlaced refresh rate on a 20×20 in. flat screen, with a video bandwidth of up to 300 MHz. This color diplay uses Sony's Trinitron technology, which combines a single electron gun and an exclusive aperture grill to improve display quality over ordinary color raster display devices. The DDM2801C is virtually distortion free, allowing 0.1-in.-high characters to be easily read anywhere on the 400-in.^{2} screen.

Circle no. 31

Circle no. 70

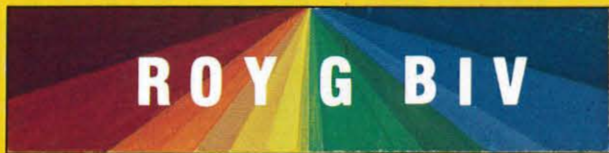
TEAM SYSTEMS
Santa Clara, CA 408/720-8877
Booths 222, 224

High-resolution video printer

Test & Measurement Systems, Inc., in cooperation with Toyo Corp. of Tokyo, Japan, is now offering the new Model TP-6490 video printer for all high-resolution and very fine gray-scale applications. The TP-6490 provides 64 levels of gray scale per pixel or dot and a resolution of up to 1280 dots/line and 1024 lines/frame. It incorporates the TEAM Systems TP-115 high-resolution video printer, a thermal printhead with 300 dots/in. resolution. It has a built-in frame memory to capture any black-and-white or gray-scale picture from today's high-resolution monitors. The printout is made from this fast memory in up to 40 sec/print. A redesigned video interface allows easy setup for different signal conditions. Price is $6950 each.

Circle no. 32

AD-MU SHIELDING DOES ENHANCE EMI SENSITIVE COLOR DISPLAYS FOR



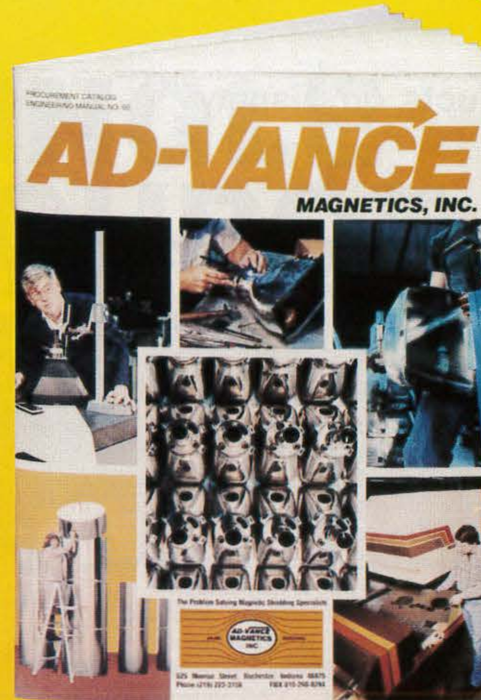
Achieve high quality hues and sharper color definition for avionics, computer graphics, medical instrumentation, military and other critical color image applications.

A properly selected shielding alloy . . . placed around or adjacent to a circuit component . . . suppresses radiated magnetic fields interferring with other nearby components, or vice versa.

That's how AD-MU shielding alloys solve your problem.

56 pages of this 84-page Procurement Catalog/Engineering Manual contains useful technical data covering the entire magnetic shielding field; 28 pages consist of usual catalog type data.

Just request this vital helpful data on your letterhead and it's yours.

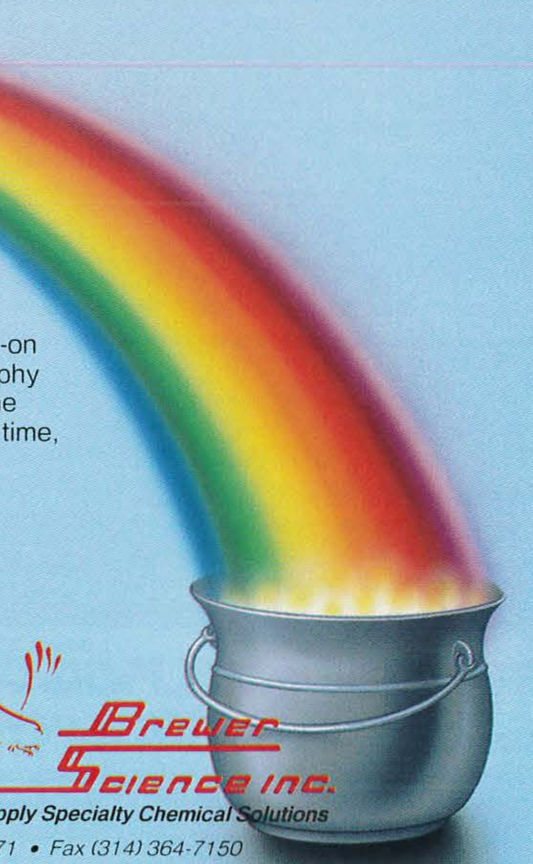


AD-VANCE MAGNETICS, INC.

