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CORPORATION
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Circle Reader Service Card No. 66

Volume 5 Number 6 November/December 1968

Information Display

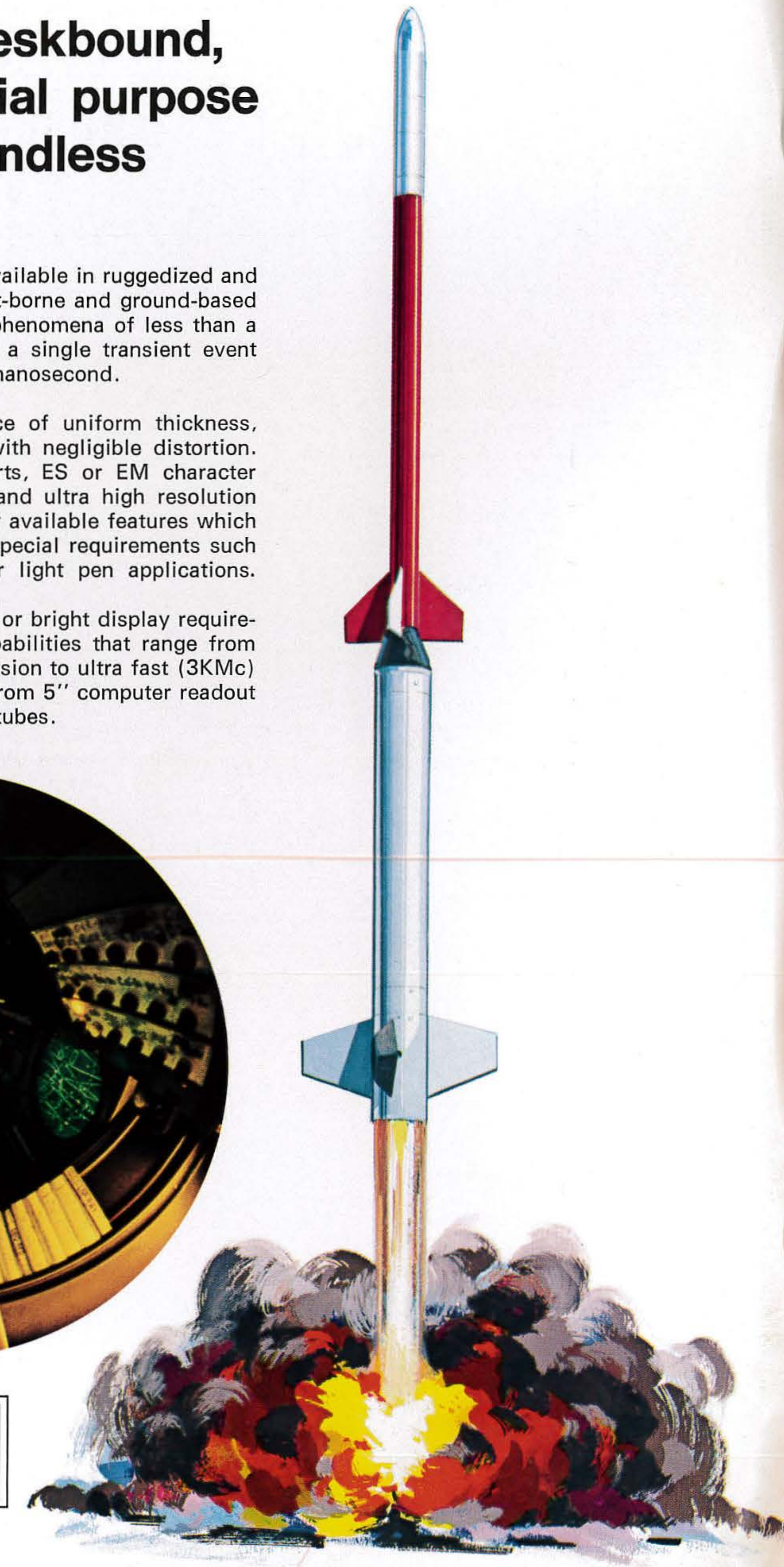
Journal of the Society for Information Display

Airborne or deskbound, Rauland special purpose tubes are boundless performers!

Rauland Scan Converters are available in ruggedized and miniaturized versions for rocket-borne and ground-based applications. They can record phenomena of less than a billionth of a second, such as a single transient event with a risetime of less than 0.5 nanosecond.

Rauland CRTs, with a flat face of uniform thickness, permit a wide viewing angle with negligible distortion. Dual necks and projection ports, ES or EM character generation, Hybrid phosphors and ultra high resolution guns, are but a few of the many available features which make Rauland CRTs ideal for special requirements such as precision analog display or light pen applications.

Whatever your scan conversion or bright display requirements, rely on Rauland for capabilities that range from Standard TV to TV Scan Conversion to ultra fast (3KMc) transient pulse recording; and from 5" computer readout CRTs to 24" flat face display tubes.



RAULAND
DIVISION OF ZENITH RADIO CORPORATION

Circle Reader Service Card No. 1

4 breakthroughs: new NIXIE® tube

1 size
.530" dia. x 1.5" for IC compatibility — largest numeral height provides best readability.

2 anode strobing
new design permits all like-numerals to be driven in parallel for time sharing operation with improved brightness.

3 pin spacer
simplifies both PC board layout and tube insertion.

4 price
in quantities of 1,000 — only $3.95 each.

ACTUAL SIZE

This new tube, type B-5750, has been engineered to achieve all these outstanding breakthroughs in a single design. The new slim-line tube not only has two internal decimal points but also has an "in-line" lead arrangement which is compatible with dual in-line IC's. In addition, the numeral aspect ratio has been designed to provide the optimum in readability and viewing distance.

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Burroughs

Circle Reader Service Card No. 2

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Volume 5 Number 6 November/December 1968

Information Display

Journal of the Society for Information Display

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the cover

"Eclipse," shown on the cover, was drawn on a CalComp model 835 electronic plotter, which 'talks' to a computer, causing images to be formed on a TV type tube. These images are then automatically photographed with a special high-precision camera in the Model 835 plotting system on 35mm or 16mm film. "Eclipse" was created as test patterns for the 835 and was then hand-colored.

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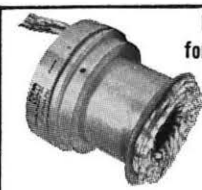
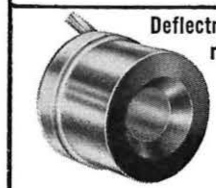
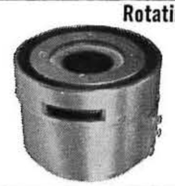
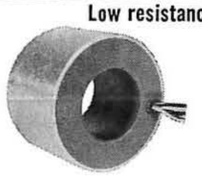
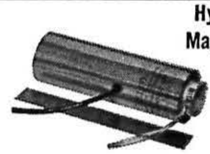
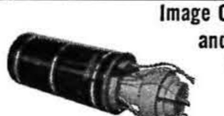
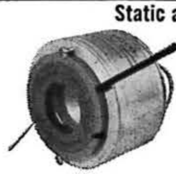
STANDARD DEFLECTION YOKES

AND CRT COMPONENTS

 Low cost stator type yoke for high grade commercial applications **TYPE KY**	 Low LI^2, high sensitivity for 42°, 52°, 70° and 90° 1 7/16" CRT neck **TYPE FY**	 High quality general purpose, moderate resolution low residual, for 52°, 70° and 90° 1 7/16" CRT neck **TYPE AY**
 Fast core general purpose, moderate resolution, for 52°, 70° and 90° 1 7/16" CRT neck **TYPE HY**	 Deflectron®, general purpose for 42° 1 7/16" CRT neck **TYPE HD**	 Fast core, low LI^2, low distributed capacity for 52° 1 7/16" CRT neck **TYPE GD**
 Deflectron® for high resolution recording storage tubes Scan converter applications **TYPE QD**	 Recording storage tube yoke Scan converter applications **TYPE QY**	 Writing yoke for high frequency beam modulation Celcaloy, ferrite and air core for 1 7/16" CRT neck **TYPE AW**
 General purpose yokes for 7/8" CRT neck **BY** 1" storage tube **CY** for 1 1/8" storage tube **CYT**	 Miniature yoke for 7/8" CRT neck and special unit construction **TYPE MY**	 Rotating yoke for 52° and 70°, 1" and 1 7/16" CRT necks Includes bearings, gear and sliprings **TYPE RY**
 Low resistance version of type BY Available for types CY and CYT **TYPE YY**	 Character and storage tube yoke for 2" CRT neck Type DY 2¼" CRT neck Type DJ **TYPE DY**	 Coils for centering and beam alignment, aiming, flooding for 1 7/16" CRT neck **TYPE KC**
 Pincushion corrector, electromagnetic, low cost, general purpose **TYPE L**	 Pincushion corrector, permanent magnet Specials available **TYPE M**	 Focus coil, dynamic for high resolution Many other standard types available **TYPE HLF**
 Vidicon yoke, focus and alignment coils 1" For slow scan, high resolution **TYPE WV**	 Hybrid vidicon yoke, 1" Magnetic deflection coil with shielding **TYPE HV**	 Vidicon yoke, focus and alignment coil 1" For standard TV applications **TYPE TV 129**
 Image Orthicon yoke, focus and alignment coils 3" For high resolution, slow scans **TYPE AV 172**	 Image Orthicon yoke, focus and alignment coils 3" For standard TV applications **TYPE TV 172**	 Static astigmatic corrector and dynamic focus coil For high resolution 42° CRT **TYPE NC**

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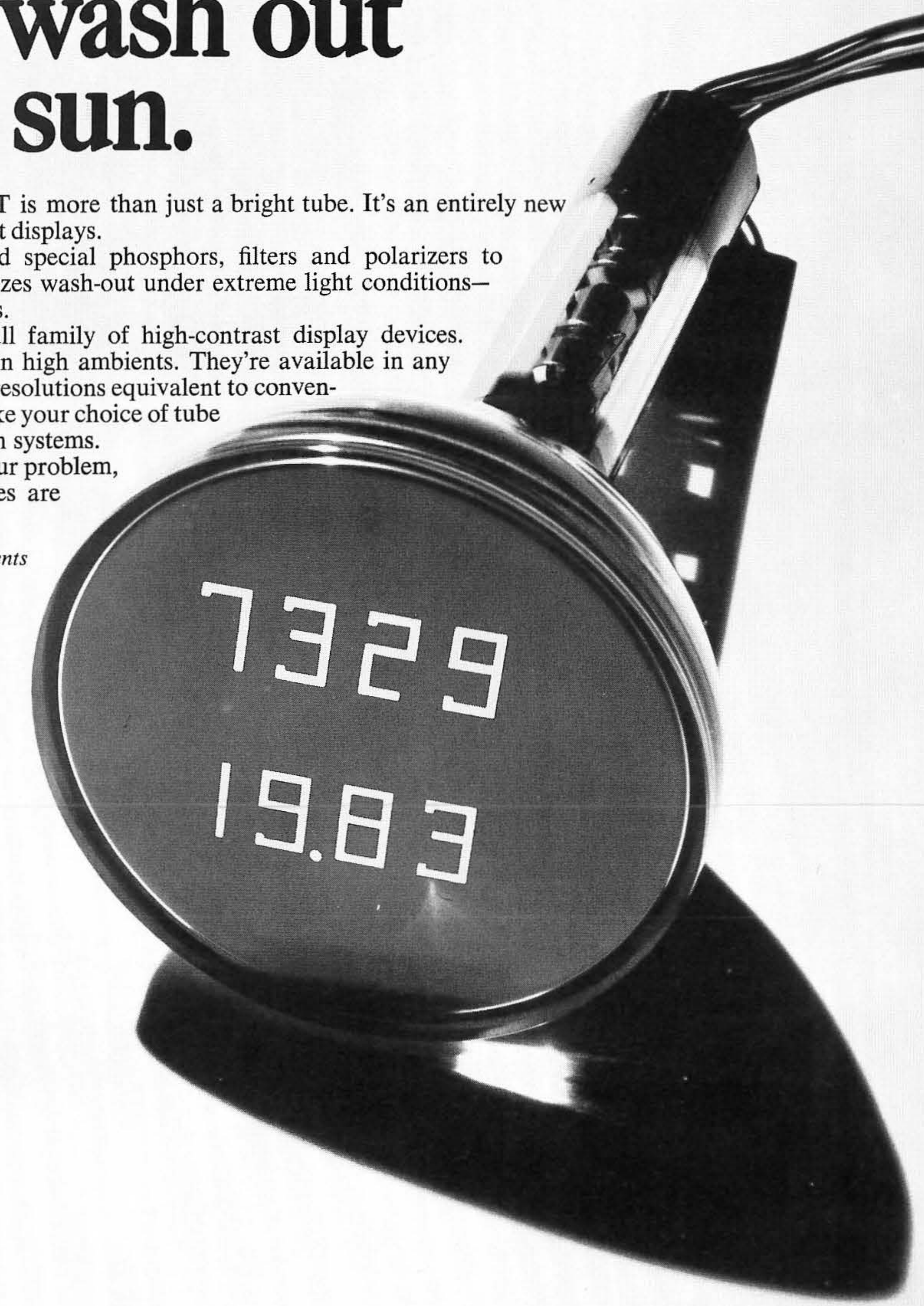

Our sunproof CRT is more than just a bright tube. It's an entirely new approach to high-ambient displays.

Sylvania developed special phosphors, filters and polarizers to make a tube that minimizes wash-out under extreme light conditions—even 10,000 foot-candles.

The result is a full family of high-contrast display devices. Readouts you can read in high ambients. They're available in any size from 1" to 27" with resolutions equivalent to conventional CRTs. You can take your choice of tube geometries and deflection systems.

If bright light is your problem, Sylvania's sunproof tubes are your answer.

Sylvania Electronic Components
Electronic Tube Division
Seneca Falls, N.Y. 13148

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Circle Reader Service Card No. 9

Circle Reader Service Card No. 10 →

We have more than 200 models within easy reach. And we're adding more.

That's the way this business goes. You start with a CRT that's almost a scientific curiosity—thirty years later you wind up with an inventory. All because someone is constantly thinking of something else a CRT can do.

Obviously, we were lucky enough to have men who knew what they were doing. Our product line proves that. Round face, rectangular, fibre-optics or standard—short necks or long, one gun to twelve gun, transparent multicolor phosphors and distortionless rear windows. Name it. We've got it. Order it. It's yours.

You'd think we'd stop and just keep someone watching the store. But that's not the way this business goes.

Somewhere out there, right now, somebody is thinking of something new for a CRT to do. That's how we add to our line.

If you're looking for any kind of quality CRT, our kind of inventory gives you the best place to start.

One thing is sure. We've got enough to say yes, rather than maybe. Try us. Write or call. And send for our free literature. It's free.

Electronic Tube Division, General Atronics, Philadelphia, Pennsylvania 19118

GENERAL ATRONICS

What of the future display device?

Writing in *Information Display* two years ago, George Chafaris speculated on the types of display devices and systems which might exist in the 1970-1980 era. Although such speculation always sounds somewhat like a dream—perhaps more like a nightmare for some—we are all trying to realize these dreams. The field in which development has lagged most is in the display device itself.

For a long time the cathode-ray tube has been the dominating display device. This situation will not change for at least 5 to 10 years. This does not mean that there has not been a considerable amount of progress, which in fact, continues. The CRT is being developed still further and the variety of CRTs available continues to grow. In addition, the driving circuits can be made better because of the fast development in electronics. Many future requirements can therefore be met by the CRT. Nevertheless, there are some serious disadvantages. The brightness is not very high; it is a bulky device with limited screen size; it needs extra provisions for incorporating memory and, finally, it is certainly not ideal for data display in color.

To solve these problems scientists and engineers all over the world are searching for alternative information displays. This research follows two main lines.

Work is being done on cross-bar type light-emitting displays, such as electroluminescent and gas discharge panels. The renewed interest in, and work on, gas discharge are due to disappointment with the solid-state light source. For this type of panel, in which a cross-bar system seems a necessity, the fast development taking place in electronics from integration towards large-scale integration or some type of hybrid LSI is playing an essential role.

A great deal of research is being devoted to devices in which either the ambient light ("passive displays") or that from an external light source (Eidophor type) is modulated in some way. This entails much study of new materials which change the absorption, reflection or polarization of light in an effective and simple way under the influence of light, heat or electric or magnetic fields Many promising results are forthcoming along these lines, but it is too early to decide about the best choices.

In the future a wide variety of display devices is needed: monocolor and multicolor, with and without inherent memory, with and without gray scale, a large range of screen sizes, all with the appropriate brightness, contrast and resolution. If these needs are to be fulfilled much work must be done; work which requires not only our best talents but also a belief in the important function our Society performs in the information display field.