625 MONROE STREET, ROCHESTER, INDIANA 46975
(219) 223-ADMU

The Problem Solving Magnetic Shielding Specialists—4 Decades of Magnetic Shielding Leadership

Circle no. 71



The Color of Profits

The Brewer Science PiC products provide the highest quality multicolor process available . . . a process which uses a spin-on technique, can be integrated into any standard photolithography equipment, and results in fewer defects and higher yields. The PiC technology provides more precise color, and at the same time, increases your profits dramatically!

PiC is a polyimide color filter material for production of multicolor displays, color camera chips and color copiers.

Process Advantages

- Compatible with positive photoresists and developers
- Resolution to 6 microns
- All colors patterned onto one level
- Yields of 95% and higher
- Implementation in just two days
- Outstanding coating uniformity
- Excellent light and thermal stability

Achieve the ultimate in color filter technology and discover the color of profits with PiC.

Brewer Science inc.
Supply Specialty Chemical Solutions

P.O. Box GG • Rolla, MO 65401 • USA • (314) 364-0300 • Telex 361471 • Fax (314) 364-7150

Circle no. 72

THOMSON ELECTRON TUBES & DEVICES CORP.
Dover, NJ 201/328-1400
Booths 312, 314

19-in. color shadow-mask CRT

Thomson's 19-in. color shadow-mask CRT has been ruggedized to meet full MIL-SPEC requirements and employs a specially developed and patented saddle-saddle shieldable deflection coil design. Instead of convergence magnets, convergence coils unitized with the deflection yoke make it possible to achieve stable purity and convergence in a wide operating temperature range.

Circle no. 33

TOSHIBA AMERICA, INC.
Deerfield, IL 312/945-1500
Booth 520

21-in. flat-square color tube

A 21-in. high-resolution flat and square color display tube from Toshiba's Electron Tubes & Devices Division uses a new electron gun design to achieve 30% better focus at the screen periphery. The DAC-QPF electron gun has six electrodes so that it can operate as a compensating four-pole lens for both horizontal and vertical astigmatism. A dynamic voltage of up to 800 V is applied to this quadrapole lens to control it according to the deflection value from the center to corners of the screen, which corrects the astigmatism of the electron-beam spot in the screen corner.

Circle no. 34

WELLS-GARDNER ELECTRONICS CORP.
Chicago, IL 312/252-8220
Booth 413

Industrial-grade touch screen

The Cyclops ES series, an optical touch screen with only one LED and one CCD detector, has recently been released in a ruggedized industrial version for outdoor harsh environments. This model has been tested to meet the following environmental requirements: −40°C to +85°C temperature range; operational in direct sunlight; and able to withstand high vibration, severe thermal shock, and rapid changes in temperature and humidity. The ruggedized version is available in 5- and 9-in. sizes for CRT applications and in 4×8 in., 4×9 in., and 5×8 in. sizes for flat-panel applications. ■

Circle no. 35

Circle no. 73

Circle no. 74

HVCMOS® IMAGING

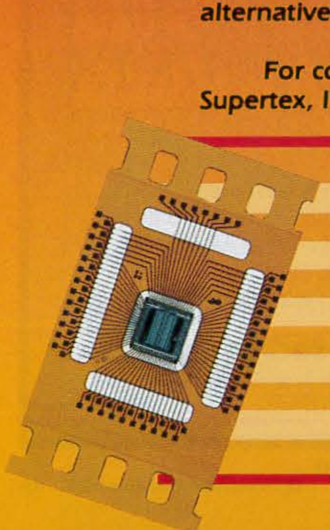
Supertex inc.

Leadership in CMOS/DMOS Technologies

Pushing the leading edge of display technology, the Supertex family of HVCMOS* drivers & multiplexers permit major breakthroughs in computer graphics, electroluminescent, gas plasma, LCD & vacuum fluorescent displays. This advanced technology also opens up a wide range of applications in ultrasound imaging, robotics, telecommunications, test systems and high performance printers.

High density HVCMOS drivers combine high speed with low power consumption to produce bright, high-resolution images. Investigate HVCMOS . . . a most attractive alternative to cumbersome boards or hybrids.

For complete specifications, application data or custom information, write or call:
Supertex, Inc., 1225 Bordeaux Drive, Sunnyvale, CA 94088 (408) 744-0100. Telex 6839143 SUPTX



PRODUCT	VOLTAGE	DESCRIPTION
AN01	160 to 400V	8 N-Channel Low Leakage Common Source Driver
AP01	160 to 400V	8 P-Channel Low Leakage Common Source Driver
HV01	60V	16 Channel, 16 Level Gray Shade Push-Pull Output Driver
HV02	250V	16 Channel, High Current Open-Drain Output Driver
HV03 & 05	200 & 300V	64 Channel Serial to Parallel Converter with Open-Drain Outputs
HV04 & 06	40, 60, & 80V	64 Channel Serial to Parallel Converter with Push-Pull Outputs
HV10-18	140 & 160V	4 or 8 Channel Bilateral Analog Switch
HV30	180V	7 Segment Decoder with Open-Drain Outputs
HV51 & 52	225 & 300V	32 Channel Serial to Parallel Converter with High Voltage Open-Drain Outputs
HV53 & 54	40, 60, & 80V	32 Channel Serial to Parallel Converter with High Voltage Push-Pull Outputs

Circle no. 81

*HVCMOS is a registered trademark of Supertex, Inc.

See us at SID '88—Booth 217

NEC OUTSHINES THE COMPETITION.

Brilliant solutions to your display needs from World Products, Inc.

Plasma Display Panels

NEC plasma displays are lighter and brighter than ever before, with reduced power consumption and twice — even three times — the life.

- 9" through 26" displays
- High contrast, low power consumption
- 40,000-hour life with uniform brightness
- Many matrix choices: 512, 576, 640, 720 format with full graphic arrays
- Gray shades capability
- Wide viewing angle
- Easy interface, 5 & 12 volt operation
- Multimode EGA, CGA & Hercules Monochrome compatible

High Resolution Color CRT's

NEC's color CRT meets the demand for performance, reliability, and ergonomic efficiency.

- Choice of 9", 10", 12", 14", 15", 16", 20" diagonals
- Resolution: .21 through .39 dot pitch
- Conventional, flat-face, non-glare and anti-reflection types

Electroluminescent Lighting

NEC backlighting illuminates virtually any LCD.

- Custom configurations
- Sizes from 20 × 14 mm to 450 × 200 mm
- Uniform brightness and low power consumption

Circle no. 82

The Bright Side: Domestic Distribution

How can you get NEC performance and NEC quality, with domestic convenience? Call WPI's System Devices group. Our domestic distribution point assures you quick-response service and competitive turnaround schedules, with the industry's best product and technical service.

World Products Inc.
System Devices Group

P.O. Box 517 Sonoma, CA 95476
Telephone: (707) 996-5201
Fax: (707) 996-3380

WORLD PRODUCTS INC.

sustaining members

Ad-Vance Magnetics, Inc.
AEG Corp.
Alphasil, Inc.
Amuneal Manufacturing Corp.
Applied Films Lab, Inc.

Babcock Display Products
Ball Electronic Systems Div.
BDH Ltd.
Bendix Corp.
Brewer Science, Inc.

Canon, Inc.
Cardion Electronics
CELCO
Cherry Electrical Products Corp.
Clifton Precision/Special Devices
Clinton Electronics Corp.
Computing Devices Co.
Connector Corp.
Conrac Corp.
Corning Glass Works

Dale Electronics
Data Images
David Sarnoff Research Center, Inc.
Digital Electronics Corp.
Displays Inc.
DISCOM/Display Components, Inc.

EEV, Inc.
EG&G Gamma Scientific
Electronic Display Systems, Inc.
Electro-Plasma, Inc.
Endicott Research Group, Inc.

Ferranti-Packard Electronics, Ltd.
Futaba Corp.

GEC Avionics, Inc.
General Atronics Corp.
General Electric Co.
GML Information Services
GTE

George D. Harris Assoc., Inc.
Hartman Systems
Hazeltine Corp.
Hewlett-Packard Co.
Hitachi, Ltd.
F. Hoffman La-Roche & Co., Ltd.
Hoya Optics, Inc.
Hughes Aircraft Co.
Hycom, Inc.

IBM Corp.
Imapro Corp./Imaprint Design, Inc.
Incom, Inc.
Industrial Electronic Engineers, Inc.
Infodex, Inc.
Interstate Electronics Corp.
Inter-technical Group, Inc.
ISE Electronics Corp.

K & R Engineering Sales Corp.
Kollmorgen Corp. Photo Research Div.