Dr. Th. J. de Boer
Philips Research Laboratories
Member-Publications Committee

Circle Reader Service Card No. 11 →

SWITCH CRAFT FORUM

Ho-hum, another Forum. What have you got to say about "Multi-Switch" switches that's new and exciting? Frankly, I get tired of just rehashing old product specs.

So do we. But, just the other day we discovered that a long standing customer of ours didn't know about our "Multi-Lite" pushbuttons that can couple two adjacent stations on a "Multi-Switch" switch.

Two stations?

Right. But, maybe we ought to start from the beginning. A single station can accommodate up to 6PDT circuitry. The "Multi-Lite" arrangement mechanically interlocks two adjacent stations for twice the switching capability without adding to the overall height of the switch stack. And, each station has a total of four lamps for sectionalized or redundant lighting, since we have combined two, dual lighted pushbottons. Fig. 1. gives a good example of the flexibility we're talking about.

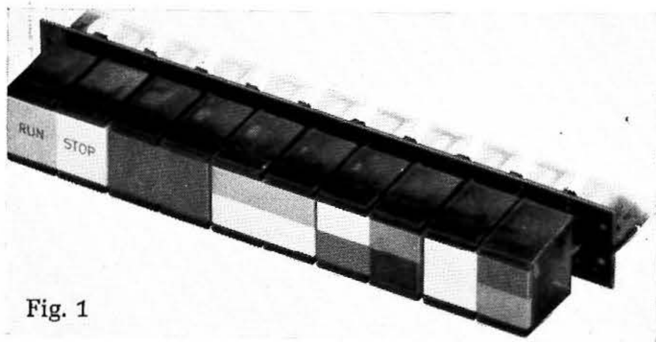


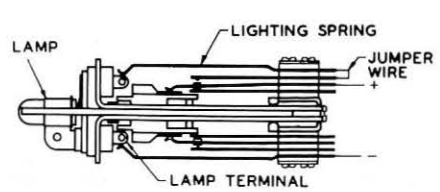
Fig. 1

How does the "Multi-Lite" arrangement tie into the mechanics of your switch? I'm talking about lighting circuitry and switch functions.

Lighting circuitry on the Series 37000 & 38000 little "Multi-Switch" switches is accomplished by means of a lighting stack of the type shown in Fig. 2. The extra-long lighting springs extends the lighting circuit from the lamp terminal to the rear of the switch for convenient wiring to the N.O. or N.C. contacts on the lighting switch stack. Naturally, direct wiring to the pushbutton lights is another alternate.

Regarding switch functions, the coupled stations can be furnished for interlock, momentary, push-to-lock,

Fig. 2



push-to-release, and all-lock operation. Of course, the all-lock arrangement will require a single button for a release station. (Forum readers may obtain complete info on switch functions from our engineering specification catalog. Just circle the reader service number below.)

The increased size of the "Multi-Lite" pushbutton would be ideal for a cancel bar on our new check-writer, but we'll need smaller pushbuttons for most of the other functions. How much legend information can I get on either type? And what about display screen colors and lamps?

The "Multi-Lite" pushbuttons will accept up to 4 lines of 11, ⅛" high characters per line. The smaller pushbuttons provide a 31⁄32" x 19⁄32" rectangular area for hot stamping or engraving. This should accommodate any of your legend requirements for each station. We have nine standard display screen colors plus color inserts to give you unlimited color flexibility.

As a convenience, Switchcraft has available, standard industry lamps #328 (6v.), #718 (6v.) or #327 (28v.). Or if you need **zero** power consumption on an "illuminated" switch, why not use the Switchcraft "Glo-Button." Available on certain switches, the "Glo-Button" produces a highly visible illumination change by strictly mechanical means without consuming any power.

I must admit we've learned something, but I suspect the Forum won't be dismissed until we've heard a "life & versatility" pitch.

Our catalog tells all about "life & versatility" and how you can specify a "Multi-Switch" switch anywhere from 1 to 18 stations in a row or up to 100 stations in ganged and coupled matrixes. The almost unlimited adaptability of this switch to countless applications is difficult to express. When we sit down to discuss your requirements in detail, the value of a "Multi-Switch" switch will become more apparent. We've dwelled on lighting pretty much, but the total versatility of these units doesn't begin to "shine" until you can see it solving your particular application problems.

Forum dismissed, but but don't forget that we have extra bound copies of "FORUM FACTS on 'Multi-Switch' Switches", that describes these units, their accessories and applications. Just have your engineers drop us a line on your company letterhead, asking for this handbook. We'll also place their name on our mailing list for TECH-TOPICS, our semi-monthly application engineering magazine. Ten-thousand engineers already receive TECH-TOPICS and tell us that the technical stories are interesting and useful.

SWITCHCRAFT INC.®

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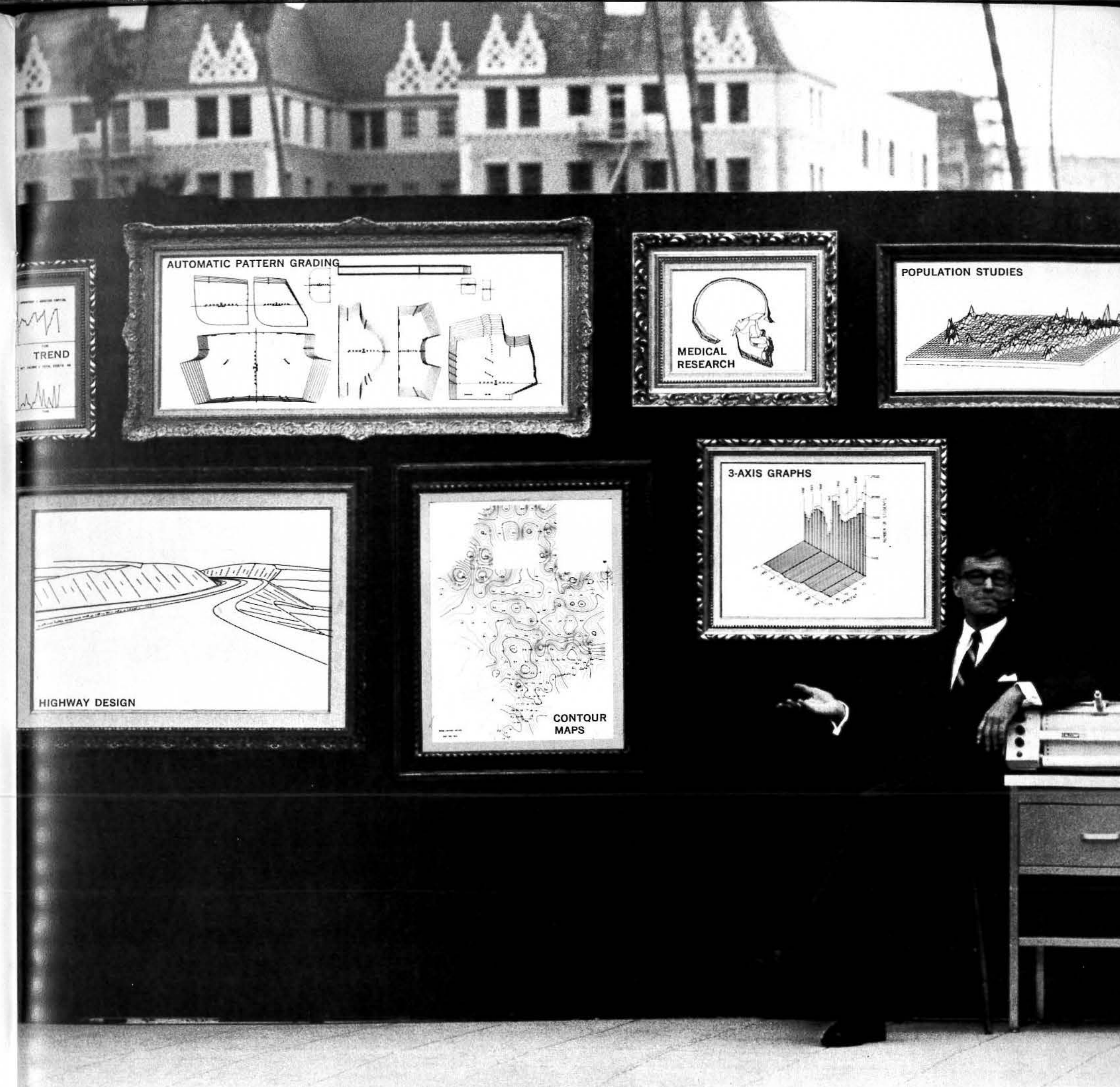
Circle Reader Service Card No. 14



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CALCOMP Leader in Computer Graphics

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Heard the one about a $100-$200 solid state keyboard promised by a major supplier for 1970 marketing?

It's a good, reliable company and we have no doubt they'll make it ok.

If this seems a little long for your plans, consider this:

As of November 1, 1968, you can have production quantities of high-reliability, field-tested, solid state keyboards at a flat $150, delivered!

In keyboards, everyone knows the way to go is solid state. And a lot of people are trying. But IKOR has it. Now. And you can get it. Now.
Here's a keyboard with great application versatility available in a wide range of configurations. It interfaces with virtually any data handling device.
Being solid state, its reliability is inherent. The keys are electronically interlocked to prevent errors caused by striking more than one key at a time. Each key generates its own code so it's easy to get exactly the keyboard arrangement you want without wiring changes. Diode matrices, mechanical switching or photo-electric devices are eliminated.
The IKOR board provides serial or parallel inputs to any information system by generating any required code including ASCII, EBCDIC, BAUDOT, Teletype, etc.
It is accurate, simple and trouble-free. For more information send in the coupon. It beats the reader service card by days and we know you're in a hurry . . .

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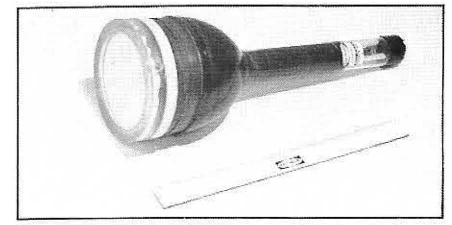

This new cathode-ray projection tube offers more light, higher resolution, and longer life than is available with other such tubes. With it, any conventional type of CRT display can be projected for viewing by large or small groups.

The tube features small packaging, conventional circuitry requirements, and rugged construction. Using a beaded viewing or rear-projection screen, a brightness of 50 foot lamberts can be achieved on a 3′ x 4′ display. Resolution exceeds 600 lines. And the tube's life expectancy—under high brightness conditions—exceeds 500 hours.

Projectoray's advanced technical features are the result of these major developments:

1. The use of an optically clear, thermal conductive face panel that cools the phosphor with a rim-mounted heat exchanger. This new concept in phosphor cooling inhibits electron beam damage to the phosphor, greatly reduces the saturation effect on light output, and increases tube life.

2 A tube design that permits the use of a highly efficient lens system, which provides focusing over various projection distances for large or small groups.

For a demonstration of the Projectoray in operation at our plant, call or write: *Raytheon Company, Industrial Components Operation, 465 Centre Street, Quincy, Massachusetts 02169. Tel: 617-479-5300, Ext. 337.*

RAYTHEON

New Projectoray™ CRT brings long life and high light output to large screen displays.

Vision and lasers: human factors of laser displays

by
JOHN D. GOULD and
WALTER L. MAKOUS*

ABSTRACT

This paper discusses the visual factors of laser displays. General human factors recommendations for several visual variables are provided.

INTRODUCTION

A potential application ascribed to lasers has been their possible use as a radiant source of visual displays, primarily because of their potentially great luminous output. Although cost considerations presently prohibit laser displays from competing with more traditional display techniques, rapid advances in laser technology suggest that in the future laser displays may become more competitive, especially for certain special applications such as large screen graphic displays.

The recent development of prototype laser displays (Baker & Rugari, 1966; Korpel, Adler, Desmanes, & Watson, 1966) calls for a thorough analysis of the related visual requirements. Such a human factors analysis serves many purposes, such as 1) to provide recommendations concerning the value of each important visual display variable; 2) to treat the question of whether lasers as a source of light lead to any different visual effects than do other sources of light; 3) to avoid unnecessary research, either because the results of research done in other contexts can safely be generalized to laser displays or because certain answers can be predicted from a basic understanding of the human visual system; 4) to focus attention upon areas that do need research; and 5) to avoid errors caused by ignorance about the functioning of the human visual system.

*Present address: Psychology Department, University of Washington, Seattle, Washington 98105.

Eight problems pertaining to the use of lasers as the source of light for visual displays that can be anticipated now are: 1) luminance of the display, 2) wavelength of the source, 3) display contrast, 4) display flicker, 5) the lack of screen

VISUAL VARIABLE	MINIMUM SATISFACTORY LEVEL	MAXIMUM USEFUL LEVEL	LIMITING FACTORS
Luminance	10 mL	50 mL	Power of laser; size of illuminated part of the display; luminosity of wavelengths emitted by the laser
Wavelength	490 nm (green)	650 nm (orange)	Wavelengths available from laser
Contrast	10	30	Ambient and stray light; maximum luminance available from laser
Regeneration Rate	40-60 hz	60 hz	Scanning pattern; techniques for deflecting beam; bandwidth of control system
Resolution	1 min of arc between adjacent points	½ min arc between adjacent points	Precision of beam control; screen size
Size	More than 1 min of arc between details to be distinguished	No more than 1 min between points intended to present homogeneous appearance	Power of laser; luminosity of available wavelengths; deflection system

TABLE I: Appropriate useful range of visual variables and present limiting factors on each persistence, 6) sparkling effects resulting whenever coherent light is reflected from nonspecular surfaces, 7) screen size, and 8) display resolution. The first three can be quickly covered since the use of a laser as the source of illumination leads to human factors conclusions similar to those already established using other sources. A comprehensive discussion of any of these problems would include a description of the effects of many variables which are beyond the scope of this paper, but are covered in the secondary references cited. To emphasize the general, as opposed to the specific, nature of our recommendations secondary references are usually cited in preference to primary references.

Display Luminance

In rough numbers, the recommended luminance level of the illuminated areas on the screen may be estimated as 10-50 millilamberts (see Bartley, 1951, p. 945; Graham, 1965, p. 26; McCormick, 1964, Chapt. 13). Table 1 summarizes the appropriate estimates of the useful range of luminance, as well as the estimated ranges of other variables to be discussed, and indicates the limiting factors for each variable. We have described the calculation of retinal illuminance by lasers and have summarized the evidence relating lasers to eye damage elsewhere (Makous and Gould, 1968).

Wavelength of Source

The wavelength of the source naturally is determined by the laser used, and the relative luminance of the source is partially determined by its wavelength because of the spectral sensitivity of the human eye (Figure 1). The greater the luminous efficiency of the wavelength used, the less the power required to illuminate a display. For example, as can be seen in Figure 1, the luminance of a laser emitting a wavelength of 550 mμ 680 ℓm W^{-1}) will be about 65 times greater than an equivalent laser emitting red light of about 680 mμ (11.6 ℓm W^{-1}) because of the spectral sensitivity of the eye. Although the chromaticity, sometimes called color, of a display is not without effect upon perception, visibility of alphanumeric characters depends more upon brightness and contrast (Fitts, 1951).

Luminance Contrast

The third problem is concerned with the contrast between the illuminated and unilluminated parts of the screen. The luminance of the unilluminated parts is determined by the reflections or transmission, at the display surface and at any "transparent" layers covering the image, of both ambient light and of stray light from the illuminated parts of the image.

The needed contrast depends upon several variables, especially the angular size of objects that the viewer must discriminate (McCormick, 1964, chapts. 4 & 13). If it is assumed that the viewer must be able to discriminate between two parts of an object when the angle subtended at the eye between these two parts is not greater than one minute (this is the angular subtence of the separation of horizontal bars of the "E" on Snellen visual acuity charts for viewers with 20/20 vision, and that the luminance of the illuminated parts of the screen is 10 millilamberts, then, based upon the data cited by McCormick (1964), an attempt should be made to have at least a one-log unit difference in luminance between the background and the illuminated parts of the screen. Preferably, although more difficult to obtain on a screen viewed in normal ambient illumination, an even higher contrast should be used. However, to obtain considerably high contrast values and yet to prevent the image from becoming too bright, it might be necessary to project the image on a black screen having a reflectance of only a few per cent if an ambient filter is not in front of the screen. Such a screen would of course result in a considerable loss of source power, as may be seen from the *R* term in the equation used below to calculate maximum screen size. Such a loss is not tolerable now, since at present CW lasers do not exceed the light output of CRT's.

Display Flicker

Assuming a laser display of the regenerative rather than storage type, if its image is not regenerated fast enough it appears to flicker. Unlike, for example, television or motion pictures, the image traced by a scanning laser beam might have no persistence whatsoever on the screen. The problems here are to predict whether such a display is feasible and, if so, to predict the needed regeneration rate of the image to prevent it from flickering.

The perception of flicker depends upon many variables (see, for example, Bartley, 1951; Brindley, 1960; Graham, 1965; LeGrande, 1957), but for present purposes it is helpful to distinguish two aspects of flicker. The first is concerned with "between frame" flicker of a displayed image. In home television, the 525 lines of the receiver are completely regenerated 30 times per second. However, this regeneration rate normally leads to the perception of flicker; to reduce this flicker the odd lines are scanned in 1/60 of a second and then the even lines are scanned in the next 1/60 of a second. The repetition of the interlaced fields at the rate of 60 fields per second has generally proved successful in eliminating much of the disturbing flicker. This is true in spite of the fact that the P4 phosphor widely used in home television receivers has a persistence (approx. 60 μsec to 10 per cent of peak luminance; JEDEC, 1966) that lasts for less than one per cent of the regeneration period or the time between fields.

The general reason that flicker tends to be eliminated with a 60 cps regeneration rate even though the image is present on the screen for only a small fraction of each cycle is because the human visual system integrates the illuminance falling on each small area of the retina during a short time interval. Within this interval, the visual response depends upon the product of the duration of the illumination and its intensity. That is, the product of duration and intensity of illumination leads to a constant visual response over a specific range of time. This general conclusion, as might be expected, has recently been affirmed for conditions simulating those of a laser display (Easton, Markin, and Sobel, 1967). The upper boundary of this time interval or integration time (below which intensity times duration is a constant) is, depending upon circumstances, 10-100 msec (see for example, Graham, 1965, p. 76; Kahneman & Norman, 1964).

A general deduction from the above for any display is that persistences shorter than the upper boundary of the integration time of the eye need be dependent upon technical design needs rather than perceptual considerations. Specifically, it is reasonable to conclude that insofar as "between frame" flicker is concerned, displays having a shorter persistence than that of the P4 phosphor, including no persistence whatsoever, would not only be feasible but would need about the same regeneration rate as that of home television. Turnage (1966) has recently developed this argument using fourier analysis of the persistence characteristics of the display.

Flicker is, of course, not determined by persistence alone. Even in commercial motion pictures, in which each frame of film "persists" with no decay throughout its entire exposure, in order to reduce the perception of flicker the projection of each frame is interrupted once, which leads to 48 "flashes" or frames per second rather than the more straightforward 24 frames per second that corresponds to the film speed. The doubling of the effective regeneration rate leads to the disappearance of annoying flicker because this rate now exceeds the thresholds of many observers for detecting flicker. A regeneration rate of about this magnitude is also needed to present the appearance of smooth continuous movement in a dynamic image.

Screen persistence will, to a first approximation, lengthen the duration during which an image will be perceived as illuminated if and only if its persistence is longer than the critical duration during which the eye responds to total integrated energy, not to luminous power. In this case, the image will naturally appear less bright, assuming a constant amount of luminous energy spread out over a greater time. It hardly needs to be mentioned that, for persistence longer than the reciprocal of the regeneration rate, fresh images are superimposed upon previously displayed images, and this leads to undesirable effects.

The second point to consider in regard to the perception of flicker is what happens within a frame. No research has been done, to our knowledge, that directly answers this question. However, there is indirect evidence that permits some conclusions. Obviously, the possibility of annoying flicker within a frame depends upon, among other variables, the duration of the frame and the persistence of the image. At one extreme, a single frame of a motion picture is "scanned" only in the sense that the shutter takes a finite time to expose that frame. Since the shutter's wipe-time is typically short, the viewer perceives this frame as presented simultaneously, and since the entire image remains on the screen with no decay, the entire image is perceived during its entire duration. At the other extreme, consider a hypothetical raster scan system in which a laser beam scans, for example, a nonpersisting, back-projected ground glass screen. It would be possible to scan this screen so slowly that the viewer would not see, at one time, the entire image on the screen.

The important question, then, is what are the critical values which lead to the perception of the screen being simultaneously illuminated across its entire surface. Stated most simply, the eye perceives events as occurring simultaneously if they occur within about 25 msec or less (Graham, 1951; Graham, 1963; Kolers, 1964). Thus, to a rough approximation, a single frame will be perceived as simultaneously illuminated. This of course is true even if screen persistence is less than 25 msec (including the case of no screen persistence) because of the integration time of the eye. Since the period or reciprocal of the regeneration rate that might be used with a laser display (16 msec for 60 cps) is less than 25 msec, there should be no difficulty in perceiving the screen as simultaneously illuminated. Accordingly, the conclusion at this point is that a regeneration rate of about 60 cps would be sufficient to produce a useful laser display.

But so far in the discussion of what happens inside a single frame, no mention has been made of the effect of eye movements. In regard to large amplitude eye movements (i.e., neglecting the constantly occurring smaller amplitude tremors, flicks, and drifts), it might be thought possible for a viewer, within a given frame of a raster scan of a nonpersisting screen, to move his eyes down the screen ahead of the scan line such that he would perceive at least part of the screen as not illuminated. The velocity of gross eye movements is generally linearly related to amplitude of movement; for example, a movement of 90 deg lasts about 0.19 sec, while a 15 deg movement lasts about 0.045 sec (Alpern, 1962, p. 87). But these times are greater than the periodicity of a 60 cps regeneration rate that might be used with a laser display. Thus, the likelihood of the eye moving as fast or faster than the scan line is small. However, even if events were such that the eye did not move ahead of the scan line for one frame, the eye could not also lead the next frame, since there is a delay of reaction time between the termination of one eye movement and the initiation of the second. In general, then, the effect of eye movements may be neglected.

Nonpersisting Screens

The above discussion together with other lines of evidence indicates the feasibility, insofar as visual problems are concerned, of constructing a laser display having a screen with nonpersistence. For most conditions the regeneration rate needed to eliminate "between frame" flicker on a display rather than that needed to eliminate "within frame" flicker is the limiting factor. It is probable that for displays of the angular size of home television sets no visual problems will arise so long as a nonpersisting screen is scanned at about the rate that home television sets are presently scanned.

Sparkling Images

Light from a laser which is reflected into the eye from a

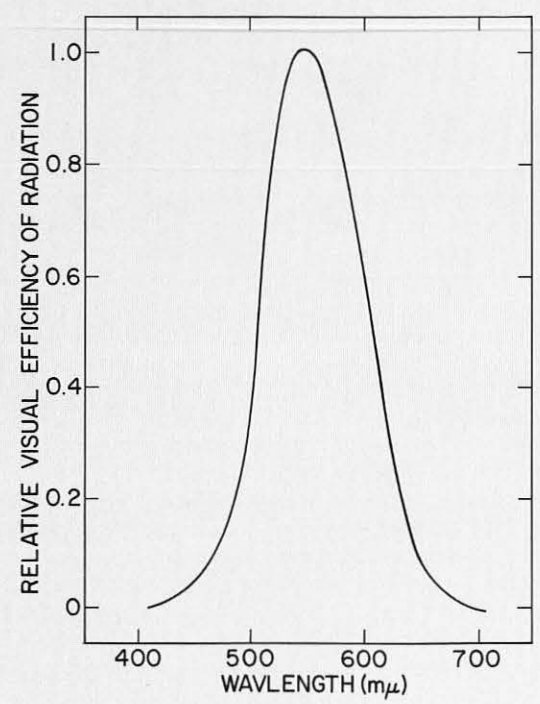

Figure 1: Spectral sensitivity of the human eye for photographic light levels.

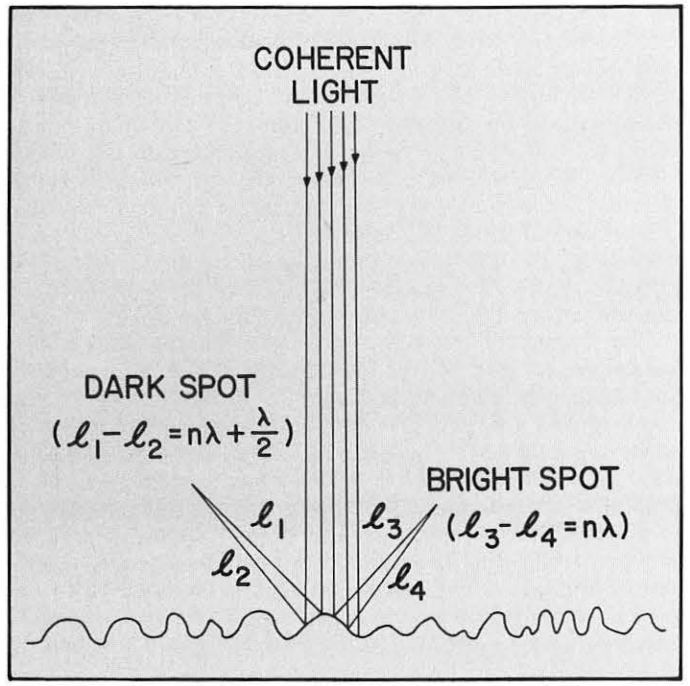

Figure 2: Schematic showing destructive interference (left) and constructive interference (right) due to the reflection of coherent light from a rough surface. The surface irregularities are not perceived by the eye, however.

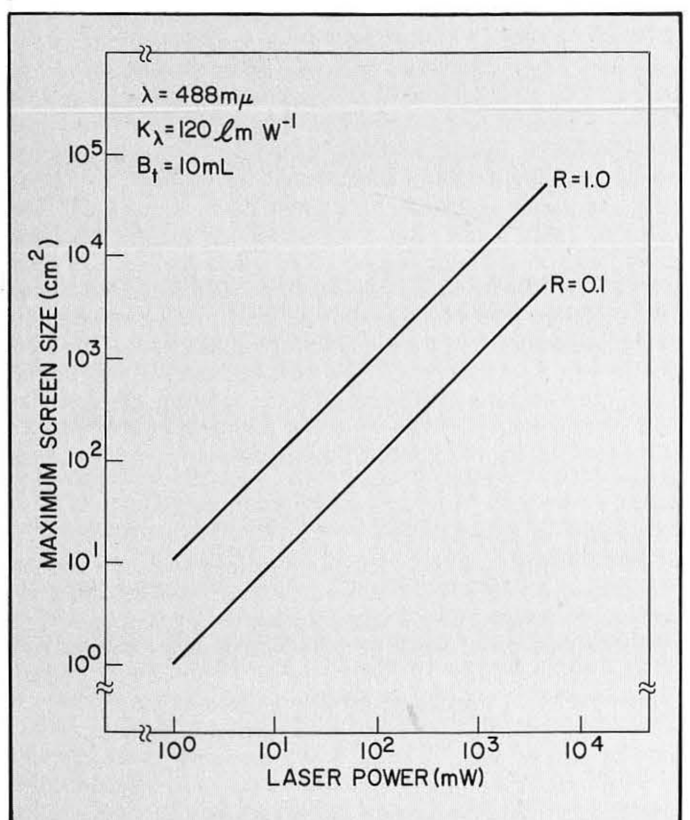

Figure 3: The relationship between laser power and maximum screen size for extreme values of R, where R is the total per cent of light that is not "lost" in the system.

rough surface, such as paper or a ground glass screen, appears different than light from a noncoherent source reflected from these same surfaces. Figure 2 is a schematic showing coherent light being reflected from such a surface. Although these surface irregularities, which cannot be resolved by the eye, do not matter in the case of incoherent light, interference patterns are set up when coherent light is reflected from them which tend to make their image appear grainy. As illustrated on the right side of Figure 2, constructive interference occurs when the difference in the distance which two (or more) rays travel before they meet due to reflection is equal to an integral number of wavelengths of the source. Constructive interference results in a small bright spot within the reflected image. As illustrated on the left side of Figure 2, destructive interference occurs when the difference in the distance which two (or more) rays travel before they meet, due to reflection, is equal to an integral number of wavelengths of the source plus one-half wavelength. Destructive interference results in a small dark spot within the reflected image.

Changes in the interference patterns imaged on the retina cause the grainy image to appear to sparkle or scintillate (Cutler, 1963; Oliver, 1963; Rigden & Gordon, 1962, Schawlow, 1965). If this sparkling is judged to be disturbing on a display, as we assume it will be, there are several ways to eliminate it. It can be eliminated by phase scramblers, such as: vibrating interference gratings which intercept the beam (Hopkins, 1966); a projection screen covered by a thin layer of a colloidal solution; a vibrating or rotating screen; or compensating wedges, one of which vibrates in a direction perpendicular to the beam, thereby varying the thickness of the glass through which the light must pass—and thus phase at the last interface—without introducing undesirable side effects. The scanlaser being developed by Pole and Myers (1966) uses a mercury laser which does not produce a sparkling effect because of the relative incoherence of its emission.

Display Size

The maximum size of the screen that can be illuminated by a given laser such that the screen is bright enough for comfortable viewing may be computed by the formula:

$$A_m = RPK_\lambda/B_t$$

where A_m is the maximum area of an opaque screen having a reflection factor, R, or of a lambert screen having a transmission factor, R, that can be sufficiently illuminated by a laser of power P, in order for a human viewer to perform a task, t, normally requiring a luminance, B_t. K is the luminous efficiency for wavelength λ. In this formulation A_m is expressed in square centimeters, P, in watts, K_λ in lumens per watt, B_t in lumens per square centimeter; R, which varies between 0.0 and 1.0, is dimensionless. For example, a one-watt CW laser emitting a wavelength of 488 mμ, the luminous efficiency of which is 120 ℓm W^{-1}, produces a luminance of 10 mL (i.e., 10^{-2} ℓm cm^{-2}) on a display of about 12,000 R cm^2 in area. This luminance is about the minimum level leading to comfortable viewing. Since R cannot exceed 1.0, and generally does not approach it, the screen would be something less than one meter on a side. To the extent there is loss of light in the display system, A_m is further reduced.

Figure 3 shows the maximum screen size as a function of laser power for the conditions assumed above. It is likely, in practice, that values of screen size will be near the lower curve.

The maximum size of the screen can be increased by using a more powerful laser, by using a laser which emits wavelengths closer to 550 mμ, or by using a screen with a relatively high R. It is thought (Paananen, 1966) that argon CW lasers will be available in the near future that operate at up to 100 W and that emit strongly at 488 mμ and 514 mμ. By increasing R, the luminance of both the illuminated and unilluminated parts of the screen is increased and thus, without additional refinements, luminance contrast is reduced. In one laser display a screen with a "gain", based upon a reduction in relative diffusivity at the expense of a reduction in viewing angle, has been used to increase the maximum display size (Baker & Rugari, 1966). It should be noted that, although a 100 mW laser emitting light of 663 mμ will, if directed into the eye, permanently damage the eye (see Makous & Gould, 1968), a display area no larger than seven inches on a side can be illuminated at a luminance level of about that needed for comfortable reading. This is so, of course, because of the differences in flux densities. In the first case the eye focuses the parallel beam to a very small retinal spot, whereas in the second case the screen diffuses the light over a solid angle of 180 deg. and only a small portion of this diffused light enters the eye, and even this small portion is spread over a relatively large retinal area.

The formula given above defines only the maximum area that can be illuminated. However, if only ten per cent of the screen is illuminated, e.g., by line drawings or by alphanumeric characters, the screen could theoretically be ten times as large as A_m. This is not practical is devices based on a scanning or tracing principle because of the problems of moving the beam over the dark portions of the screen. It might be possible, however, to introduce a mask within the cavity in a way somewhat analogous to a frame within a motion picture projector, but the rate of frame replacement would be limited by the time required for a new mode of oscillation to be established after each change of frame.

Display Resolution

The final topic considered is the resolution of the display. Unfortunately, this is also a complex question depending upon technical, cost, and perceptual requirements. If bandwidth is limited, or related to costs, the aim is to sacrifice image quality by providing no more than that resolution needed for comfortable perception. Regardless of whether the display is raster-scanned, or directly addressed, the aim is to eliminate the perception of the scan lines or matrix spots and create the illusion of a continuous image.

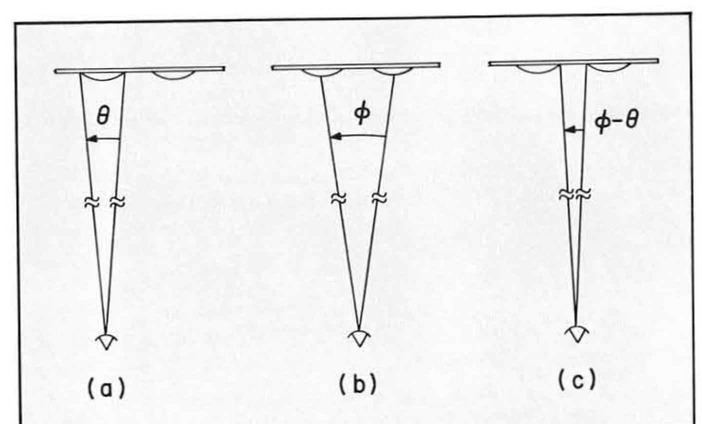

Figure 4: Schematic showing the angle, θ, subtended at the eye of the observer by a single spot (a); the angle, φ, subtended by the distance betwen the centers of two adjacent spots (b); and the angle, φ — θ, subtended by the distance between the edges of two adjacent spots.