Litton Panelvision Corp.
Litton Systems Canada Ltd.
Litton Systems, Inc. (2)
Los Alamos National Laboratory

Magnavox Government & Industrial Electronics Co.
Magnetic Radiation Laboratories
Microfield Graphics, Inc.
Microphase Laboratories
Microvision
Minolta Corp.
Mitsubishi Chemical Industries America, Inc.
Mitsubishi Electronics America, Inc.
Monitronix Corp.
Murata-Erie North America, Ltd.

NEC Electronics, Inc.
NEC Home Electronics (USA), Inc.
Norden Div. United Technologies Corp.
NYNEX Science & Technology

OKI Electric Industry Co., Ltd.
Optical Coating Lab., Inc.
Optical Radiation Corp.
Orwin Associates, Inc.
Ovonic Imaging Systems, Inc.

Penn-Tran Corp.
Philips Electronics, Ltd.
Phosphor Products Co., Ltd.
Photonics Technology
Planar Systems, Inc.
Plasmaco, Inc.
Plessey Naval Systems
Precision Electronic Glass, Inc.
PTK/Rantec Div. Emerson Electric Co.
Quantum Data Inc.

Racal Microelectronic Systems
Rank-Brimar, Ltd.
Raytheon Co.
The Report Store
Ricoh Co., Ltd.
Rogerson Kratos Corp.

SAI Technology Co.
Sanders Associates, Inc.
Schott America—Glass & Scientific Products, Inc.
Sigmatron Nova, Inc.
Singer-Librascope
Sony Corp.
Stanford Resources, Inc.
Supertex, Inc.
Syntronic Instruments, Inc.

Taliq Corp.
Tektronix, Inc.
Test & Measurement Systems, Inc.
Texas Instruments, Inc.
Thomas Electronics, Inc.
Thomson Electron Tubes & Devices Corp.

UCE Liquid Crystal Displays
United Enclosures, Inc.

Venus Scientific, Inc.
Video Monitors, Inc.
Villa Precision, Inc.
Visual Information Institute, Inc.

Westinghouse Electric Corp.

Zenith Electronics Corp.