Needed resolution naturally depends upon the viewing distance and the application of the display. If, at the viewer's eye, a display has an angular spot width, θ, (Fig. 4a) and an angular distance, ϕ, between the centers of two adjacent spots (Fig. 4b), then the number of spots per inch, N, on a display is given by

$$N = \frac{3440}{S\phi},$$

where S is the viewing distance in inches and ϕ (as well as θ) are in minutes of angular subtense (because the factor 3440 provides the conversion from radians). The typical observer can distinguish between two displayed spots if the angular subtense of their separation, (ϕ — θ), exceeds one minute (Fig. 4c). Accordingly, if it is desired to have two adjacent spots seen as continuous, then (ϕ — θ) must be less than one minute. Therefore, the minimum number of spots per inch is

$$N_{min} = \frac{3440}{S(\theta + 1)}.$$

Thus, for a viewing distance of 16 inches and a spot width of 4.65 mils, which subtends 1 min arc at this distance, over 100 spots per inch are required.

On most CRT displays viewed at this distance, θ is rarely less than one minute because of the minimum technically achievable spot diameter. Although with a laser display it is possible in theory for θ to be considerably less than one minute, in practice one need not go to any expenditure in doing so, since a spot subtending less than one minute may be considered as a point source and a reduction below one minute does not produce any decrease in retinal image size.

If it is desired to design a display such that two non-adjacent spots appear to be continuous even though they are separated by an interval of unilluminated spots that are potentially addressable or potentially illuminated, then adjacent spots must overlap. That is, θ must be greater than ϕ. Just as before, the trailing edge of one spot must be within one minute of arc of the leading edge of another spot if the two spots are to be seen as continuous. The number of consecutive overlapping spots, N', that cannot be discriminated from each other, regardless of whether intervening spots are illuminated or not, is indicated by the expression

$$N' = \frac{\theta + 1}{\phi} + 1.$$

For example, any of 6 consecutive spots would be seen as continuous for spot sizes of 5 mils whose center-to-center distance is 2 mils and the viewing distance is 16 inches.[1]

This discussion of resolution is obviously general and assumes sharply defined spot boundaries. In practice, ϕ and θ must be determined by the luminance contrast ratio and by the precise distribution of light within a spot (Caufield, 1966). For lines or spots with relatively sharp boundaries the contrast between adjacent ones is relatively high for a given θ compared to the case in which the boundaries are not so sharp. In the first case the observer will notice a difference in luminance between two lines or spots for a smaller θ or ϕ than he will in the second case. Because of nonlinearities across the screen surface, θ depends upon the particular area of the screen discussed. It is theoretically possible, with a laser display, to keep these nonlinearities small enough such that at no place on the screen will θ exceed one minute.

GENERAL CONCLUSIONS

Laser displays are feasible from the point of view of human factors. Present technology is about sufficient to fulfill human factors recommendations. The power output from lasers presently matches but does not exceed that of the ubiquitous CRT. The future promises the potential for larger, brighter, more colorful laser displays than those presently available which are limited to about the equivalent of CRT displays. Although this suggests the potential for performing special functions not now done well by any display technology, it will be sometime before laser displays are competitive in those more numerous applications in which CRT displays are now firmly entrenched.

Visual principles established on the basis of other light sources may, of course, be expected to hold for laser sources as well. The special visual effects resulting from the unique characteristics of laser light do not pose particularly difficult problems for the display designer. Indeed, they provide the essentials for new display methods and applications.

FOOTNOTE

1. In considering display resolution, distinctions should be made between the number of addressable points, the number of physically resolvable points, and the number of perceptually different points. On at least some CRT displays there are more addressable points than physically resolvable points than perceptually resolvable points. It is a practice to design displays which have 1024 x 1024 addressable points. Rosenbloom (1966) has questioned the practice of providing a number of physically resolvable points on a display screen. Caution must be exercised if an excess of addressable points is obtained, for example, at the expense of limiting the regeneration rate of a display to marginal levels. Certainly from the point of view of using a light pen, a relatively high number of addressable points is not needed, both because the operator cannot see this many points and also because the precision with which he can aim the light pen is limited.

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A plastic virtual inifinity lens system for large aperture cathode ray tube displays

by
W. V. GOODELL
P. D. WOODSON

ABSTRACT

Recent developments in the area of real time simulation have generated requirements for large virtual infinity display optics. This paper discusses the development of a 24-inch, plastic, refractive optical system designed for a direct view simulator display system.

First the problem is discussed and then the rationale leading toward a solution. Finally, the optical design is developed taking into account the characteristics of the CRT, refractive optical materials, and fabrication problems.

GENERAL CONSIDERATIONS

Considerable effort has been expended over the past few years to develop a virtual infinity simulator display covering a total spherical solid angle approaching 4 π steradians. Generally, a virtual infinity display system is one whose ray pencils from the object generator are collimated and appear to originate from infinity. This allows the observer's eye to relax, thus producing the visual sensation of distance. The quality of such a system can be described by the usual optical properties; collimation, distortion, modulation transfer, contrast ratio, brightness, etc.

A major difficulty is to retain the optical quality of the system over a very large field of view. One solution to this problem is the use of a mosaic of optical elements opto-mechanically nested to produce a uniform scene. The elements of the mosaic occupy sections of a sphere and surround the observer located at their center.

The size and therefore the number of these elements is limited on one hand by lens fabrication capabilities and on the other by the mechanical complexity of a many-sectored mosaic. The ideal configuration would contain as few components as possible and yet retain sufficient optical quality.

Geometrical optical considerations led to gross system design goals of $f/\# \approx 1$, a viewing angle of $\pm 18°$, and a clear aperture approaching 24 inches. Virtual infinity displays for systems of large size pose difficult design and fabrication problems. Conventional virtual infinity systems such as head-up displays in fighter aircraft are restricted to small physical dimensions of a few inches, relatively long focal lengths, and small relative apertures. The viewing angle, α, and image size, X, of such a display are given by:

$$\alpha = 2 \tan^{-1} \left[\frac{f}{2(f/\#)d} \right] \quad (1)$$

$$X = 2 f \tan (\alpha/2) \quad (2)$$

where

f = focal length
d = viewing distance
$f/\#$ = relative aperture of system

A typical display of this type with $f/\# = 1$, f = 4" and d =

This work was supported by the Air Force, Wright-Patterson Air Force Base, Ohio.

23″ gives $\alpha = \pm 5°$ and $X = 0.7$ inch. The magnitude of the present problem, therefore, can be visualized when fields of $\pm 18°$, $d = 30″$, and $f/\# = 1$ are desired.

Cathode Ray Tube Characteristics

A CRT is used as the object generator or image-producing element in the simulator visual display and, as such, it represents some practical limits of the display insofar as the lens system must correct for the spectral range of the phosphor and the curvature of the phosphor surface.

While the CRT size was determined primarily by the largest tube which could maintain the desired resolution and brightness, the choice of phosphor was governed by wider and more diverse considerations such as persistence, saturation, spectral energy conversion efficiency, small grain size, and batch uniformity. The last consideration is important, of course, to a simulator with many CRT elements. Three phosphors, P-4, P-31, and P-23, were considered; all were relatively satisfactory from the criteria listed above.

Table I lists some of the electro-optical constants for these phosphors.[1,2]

TABLE I
Electro-Optical Constants
for P-4, P-23, and P-31 Phosphors

Phosphor	K_1	K_2	K_3	Chromaticity Coordinates	
				x	y
P-4 (Sul.)	290	15	43.5	0.270	0.300
P-4 (Sil.)	240	8	19.2	0.333	0.347
P-23	(Similar to P-4 Sulfide)			0.375	0.390
P-31	230	22	50.6	0.193	0.420

Where K_1 = luminous efficiency; K_2 = radiant efficiency; and K_3 = energy conversion efficiency. The chromativity coordinates show that P-4 and P-23 are white phosphors and P-31 is light green.

P-31 has one major disadvantage because it is not white. However, its superior energy conversion efficiency makes it attractive due to the high system brightness requirement. P-31 was used and system highlight brightnesses of 40 footlamberts for the 27″ diagonal CRT were obtained.

Refractive Optical Materials

Considerations of economy and weight were the primary reasons for the choice of optical grade plastics for the display optics. The use of plastics in refractive optics is certainly not new; however, their employment as components of very large, substantially corrected systems has had limited study. The concensus of most workers in the field indicates that variants of acrylic (polymethyl methacrylate) and styrene (polystyrene) polymers are excellent for optical work if properly refined.[4]

Acrylic and styrene are good visual optical materials. They have reasonably large refractive index and V-value differences, are moderately hard, and their softening points are above 150°F. Their clarity is high due to low body scattering. Table II lists these important properties. Figures 1 and 2 show the dispersive and spectral characteristics of the two polymers.

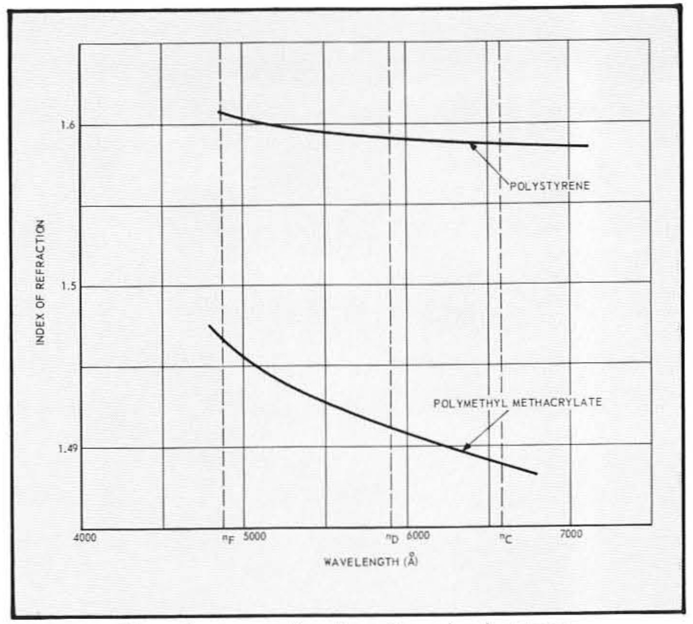

FIGURE 1: Dispersion properties of acrylic and polystyrene

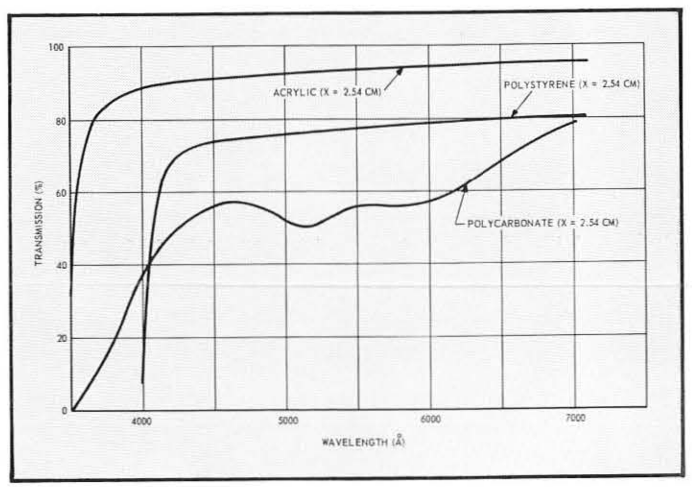

FIGURE 2: Relative transmission vs. wavelength

TABLE II

Type	n_D	V-value	Rockwell Hardness	Haze	Vicat Softening Point
Acrylic	1.49	54	M95	<3%	>200°F
Polystyrene	1.59	30	M76	<3%	>200°F

Optical Design

The unique optical requirements of the simulator display virtually ruled out optical components of standard design. As a result, two different design paths were attempted. The first was to develop a design using spherical surfaces, the second, aspheric surfaces.

The design study led to a configuration, which is basically a Petzval-type (PP) objective,[5] capable of correction for large apertures over moderate fields. The final design configuration is shown in figure 3.

This lens type achieves its performance by distributing the lens power throughout the various elements, thereby reducing spherical and secondary chromatic aberrations. The relatively high value of Petzval sum is reduced by a negative field flattener near the CRT.

In a simulator display the aberration tolerances are derived from considerations of the man-machine interface. Therefore, the degree of correction was determined by physiological effects and fire-control rather than photographic performance alone.

As an example, consider a system operating in the photographic mode. The Rayleigh limit corresponding to a wavefront optical path difference (OPD) of $\lambda/4$ requires the zonal spherical aberration, LA_m, to be:

$$LA_m = \pm 6\lambda/N \sin^2 U_m.$$
$$\text{At } \lambda = 5500\text{Å and } \sin U_m = 0.1, \text{ then} \quad (3)$$
$$LA_m = \pm 0.3 \text{ mm}$$

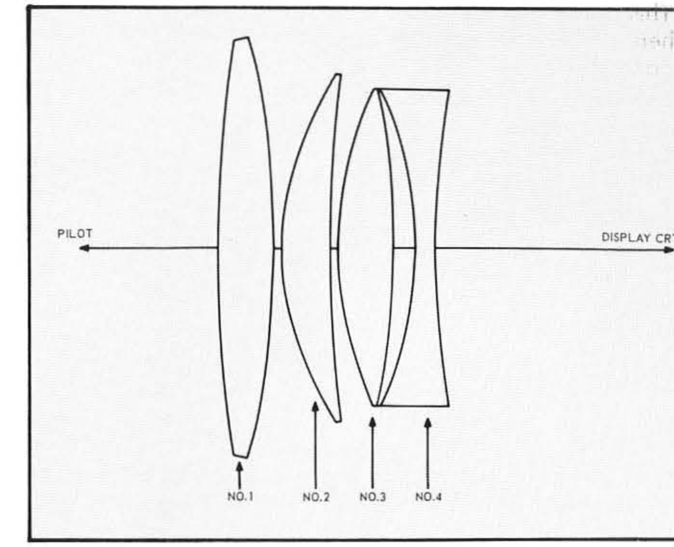

FIGURE 3: Plastic refractive component, final configuration

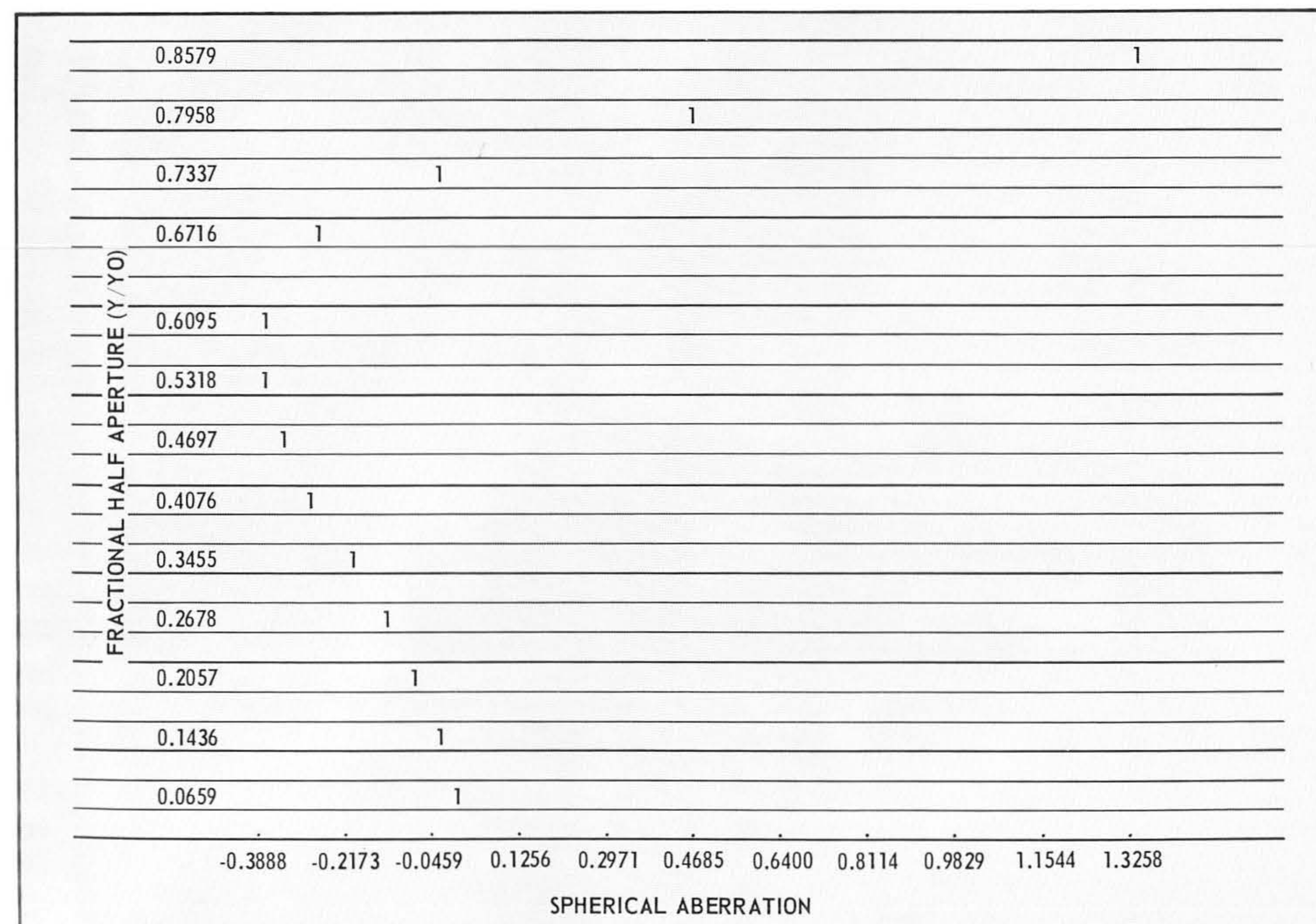

FIGURE 4: Computer plot of component spherical aberration

This value can be used as limits on the correction of spherical aberration and can be used in tradeoffs with other aberrations.

This particular design has 19 optical degrees of freedom (8 surface curvatures, 7 surfaces separations, 4 refractive indices). However, only about one-half can be used as variable in design due to physical limits imposed on the system.

A simple, yet fundamental, consideration is the restriction on curvatures and vertex thicknesses of the lens elements in order to obtain sufficiently large clear apertures. The edge thickness of E of a singlet with surface curvature, C_n, thickness, T, and radius, R, is given by:[6]

$$E = 0.5\,(C_2 - C_1)\,R^2\,[1 + 0.25\,(C_2^2 + C_2C_1 + C_1^2)\,R^2] + T \qquad (4)$$

Since large apertures and reasonable vertex thicknesses were required, individual surface curvatures were restricted to narrow limits.

Acrylic was used for the outside elements to shield the less durable polystyrene lenses. This arrangement gives a low-high-high-low index distribution. This reduces the design freedom. The positive elements were designed to be high index and the negative elements low index. This distribution is desirable in order to obtain the needed undercorrected field curvature. On the other hand, the V-value distribution should be low for the positive elements and high for the negative elements for chromatic correction.

An IBM-1130 computer was used for major design and aberration corrections while supplementary evaluation was performed using the IBM-360/40. The initial design was analyzed and gross system alterations were made, based on experience and judgement. Revised designs were tested until a promising system emerged or a different approach was seen to be required. An automatic correction routine was then called with target parameters assigned to the aberrations. The system merit function was computed and preselected optical degrees of freedom were varied until the function converged to the target values or failed.

Ultimately, three final configurations evolved from the more than 30 initial designs. The optimum design shown in figure 3 was fabricated, assembled, and tested in duplicate to determine the feasibility of nesting multiple elements of a mosaic.

System performance approached that predicted by computer. Unavoidable decentering of the 100-pound components resulted in some small losses. Table III summarizes the measured system performance when used with the CRT.

TABLE III
Refractive Display System Performance
of Field = 10°

Collimation (arc minutes)	Distortion (%)	Chromatic Ab. (mm)	Brightness (Ft-L)	Resolution (ℓp/mm)
1.5	3	3	40	4

Figure 4 is a computer plot of the spherical aberration of the component. Figure 5 is a view of a two-CRT display through the nested components.

FIGURE 5: View of a two-CRT display through the nested components

CONCLUSIONS

A fast, large aperture virtual infinity display was built with corrections adequate for simulator use. Optical grade plastics were used and found to be satisfactory from the standpoint of optical and mechanical performance, while proving to be relatively easy to fabricate.

Although adequate corrections were obtained for this system, it is doubtful that acceptable performance can be achieved for very large refractive systems faster than f/1 without using aspheric surfaces.

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Mr. Woodson received his B.S. in physics from William and Mary College in 1964 and his M.S. in physics from Brown University in 1966. He is a member of Phi Beta Kappa.

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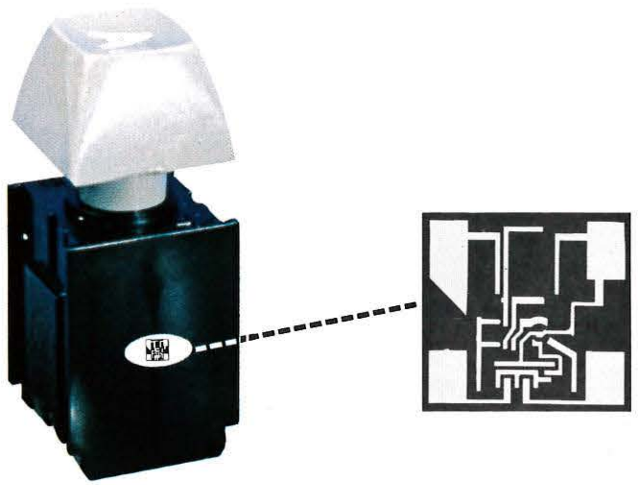

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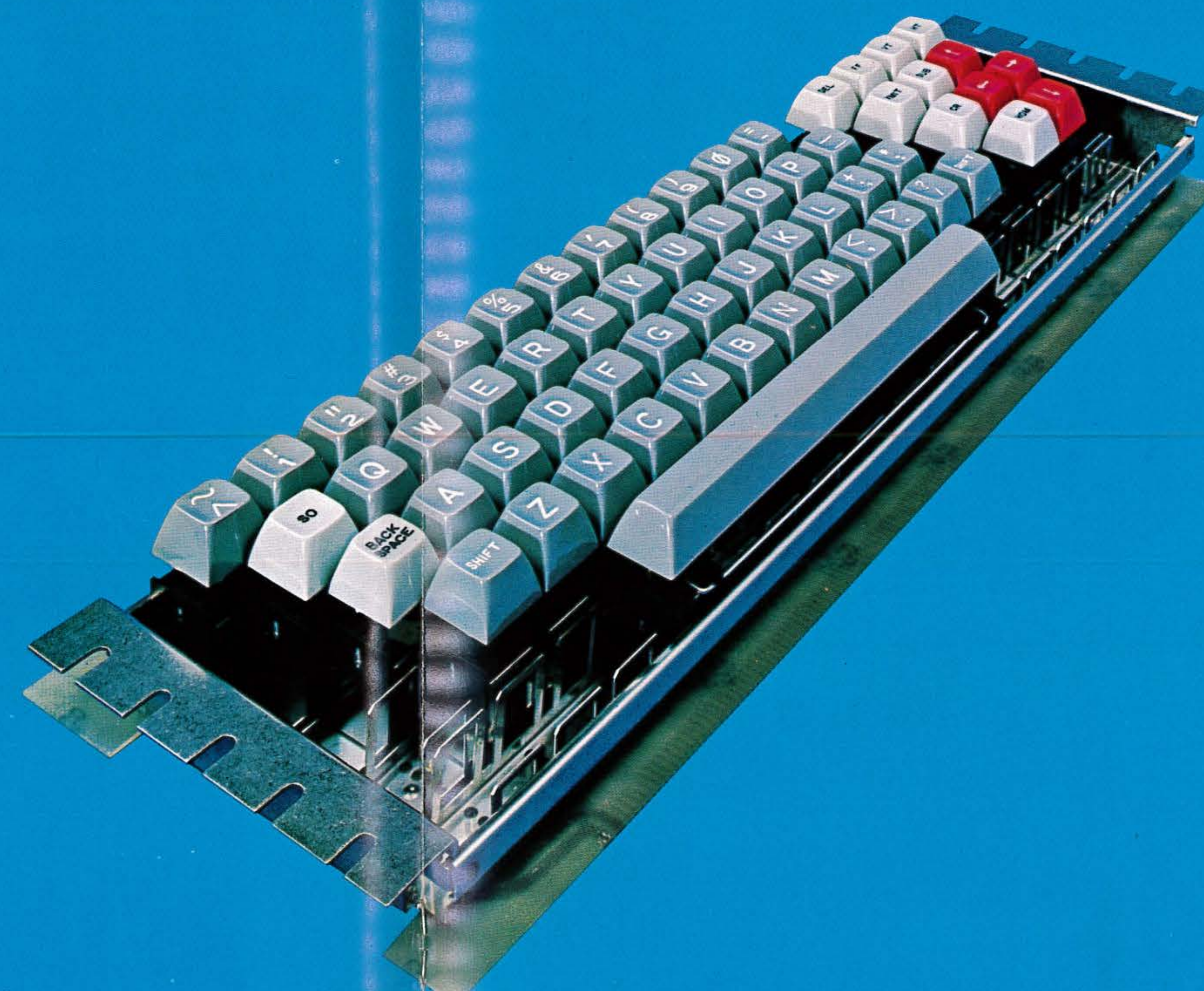

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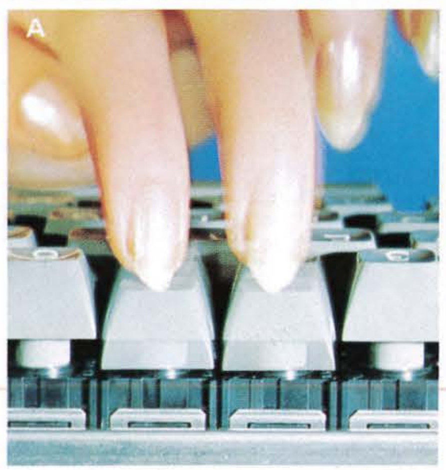

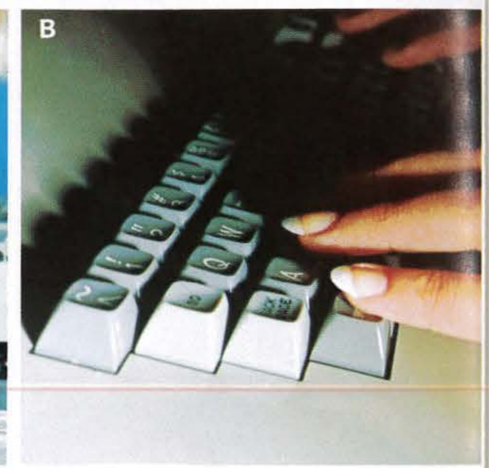

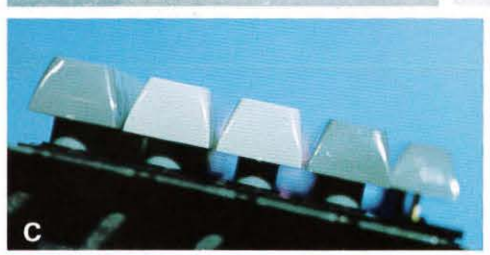

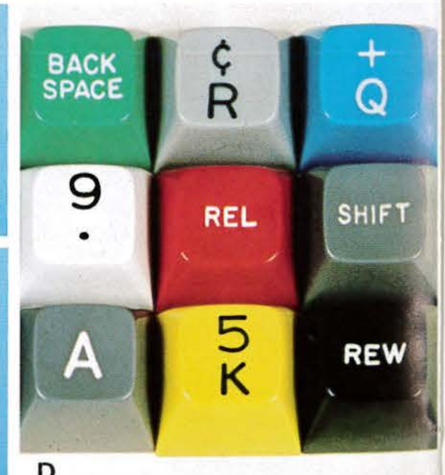

The plasma display

by R. H. WILLSON

INTRODUCTION

Although display technology has progressed rapidly during the past few years, there is at present no large tactical display which is completely satisfactory nor is there a completely satisfactory digitally controllable display for airborne systems or for ground portable van systems.[1,2] Recently, a new advance in the state-of-the-art was made with the invention at the University of Illinois of the plasma display.[3,4] Although the plasma display does not satisfy all of the conditions that one would like, it does come closer in meeting those conditions for the above systems than any other technique.[5] In the following, we will consider the characteristics of the plasma display. We will discuss the history of the development, cell construction and the experimental set up used to measure the cell's characteristics, a few of the experimental results which shed light on the mechanisms responsible for the cell's behavior, an explanation of the bistable characteristic, techniques for writing and erasing, the current status of the display, and finally problem areas which remain to be solved.

History

In order to minimize the amount of control electronics necessary to control an array of discrete light emitting elements, crossed grid arrays have been made. For instance, for a crossed grid array of n x n elements, instead of requiring n^2 control circuits, only 2n control circuits are required. However, if the light emitting elements of the array are not bistable only a single element can be selected at a time, an external memory device must be used and the display must be cyclically refreshed at a high enough rate to prevent flicker. Since only one element is on at a time, the average cell on time is low and the average cell brightness is much lower than what it would be if the cell were on continually. On the other hand, if the elements have a bistable characteristic, the display does not have to be continually refreshed, no external memory is required and on cells are on all of the time thereby yielding the full brightness of the cell.

Under appropriate conditions a larger voltage is necessary to ignite a gas discharge than is required to sustain the discharge.[6] At intermediate voltages the gas discharge has a bistable characteristic associated with it and the properties of a light source and memory are combined. Thus, arrays of gas cells are ideally suited for arrays of self-luminous elements because gas cells combine the functions of the light emitting element and memory element into the same embodiment.

One of the first arrays of gas cells was made by Skellet in 1954.[7] His design had two orthogonal sets of wires which were separated by a small distance and sealed in a neon atmosphere. There were 100 horizontal and 20 vertical wires. Skellet reported that a discharge could be confined between any crossed pair of electrodes in the array. He did not report on experiments in which more than one cell was fired concurrently. However, Harris,[8] in a memorandum on the Skellet display, pointed out that when a number of cells were ignited additional unwanted cells would also be ignited.

Moore[9] in 1963 made a rectangular array similar to that shown in Figure 1. A honeycombed glass panel was placed between two outer glass panels and parallel transparent thin film electrodes were deposited on the inside surfaces of the outer glass panels. Air was evacuated from the array and the array was filled with neon. Initially, Moore was interested in igniting only a single spot of light and in this he was successful. Later, when he tried to ignite a number of cells, he discovered that cells which had electrodes in common with the fired cells would also ignite.

Thompson,[10] in 1964, added a series resistance to each gas cell to reduce the coupling between the electrodes. He made a matrix of 10 x 10 cells, and demonstrated that any combination of cells could be fired without firing unwanted cells. One set of parallel electrodes were on the inside surface of the outer plate. The other set was isolated from the discharge cells by resistors which were connected to feedthrough electrodes, one for each cell. However, fabrication difficulties limit both the cell density and the cell size with this technique. Also, cathode sputtering and local impurities cause an undesirable variation in the cell's characteristics.

Bitzer, Slattow and Willson,[11] in 1964, placed electrodes on the outside surfaces of the outer plates. Their first experiments were on a single cell that was filled with neon. They observed that the cell had a large bistable characteristic and that the cell's electrical characteristics were time dependent. The time dependence was attributed to impurities in the cell

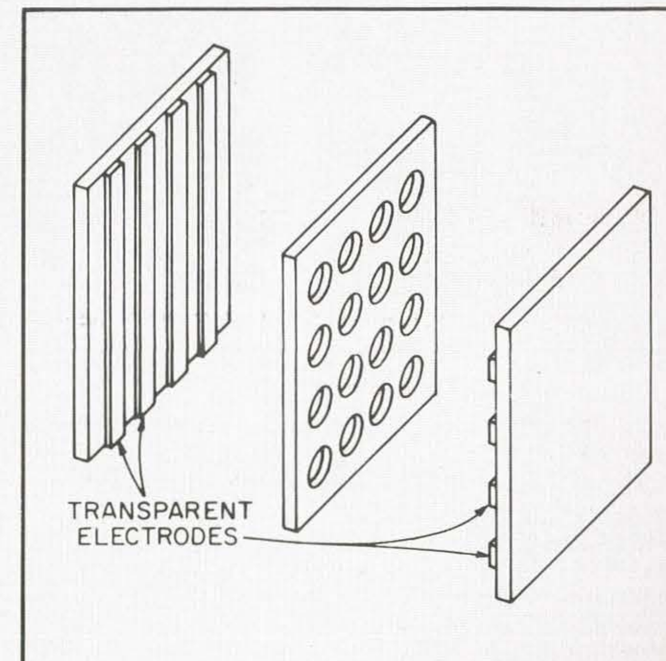

FIGURE 1a: Rectangular array of gas cells with internal electrodes

which were introduced in part, by a relatively dirty vacuum-gas filling system so a much cleaner all glass, bakeable, vacuum-gas filling system was made. Using the new system, they observed that, with neon alone, the cell had almost no bistable characteristics but with a small percentage of a molecular gas added to the neon, 5% N_2 for instance, the cell exhibited a large bistable characteristic. An explanation of the bistable characteristics and its dependency on gas mixture will be given.