id classified

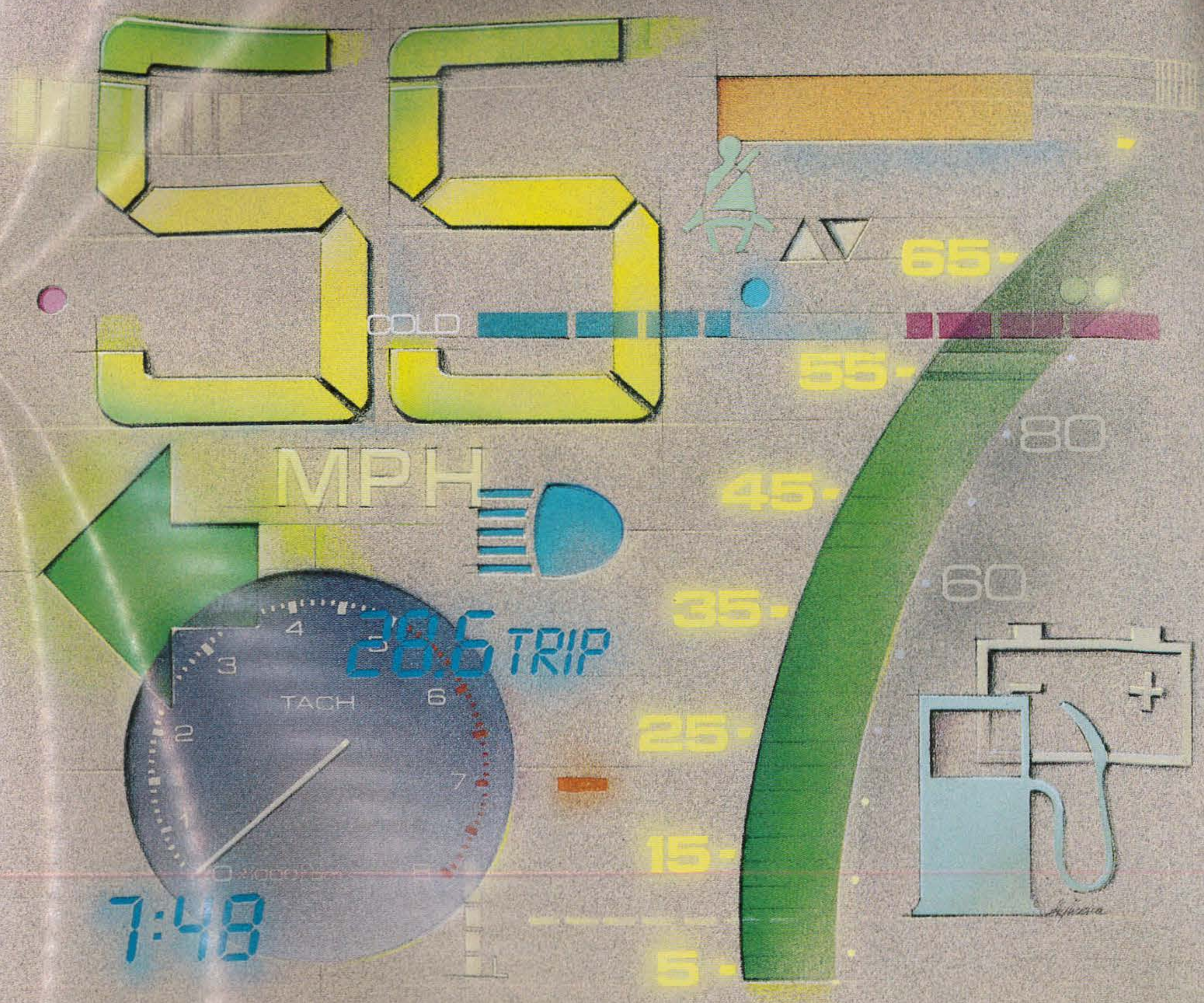
index to advertisers

Business and Editorial Offices
Recruitment Advertising
Palisades Institute for Research Services, Inc.
201 Varick Street
New York, NY 10014
Jay Morreale, Advertising Manager
212/620-3371

District Sales Office—West
Ted Lucas
P.O. Box 852
Cedar Glen, CA 92321
714/337-6627

District Sales Office—Midwest
Stephen Steeves
The Pattis Group
4761 West Touhy Avenue
Lincolnwood, IL 60646
312/679-1100

District Sales Office—East
Becky Akers
The Pattis Group
310 Madison Avenue, Suite 1804
New York, NY 10017
212/953-2121


55
MPH
COLD
65-
55-
45-
35-
25-
15-
5-
80
60
TACH
28.6 TRIP
7:48


PR-900
VIDEO PHOTOMETER
REJECT
PASS
LUMINANCE: PASS
UNIFORMITY: PASS
LINE WIDTH: PASS
MTF: PASS
CONVERGENCE: PASS
COLOR: PASS
Decisions. Decisions. Decisions.
PR-900 makes them for you.
The world's leading light measurement people have done it again! They've developed a state-of-the-art Video Photometer that can make all your CRT and display test measurement pass/reject decisions for you. Automatically!
The PR-900 dramatically reduces measurement time, and improves the accuracy and repeatability over manual techniques. It virtually eliminates the possibility of operator error. And it provides NBS-traceable luminance measurements.
Only Photo Research could have brought you this special combination of capabilities in a single instrument. The system is so flexible it can operate in the lab, the production line, as a stand-alone or in a complete ATE environment. And it is so easy to operate it requires almost no training. That's what leadership means.
The PR-900 Video Photometer embodies the latest advances in solid-state video technology and image processing techniques. Get all the facts today.
PHOTO RESEARCH®
The Light Measurement People®
Division of KOLLMORGEN
9330 DeSoto Avenue, PO Box 2192, Chatsworth, CA 91313-2192
(818) 341-5151 FAX: (818) 341-7070 TLX: 69-1427 Cable: SPECTRA
AUSTRALIA QUENTRON OPTICS PTY LTD., Ph: 08-223-6224 • CANADA OPTIKON CORPORATION, Ph. 519-885-2551 • FRANCE INSTRUMAT SA, Ph: 1-69 28 27 34 • HOLLAND INTECHMIJ BV, Ph: 020-56-96-611
WEST GERMANY OPTEEMA ENGINEERING GmbH, Ph: (0212) 67352 • JAPAN KYOKKO TRADING COMPANY, Ph: 03-586-5251 • U.K. MICRON TECHNIQUES LTD., Ph: 0202-841261 • INDIA PHOTONICS INTERNATIONAL, Ph: 366665
ISRAEL DELTA FILM LTD., Ph: 052-521874 • ITALY ELETTRONUCLEONICA, Ph: 2-4982451 • SWEDEN SAVEN AB, Ph: 08-7921100 • EUROPEAN HEADQUARTERS LUZERN, SWITZERLAND, PHOTO RESEARCH, Ph: 041-31-6194
Circle no. 86
See us at SID '88—Booths 211, 213, 215