The first successful array of cells made with external electrodes was made by Bitzer, Slottow and Arora in 1966.[12] Their array consisted of 64 cells (8 rows and 8 columns) of which 16 (4 x 4) were used to demonstrate selective writing of cells; the cell density was 40 cells/inch; see Figure 1b. In the following this type of gas discharge array will be called the plasma display. Later that year plasma displays were also made in a number of different industrial laboratories. Work on plasma displays is continuing and we will mention some of the work herewith.

Cell Construction

A plasma display is constructed from three pieces of thin flat glass panels sandwiched together. The center panel is honeycombed with holes and transparent electrodes are vapor deposited on the outside surfaces of the outer glass

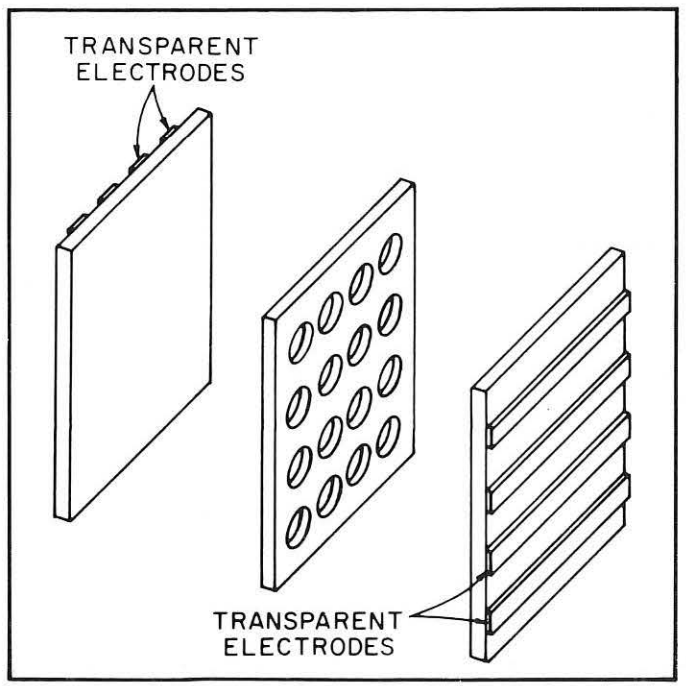

FIGURE 1b: Rectangular array of gas cells with external electrodes

panels. The two sets of electrodes are orthogonally positioned; see Figure 1b.

Each cell forms a small volume which is completely surrounded by glass. Voltages which are applied to the appropriate row and column electrodes are capacitively coupled into the cell. The capacitive reactance isolates the cells from the row and column electrodes and any combination of cells can be on at one time.

Usually the holes in the honeycombed panels are etched although early arrays were made by ultrasonically drilling the holes. Typically, the holes are .015 in square although both


FIGURE 2: Photograph of 16 x 6 element plasma display with symbol written into display

larger and smaller holes have been made. The panels are typically .006 in thick.

The sandwich of three plates is sealed with epoxy to a tube. The panel is evacuated and then filled with a neon-nitrogen mixture to a pressure of approximately 700 torr.

In Figure 2 a photograph is shown of a 16 x 16 element plasma display with a symbol written into the display. The cell density was 40 cells/inch and only sustaining voltages were applied to the array. The average cell brightness was 600 fl. and the excitation frequency was 300 KHz; the electrodes transmitted 50% of the light.

Experimental Results

Measurements of the current and the radiated light of the capacitively coupled plasma discharge cell show that the characteristics of the discharge is dependent upon the gas mixture used. For instance, discharges in neon,[3] in helium,[13] and to a lesser extent in argon, [3,13] are relatively slow in forming and are generally characterized by long light pulses that are nearly as long as a half cycle of the sustaining voltage. On the other hand, discharges in nitrogen,[3] and neon-nitrogen mixtures,[3] are formed very rapidly and are characterized by extremely short light pulses which can be as short as 40 x 10^{-9} seconds in duration. Furthermore, it was found that a significant bistable characteristic occurs only for the rapid discharges.[3,13]

In Figure 3 oscillograms are shown of the sustaining voltage and the light pulse, as measured with a photo multiplier. The light from a number of cells (about 12 cells) was channeled via a light pipe onto the cathode of the photo multiplier. A 400 element plasma display was used; the cells were .015 in. square and .006 in. thick. For Figure 3a, the cells was filled with neon only and we see that the light pulse is rather broad and persists for a large fraction of a half cycle. With 4.3 percent of nitrogen added to the neon, the light pulse is considerably narrower and larger; see Figure 3f. Figure 3b-f shows the waveforms for a number of different nitrogen concentrations. The narrower, larger light pulse corresponds to a more rapid, and more intense discharge.

A much more rapid discharge is also observed when the

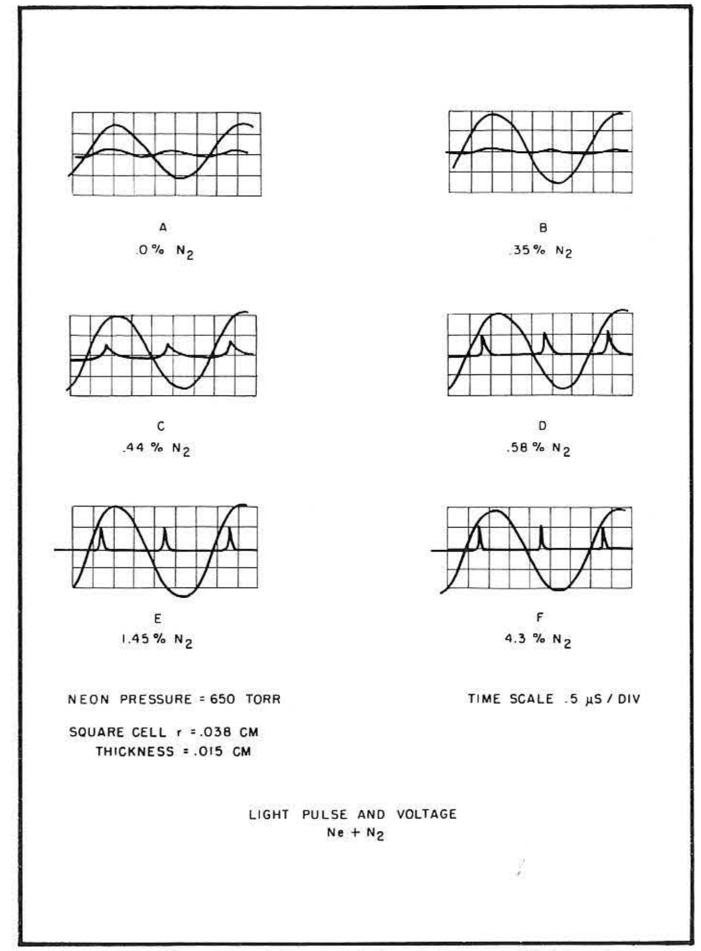

FIGURE 3: Oscillograms of the sustaining voltage and light pulse, as measured with a photo multiplier

other gases are added to neon, i.e. neon plus carbon monoxide and neon plus water vapor.[3] Likewise, helium plus nitrogen, and argon plus nitrogen[13] exhibits the rapid discharge and a large bistable characteristic.

Bistable Characteristics

It is well known that the bistable characteristic of a dc gas discharge is due to the space charge of the discharge.[6] If the space charge is removed, the full firing voltage must be reapplied to reignite the discharge. On the other hand, for the plasma display with a proper gax mixture, the discharge persists for only a short period of time each half cycle. However, once the discharge is initially ignited subsequent discharges occur even though the amplitude of the applied voltage is reduced. Calculations show that practically no particles remain in the volume between discharges so a space charge mechanism can't account for the bistable characteristic. A new mechanism is necessary to explain the bistable characteristic of the plasma display.

In Figure 4, a sectional view of a single gas cell and its equivalent circuit are shown. Capacitor C_1 represents the coupling between the external electrodes and the adjacent cell walls, capacitor C_2 represents the capacity of the unfired cell, and G represents the gas discharge.

Let us assume that the cell is filled with a proper gas mixture so that the discharge is very rapid. Let a time varying voltage be applied across terminals a-b and assume that at time t_1, the firing voltage is applied across the cell (capacitor C_2 in our model). Shortly after, the discharge starts and rapidly creates a large number of electrons and ions. The charge flows in a direction to minimize the energy of the system and shortly after the discharge was started enough change is present to reduce the cell voltage below the minimum dc sustaining voltage thereby extinguishing the discharge. Charge will continue to flow from the volume and a voltage V_w appears across the cell due to the charge which is deposited on the cell wall. It the total voltage difference across the cell does not change sign while charge is in the volume, V_w will be larger than it would be if there were a sign change of the voltage. The charge leakage time is long compared to the times between firings and V_w is essentially constant between discharges. During the next half cycle the component of the external voltage which is across the cell adds to the wall voltage, V_w, and only V_f-V_w need be supplied to ignite the

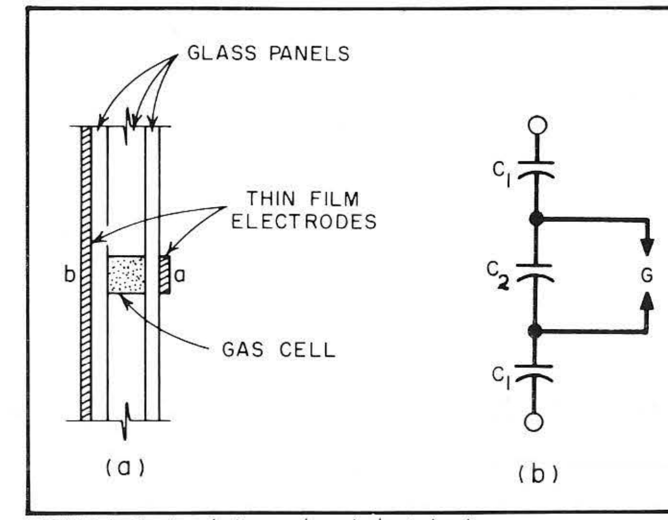

FIGURE 4: Sectional view and equivalent circuit

cell. At any voltage between V_f, and V_f-V_o, the cell has a bistable characteristic and the state of the cells is determined by the presence or absence of the wall voltage, V_o.

The time dependence of the current buildup is strongly influenced by a small increase in the applied voltage above the firing voltage; a small percentage increase in the applied voltage above the firing voltage causes a large increase in the current. Thus if the slope of the applied voltage at time t_1 is large, V_o will be larger than what it would be if the slope were smaller. As we shall see further on, this slope dependence is useful in changing the state of cells.

It appears most likely that in the rapid discharges a fast electron multiplication mechanism dominates (ion bombardment of the negative surface). A more detailed explanation of these mechanisms will be found in reference 3.

Drive and Selectron Circuitry

A number of techniques are possible for inputing data into the plasma display. The most straightforward method and indeed the first method used is to control the voltage on each row and column electrode independently. A second method is to drive the lines in parallel with a single sustaining voltage source and to add pulses to appropriate lines.[13] Each method has its advantages. Let us now consider these methods in some detail.

Fast Write and Erase

The first write-erase scheme which has been called fast write and erase, makes use of three voltage levels, V_w a write voltage, V_s the sustaining voltage, and V_e the erase voltage. Of course, $V_w > V_F$ and $V_e < V_E$ where V_F is the cell firing voltage and V_E is the cell extinguishing voltage. Through control circuits, either $V_w/2$, $V_s/2$, or $V_e/2$ is applied to a given row electrode and the corresponding voltage of opposite polarity is applied to the column electrode. Thus, the cell has either V_w, V_s or V_e across it and is written, sustained or erased. This technique is the fastest of the two techniques but relative high voltage control circuits are required.

An interesting result has been derived[12] at Illinois which interrelates the variation in the cell parameters and in the control voltages to the memory margin, α. The symbols V_F, V_E, V_e, V_w, V_s are taken to be mean values and the voltage range is assumed to be $V \pm \Delta V$ for each voltage. In general the voltage range is not symmetrical with respect to the mean voltage but assuming it is symmetrical isn't too serious of a simplification. Using the condition that unwanted cells are not fired or erased, one obtains the following.

$$V_w \geq V_F + \Delta V_F + \Delta V_w$$

$$V_e \leq V_E - \Delta V_E - \Delta V_e \qquad (6.1)$$

$$V_E + 3\,\Delta V_E + 2\,\Delta V_e + \Delta V_s \leq V_s \leq V_F - 3\,\Delta V_F - 2\,\Delta V_w - \Delta V_s$$

The memory margin, α, is defined as

$$\alpha = \frac{(V_F - V_E)}{\frac{1}{2}\,V_F} \qquad (6.2)$$

Solving for V_E in equation 6.2 and substituting for V_E into equation 6.1 one obtains,

$$2 - \alpha + \frac{(3\,\Delta V_E + 2\,\Delta V_e + \Delta V_s)}{\frac{1}{2}\,V_F} \leq \frac{V_s}{\frac{1}{2}\,V_F} \leq 2 + \frac{(-3\,\Delta V_F - 2\,\Delta V_w - \Delta V_s)}{\frac{1}{2}\,V_F} \qquad (6.3)$$

The minimal acceptable α occurs with equality of equation (6.3) and one has

$$\alpha\ \text{min} = \frac{3\,\Delta V_E + 3\,\Delta V_F + 2\,\Delta V_e + 2\,\Delta V_w + 2\,\Delta V_s}{\frac{1}{2}\,V_F} \qquad (6.4)$$

for simplicity if one further assumes that all of the ΔV's are equal than one has

$$\alpha\ \text{min} = \frac{24\,\Delta V_F}{V_F} \qquad (6.5)$$

Actually, α could be somewhat smaller than that indicated by equation 6.5 since the numerator of equation 6.4 is usually less than 24 ΔV_F. In general $V_E \leq V_F$ so $\alpha \leq 1$. If $V_E = \frac{V_f}{2}$, the cell walls are said to be completely charged. If we assume that ΔV_w, ΔV_e, ΔV_s, are all very much less than ΔV_F or ΔV_E and if we let $\Delta V_E = \Delta V_F = \Delta V$ we have

$$\frac{\Delta V_F}{V_F} < \frac{1}{12} \text{ or } 8.2\% \qquad (6.6)$$

Thus with near perfect regulation of the applied voltages and with complete cell charging, the cell's electrical characteristics must not vary by more than about 8%. Notice that even with perfect regulation of V_w, V_e and V_s, the fraction of these voltages which is applied across a cell is a function of the plate thickness and the local dielectric constant. If one is to minimize the variations in the applied voltages, both uniform plates and regulated voltages must be used.

Slow Write and Erase

A diagram of the control circuitry for the second control technique, designated slow write-erase, is shown in Figure 5. A single sustaining voltage source supplies the sustaining voltage to the whole array and all of the lines are driven in parallel. The switching networks apply voltages to selected lines through resistors R. The R-C network isolates the switching network from the sustaining voltage source and relative low voltage switching transistors can be used. Logic circuitry control the application of both the write or erase pulses and the sustaining voltage.

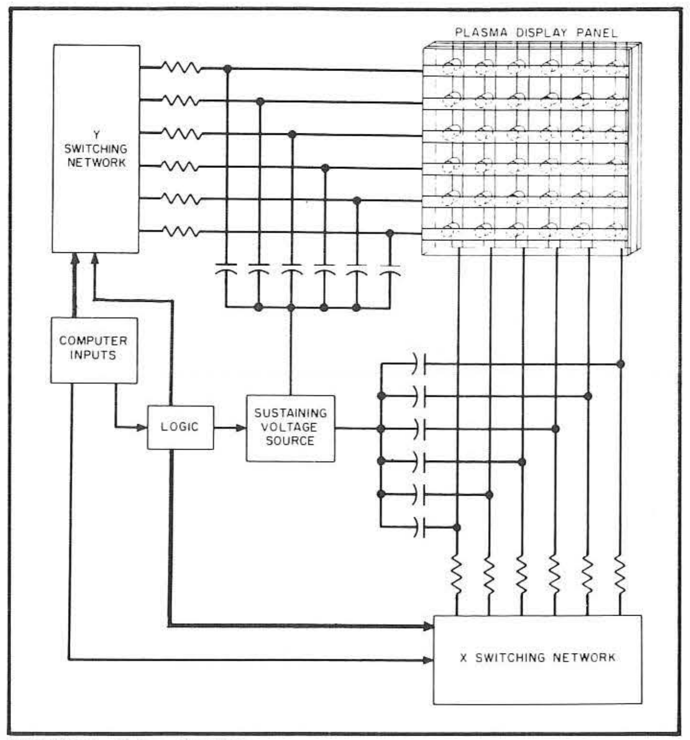

FIGURE 5: Drive circuitry

Usually, only the sustaining voltage is applied to the array and cells that are in the one state continue to refire each half cycle, but cells in the zero state do not. To fire a cell the sustaining voltage for the whole array is removed at a zero crossing of the sustaining voltage and voltage pulses are added to the selected row and column. The sustaining voltage is then reapplied and, with a proper choice of pulse amplitude, the total voltage across the cell exceeds the firing voltage and the cell fires. The cell is now in the one state and will refire each half cycle. The pulses are then removed and the cell "tracks" the voltage because of the slope dependence mentioned previously. This sequence of operations is illustrated in Figure 5.2.

To erase a cell, the pulses are added to the selected row and column before the sustaining voltage is removed and the cell tracks the resultant voltage, see Figure 5.2b. Notice that just before the erase voltage is removed, the total voltage across the cell is nearly zero. The sustaining voltage is now removed. The sustaining voltage was removed just after the wall was positively charged, and if the amplitude of the voltage pulse was appropriately chosen, no net voltage appears across the cell. With the resumption of the sustaining voltage, since the net wall voltage is zero, the cell will not ignite and the cell has been erased.

Measurements show that about four half cycles of the sustaining voltage must be allowed for the tracking of the pulse voltages.[12] Thus at least two periods must be allowed for writing or erasing the cell. Also if the sustaining voltage

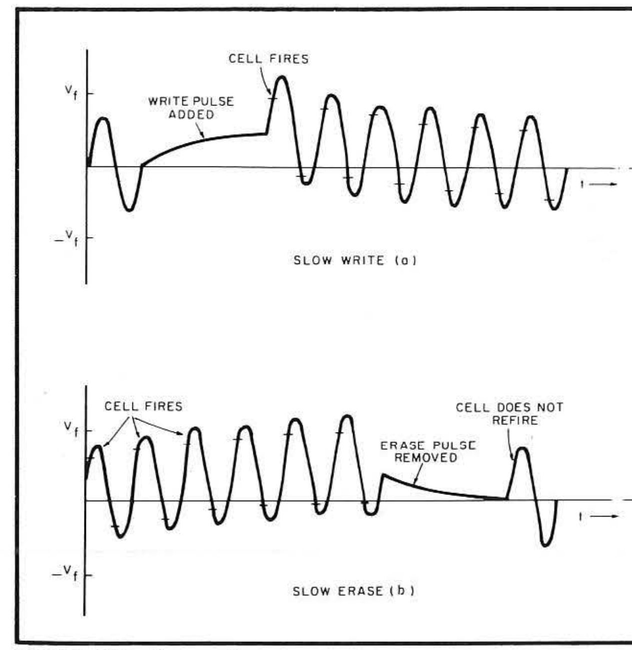

FIGURE 5.2a: Slow write-erase

is off too long, some cells might not refire.[13] The permissible off time is strongly determined by the cleanliness of the cells. We have found that for relatively "dirty" cells, the off time must be less than 15 μsec while for rather "clean" cells the off time can be as large as 1000 μsec. Typical times are 15 μsec for the total rise and fall times and 30 μsec for the switching voltage "off" time which gives a 60 μsec write or erase cycle.[14] If the cells are written one at a time, 16,000 cells can be written in a second. For most applications this speed is adequate. If the cells are written a row at a time 16,000 rows can be written in one second.

Current Status

Much work is currently being done in the plasma display area. As of August 1967 at least six different industrial and university laboratories were actively doing research and development work on the plasma display. The feasibility of the concept has been established and now the major goal is to make a reliable, reasonable size array with appropriate control circuitry. A number of problem areas must be solved, and we will discuss some of the more important problem areas later on. Let us briefly consider the status of some of the research and development work.

Bitzer, Slattow and their colleagues at the University of Illinois have confined their work to a 16 x 16 element array. They invented the two write-erase techniques and are presently perfecting them. Also they are investigating computer memory aspects of the plasma display and are looking into some aspects of the physics of electrodeless discharges which are germain to plasma displays.[15] Special concern is being given to the use of phosphers in the cell and to surface phenomena which influence the photoelectric emission from the cell surface.

Harris and his colleagues (Magnavox) demonstrated their plasma display at a plasma display symposium in June 1967. Their display was 32 cells x 32 cells with 32 cells/inch. An ultraviolet light was placed behind the display to enhance the firing probabilities of the cells. Their display could be written or erased under control of a computer but this wasn't demonstrated at that time. They used the fast write techniques. Berillium copper electrodes were used for the transparent electrode.

Mayer and his colleagues (C.D.C.) demonstrated their plasma display at the conference also.[2] Their array had 96 cells x 96 cells and had a cell density of 32 cells/inch. It was controlled by a computer (for writing only). They also used an ultraviolet source to illuminate the array. Due to the low firing probabilities associated with their cells it was necessary to cyclically rewrite the display a number of times. The fast write technique was used. Opaque berillium copper electrodes, with etched holes filled with highly transparent tin oxide were used for their electrodes. Their display was very dim and was viewed with the room lights off.

Demetrick and his colleagues[2] at Syracuse University Research Corporation have been involved in evaluation of the plasma display work and in evaluation of the feasability of the plasma display for tactical airborne systems.

Our work[14] at Westinghouse has been along a number of lines. We have made various arrays, the largest being 60 cells x 30 cells, 40 cells/inch although most were 20 cells x 20 cells. Control electronics that are digitally controllable were designed and fabricated. The slow write-erase technique was used. During the write cycle the write pulse is left on for a period of time after the sustaining voltage has been applied so that the cell firing probability is increased. An ultraviolet light is also used. Our first objective was to show feasability and to develop techniques for making both reliable arrays and less expensive electronics. Uniform arrays have been made and the first step in developing less expensive electronics has been taken. Our second objective is to consider problems associated with making larger arrays from basic modules building blocks, and we are considering various interconnection techniques for doing this. Also, techniques for enhancing the firing probabilities of the cells are being investigated with a view toward the eventual elimination of the UV source.

We have recently embarked on a program for Rome Air Development Center for an investigation of the Plasma Display for use as a large area display. Of specific concern will be to establish the optimum panel and cell configurations, together with the development of economic electronics for the display. It is anticipated that the program will provide sufficient information so that programs directed toward the development of building block panels can be undertaken.

Work is also being done in the area of color plasma displays and gray scale capabilities. Morrison, Markin and Sobel[16] of Zenith Radio Corporation are working in this area.

CONCLUSIONS

We have seen that the plasma display is a digitally controllable high brightness display with an inherent memory and that small panels have been made that show the feasibility of the concept. However there are a number of problems associated with making a larger plasma display. There are problems associated with making uniform arrays, with supplying a source of initial electrons and in making inexpensive electronics.

The thickness of the three plates and the holes in the honeycombed plate, must all be uniform. The electrodes must be placed over the cells consistently. These constraints are not difficult when none makes small arrays but for larger arrays they pose an increasingly difficult task. It appears that for arrays larger than a few inches square (larger than about 16 inches squre) a modular approach should be used. Modularization is especially attractive for displays in which the cell density can be smaller and a wider space between lines is permitted (large area tactical displays for instance).

Glass plates can be made with parallel surfaces. The honeycombed hole structure can be etched fairly uniformly, but as the plate area gets larger, inhomogenities of the glass start to influence the structure. Trade-offs between the difficulties of making larger modules and the difficulties of interconnecting smaller modules must be carefully considered.

Another problem is in supplying a source of initial electrons for cells that are off so that the cells can be fired at any specified time. A U.V. light is presently used to illuminate the array and photoelectrons are ejected from the glass surfaces by the photoelectric effect. Work must be done to enhance this mechanism and to develop photo sensitive surfaces which will operate under room illumination.

It has been mentioned that metastable atoms most likely account for the initial source of electrons between discharges for "on" cells.[3] It might be possible, with the application of an appropriate excitation waveform, to fire off cells often enough to guarantee a supply of excited atoms (metastables) but at a small enough rate so that the discharge is not visible. This firing must be done in a manner that leaves the walls of the cells in the zero state (uncharged) but that does not change the state of cells in the one state.

The easiest method for guaranteeing reliable writing of the array is to write negatively. The whole array would normally be on and writing would correspond to turning off selected cells. Cells can be erased very reliably as there is no problem of available initial electronics. However, from a human factor standpoint, negative writing might not be desirable.

Inexpensive drive and selection electronics must be developed. Indeed, it appears that the major expense of the display will be the control electronics. It should be possible to make the line drivers from microelectronics using thin film—discrete chip components. This technique would significantly reduce the cost of the display and is being investigated.

Although there are a number of problems that must be solved, it appears that with the proper integration of surface physics, gas discharge physics and engineering that these problems can be solved. Indeed, the plasma display should be a prime candidate for large area tactical displays.

ACKNOWLEDGEMENTS

Many people have contributed to the development of the state-of-the-art of plasma displays and as far as was practical we have referenced their work. A special thanks is due W. Hoff and D. Bartling who contributed much in developing the author's solid state electronics, and to E. Heitman who developed etching techniques. Also, the continuing support and encouragement of T. Hamburger is gratefully acknowledged.

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ROBERT H. WILLSON was born on November 14, 1936 in Springfield, Illinois. He received the B.S. degree in engineering physics in 1959, the M.S. degree in physics in 1961 and the Ph.D. degree in electrical engineering in 1966, all from the University of Illinois, Urbana, Illinois.

He worked for Sangamo Electric Corporation on sonar problems during the summers of 1955 through 1958, and for Autonetics North American Aviation, working on problems associated with parametric amplifiers, during the summer of 1959, through 1961. He was a consultant for Autonetics during the fall of 1961. He was a teaching assistant in physics for three semesters and a research assistant in the Coordinated Science Laboratory for six years during which time he was the co-inventor of the plasma display. He is currently employed by the Surface Division of Westinghouse Electric Corporation and is the project engineer of Westinghouse's plasma display projects.

Dr. Willson is a member of the IEEE and *SID* and is a registered professional engineer in Maryland.

Promenade—an interactive graphics pattern-recognition system

by

D. J. HALL, G. H. BALL,
D. E. WOLF, J. W. EUSEBIO

ABSTRACT

This system provides a variety of data analysis processes through man/machine interaction using a high-performance CRT display and keyboard. These processes allow (1) graphic exploration via dynamic plots. or views of the multivariate data, (2) numeric processes for calculation of statistics, clustering, and pattern classification, and (3) the ability to manipulate large files of data by selecting subsets of samples or variables. The system is convenient and simple to operate and can provide hard-copy plots, photographs, or movies. This paper gives an example of the use of the system on a well-known data set, including photographs.

INTRODUCTION

This paper describes the results of a two-year research effort to explore, implement, and then evaluate graphics for the recognition of patterns in data. Before formalized pattern-recognition algorithms can be applied to a set of data, a more exploratory process of measurement selection, scaling of variables, clustering, feature selection, etc. must take place. The PROMENADE system (1), allowing flexible control and high-performance CRT display to a human operator, is designed to aid in this exploratory data analysis by providing a convenient tool to search for parsimonious characterization of data. To find succinct representation of a data set, the typical procedure is to process the data through the various graphic and numeric techniques available in the system. Subsets of variables or samples can be selected with relative convenience by employing run-time formats or keyboard commands to control the file-handling subsystem that uses disk memory.

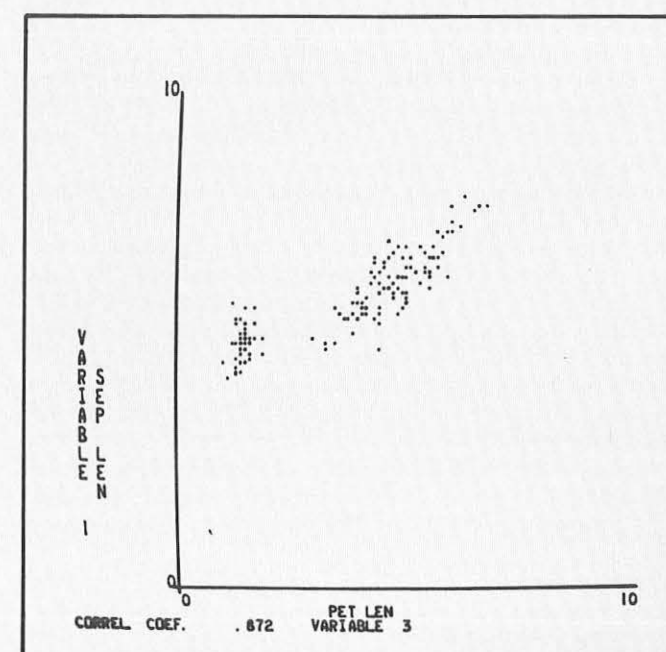

FIGURE 1: Dispersion properties of acrylic and polystyrene

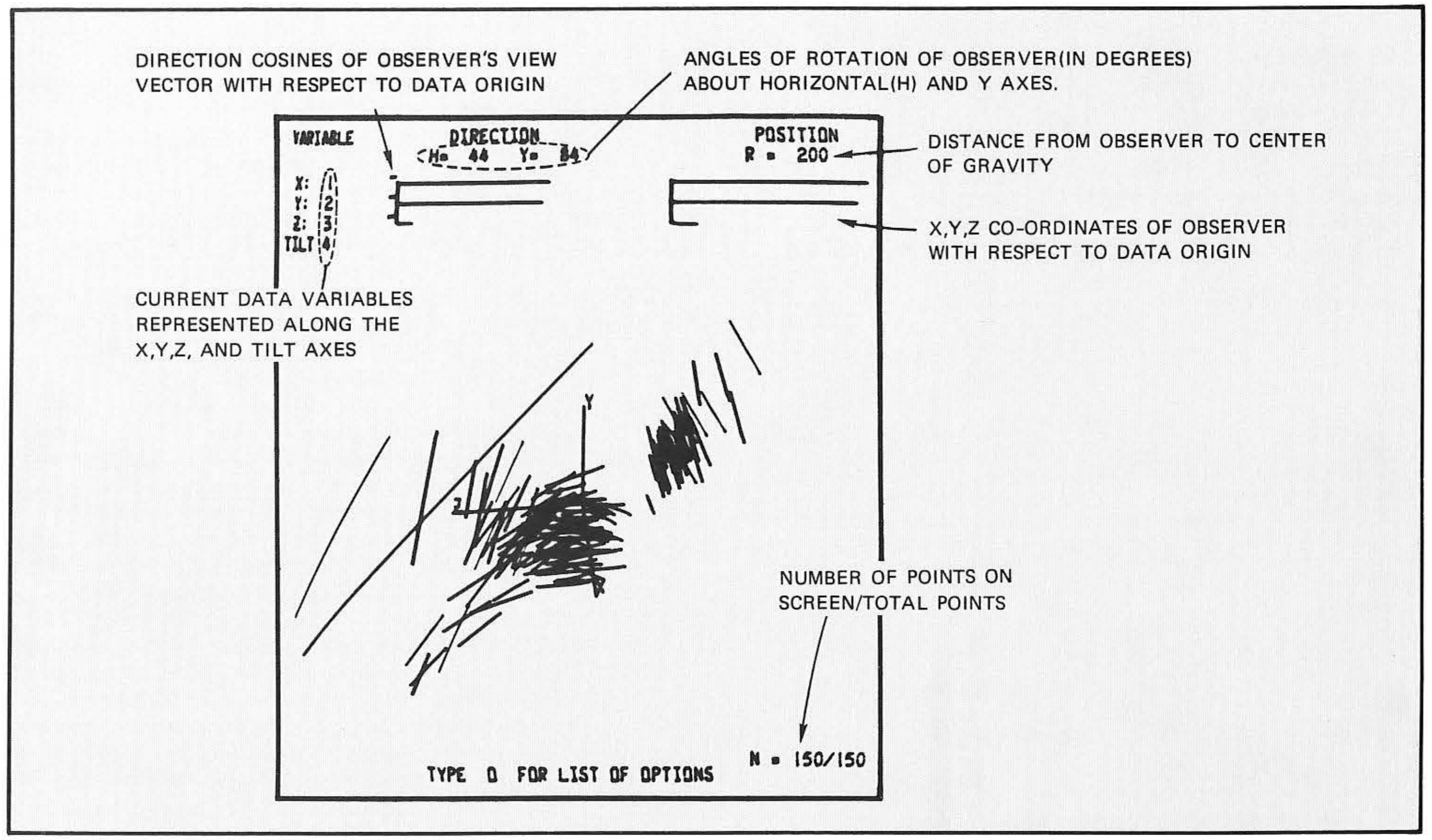

FIGURE 2: Relative transmission vs. wavelength

GRAPHIC PRESENTATION OF DATA IN DIRECT AND TRANSFORMED FORMAT

The best way to understand data is to see it as directly as possible, not in the form of a large table of numbers. By directly, we mean in a manner natural to our visual experience, without any intervening process of transformation. Data points in two dimensions can be represented directly on a sheet of paper or display screen. The system can provide such scatter-plots with scaling, marking of axes, and correlation coefficient, automatically produced (see Fig. 1). Selection of the next pair of variables for display is done automatically, or specific variables can be selected from the keyboard.

We have also developed pseudo three- and four-dimensional plots so that fairly direct viewing of subsets of the data can be achieved (see Fig. 2 and later explanation). Perspective views from any position in the viewer's three-space can be obtained by typing in suitable commands at the keyboard. Approximately 40 different run-time commands that are in some cases associated with parameter value changes can be given to control this subsystem.

Because of the limited experience of humans beyond three dimensions, it is not easy to meaningfully display data that might, for example, consist of 2000 samples of 10 dimensions or variables. Therefore, some compression or transformation of the data is resorted to in order to display a representation of it. A plot of this type that we have developed is the multivariate histogram, shown in Fig. 3.

Other plots that are available are "distance-away-versus-distance-along" a projection line, the link-node plot, and a waveform or profile plot.

Both numeric subsystems are iterative and adaptive and allow for "birth" and "death" processes for cluster centers (prototype data vectors). The parameters controlling the operation of these algorithms can be changed from the console. Summary information is output to the display screen and more copious statistics go to the line printer.

HOW THE SYSTEM IS OPERATED

The system programs and some data sets are stored on one magnetic tape and one disk-memory pack. These can be loaded into the computer in about 60 seconds. The user sits at the interactive console and makes subsystem choices by reading the instructions on the screen and making a selection by keyboard or "mouse." This device has two wheels at right-angles, each attached to a potentiometer shaft, and can be moved on a tabletop, causing the wheels to be turned (2). We use the mouse in preference to a lightpen or trackball, for selecting data points or moving items on the screens or for drawing lines. Two types of commands or options are available to the user. Global options remain the same throughout the system, at any time. Local options apply only to certain subsystems and bear mnemonic relationship to the required functions. These options are generally one or two keystrokes. One global option, namely "O", will always display a list of local options and brief descriptions of their functions. Exploration strategy is left to the user, except that "space bar" means "do the next sensible thing." The system has built-in checks for illegal commands so that a user cannot destroy the system. It always provides some feedback to the user to give him confidence that the system is responding and to provide close interaction with the computer. A loudspeaker attached to the upper 3 bits of the accumulator is very helpful for this feedback, but we do not program it purposefully for auditory effects.

Research supported by Rome Air Development Center, Rome, New York, under Contract F30602-67-C-0351. Project Engineer: Dr. John W. Sammon.

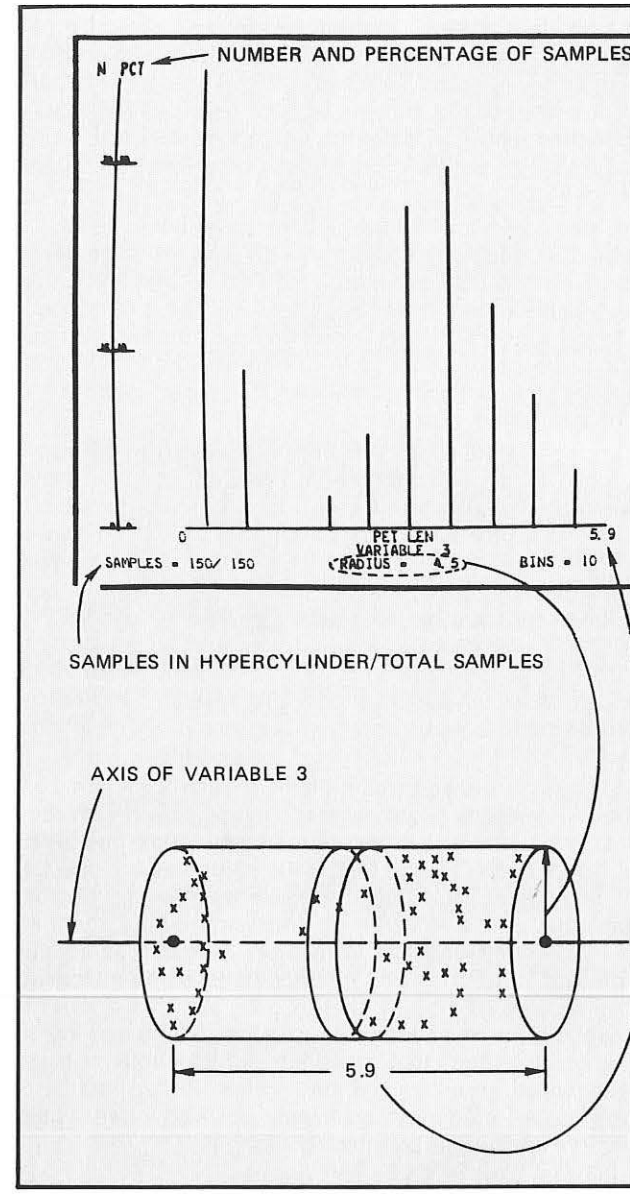

FIGURE 3: Plastic refractive component, final configuration

*A metroglyph is a symbol used to represent the value of more than one variable. A few seconds after striking the appropriate option key, each data point can alternatively be displayed as (1) a cross, (2) a square with a label character, or (3) a label character. The label character can be related to category, cluster, or sequence number of the data point.

AN EXAMPLE ILLUSTRATING THE USE OF THE SYSTEM

As an example, we describe the processing of data that consists of 150 samples, of four variables each. The measurements, which were first reported by E. Anderson (3), were used by R. A. Fisher (4) in his first paper on discriminant analysis. The data are size measurements on various species of Iris. Each of the 150 Irises was measured and classified by a botanist. This example has been used to test and evaluate the system, and our results were compared with those previously reported (5). In Fig. 2, each data point is represented by a metroglyph* that represents four variables. The length of line is proportional to the third variable, and the tilt of the line is proportional to the fourth variable. Using the four-dimensional plot, we can "fly" around (in a three-dimensional subspace of the four-dimensional data space), viewing all four variables of all the data. Note that one cluster of data points (Setosa) is distinctly separated from the other data (Versicolor and Virginica). This clustering is also evident in the other figures that all relate to the same data set.

One of the numerical processing algorithms that is currently available is a clustering program called ISODATA (6). This routine finds suitable cluster points to represent groups of multivariate samples that are similar. These samples may or may not emanate from the same population, and no account is taken in ISODATA of any category information. A clustering characteristic curve that exposes the overall data structure can be obtained from ISODATA, as shown in Fig. 4

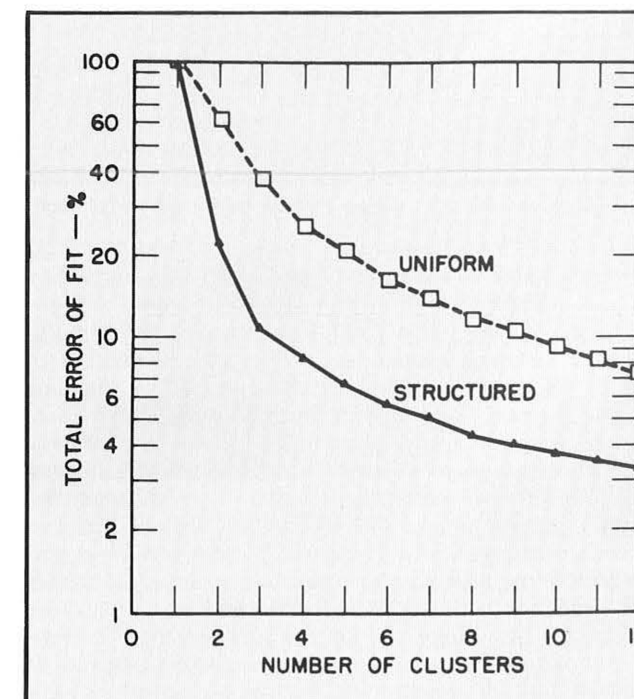

FIGURE 4: Computer plot of component spherical aberration

for this set of Iris data. The upper curve is for uniform random data and is an upper bound, representing the most unstructured type of data set. Many other characteristics of the data clustering are also obtained:

(1) The number of patterns in each cluster and their sequence numbers.

(2) The components of each cluster center and the standard deviations along each component or dimension.
(3) Various distances, such as a distance matrix that gives distances between all pairs of cluster centers. This distance matrix can be displayed graphically by a non-geometric link-node plot, as shown in Fig. 5. This represents, on a flat surface, multivariate data points. The clusters or nodes may be joined by links, depending on a distance threshold that the operator can vary. The links and nodes can be moved around on the screen, using the mouse, to allow investigation of the nature of the network and its adjaceny properties.

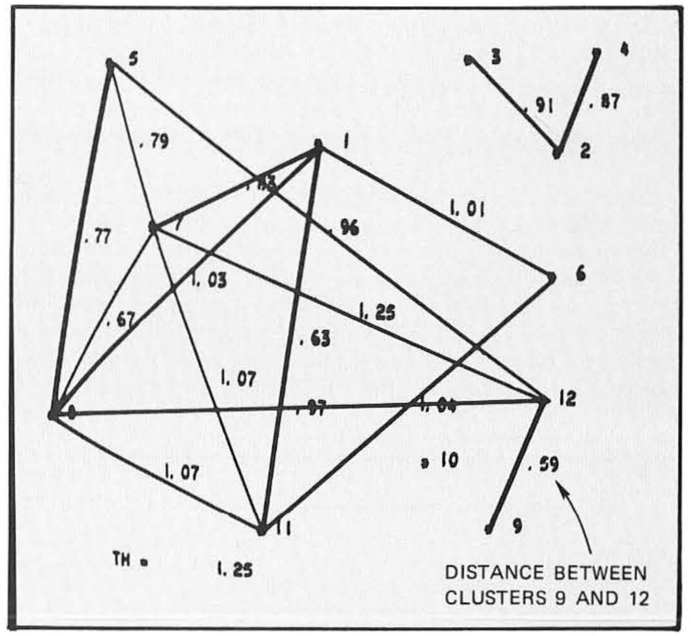

FIGURE 5: View of a two-CRT display through the nested components

Another routine (7) known as the Rosen-Hall algorithm, makes use of category information about each sample, and is also available to the PROMENADE system user. With multi-modal data in which each category may have a number of modes of the same category widely separated in the data space, the method finds each of the modes as an individual cluster. In each such cluster or partition of the space, patterns of only one category are allowed. During the training process, the category of each pattern is provided in the data set, but during the testing phase, the recognition system provides the category automatically. Using all 75 odd-numbered patterns for training, after six iterations there were eight cluster centers produced and one pattern misclassified. Using these eight clusters for testing the classification of the 75 even-numbered patterns, two patterns were misclassified. Reversing the pattern sets for training and testing, nine clusters were produced during training, in six iterations, with one pattern misclassified. Using these nine clusters for testing, four patterns were misclassified. The results from this routine can also be displayed on the link-node plot, because interface to this display is automatic via the file-handling subsystem.

OTHER APPLICATIONS, LIMITATIONS AND FUTURE DEVELOPMENTS

Other applications have made use of this system. Economic data relating to the planning of the infrastructure of Indian cities was studied. Medical history and clinical measurements on diabetics and nondiabetics were explored in an attempt to find early indication of this disease. Agricultural data related to the growing of pineapples in Hawaii was also processed. Artificial data, having known statistical properties, sometimes related to properties of real data, have also been studied.

Many demonstration of the system have been given to hundreds of visitors to SRI. Unfortunately, too few have been able to invest the time and effort required to actually bring their own application data to the system and use it for several hours to get practical results. However, the number who do so is increasing, and we are able to improve the system and incorporate new features to make it still more useful as a result of this added experience.

Currently the system can *accept* 50 variables and as many data samples as can be stored on an IBM 1311 disk (i.e., tens of thousands). The data can be read in any repetitive format that is the same for each data point. The numeric routines can process large quantities of data, in time. The time per iteration is linearly proportional to number of points, number of variables, and number of cluster centers. Unfortunately, our CDC 3100 computer is not equipped with floating-point hardware. The graphic processes can handle only about 2000 samples in character-display mode and several hundred in line-display mode before flicker on the screen becomes objectionable.

The design of software to implement such a system has brought up interesting problems that must be solved with due regard to hardware limitations. Our programming has been mainly in FORTRAN, for the CDC 3100 computer and special display equipment. FORTRAN subroutines provide display functions that call a lower-level display-refreshing routine, written in assembly language. A memory overlay scheme has been devised, and a paging method is used to maintain desirable sections of the disk files in core. Which sections or buffers should be overwritten in core is determined by a supervisory algorithm that considers which buffers have been referenced recently, and how often. Buffers that are not likely to be referenced again may be overwritten when new sections of the file are needed (8).

We look forward to upgrading our display hardware, and particularly toward use of a new high-level language—which has been developed at SRI—for man/machine control and displays. Many advantages such as clarity of expression, good code, and debugging features will be gained. Programs in this language, named EUCLID, are compiled by a computer automatically produced by our META compiler-compiler system that is syntax-directed. (Versions of the compiler can produce FORTRAN, assembly code, or interpretive code.)

As the system expands and our use of it becomes more sophisticated, we realize the importance of a good strategy for sequencing various analyses, the interactions between them, and the dependence of the strategy on the nature of the data. For interactive data analysis processes to be generally useful, they must interface in such a way that output from one analysis process can be treated as input to another.

Polaroid pictures can be taken conveniently in about 20 seconds, using a camera hood that swings over the display screen. Hard copy can also be obtained from an off-line plotting table. The software that drives this plotter interprets display instructions and data stored in display buffers and converts them into appropriate pen movements. A movie has been made to illustrate some of the features of the system.

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JAMES W. EUSEBIO, Mathematician, Scientific Computer Programming Group Mathematical Sciences Department, joined the staff of Stanford Research Institute in 1965. His assignments have included: implementation of two multivariate statistical clustering algorithms in ALGOL for the Burrough's B5500 and in FORTRAN IV for the CDC3100; comparative studies of matrix algorithms for the B5500; design and implementation of parts of PROMENADE, an online interactive pattern recognition and data analysis system featuring a console controlled CRT display; Fourier analysis of time-series data.

Mr. Eusebio received an A.B. degree in mathematics from the University of California at Berkeley in 1960 and an M.A. degree in Mathematics from U.C. in 1965. He is a member of Phi Beta Kappa and an associate member of GAMM. He holds a California Junior College teaching credential and has taught mathematics at San Jose City College.

Publications: (with G. H. Ball) "ISODATA-LINES—A Program for Describing Multivariate Data by Piecewise-Linear Curves", to be published in the *Proceedings of the First Annual Hawaii International Conference on System Sciences*, Jan. 1968.

DAVID J. HALL, Senior Research Engineer, Systems Development Group, Information Science Laboratory, joined the staff of Stanford Research Institute in 1962, and has been primarily engaged in work related to various aspects of pattern recognition machines, such as Minos II. His interest in preprocessing of data contributed to the development of iterative training techniques such as ISODATA. He is also interested in software systems and programming languages, solid-state switching, relay logic, psychometric methods, and reliable systems and safety devices with fail-safe characteristics, as well as industrial applications of radio isotopes, particularlly for density control.

He received a B.Sc. (Eng.) degree from the University of Witwatersrand in Johannesburg in 1954 and an M.Sc. (Eng.) degree from London University in 1957, both in Electrical Engineering. He also obtained Diplomate Membership of the Imperial College of Science and Technology (D.I.C.).

He is a member of the Professional Electrical Engineering Institutions of Britain and South Africa. Mr. Hall was awarded the Swan Memorial Scholarship in London and the British Admiralty Research Grant (1956). He reads, writes, and speaks Afrikaans, and reads both French and German.

DANIEL E. WOLF, Mathematician, Mathematical Sciences Department, joined the Simulation and Gaming Group of Stanford Research Institute in January 1966. Since then he has worked closely with the Scientific Computer Programming Group, writing in FORTRAN and ALGOL for various computers such as the B5500, CDC 1604, 3200, 6600, IBM 7090, and IBM 360/67. Typical problems include the design of a microwave antenna, a chemical mass spectrum regression analysis, the simulation of the buckling of a cylindrical shell under pressure, and an on-line general data analysis system.

Since June 1966, Mr. Wolf has worked with the Systems Engineering Laboratory on man/computer interaction problems using a Control Data Corp. 3100 computer with a cathode ray tube display scope. He has helped with the development of a general pattern-recognition system.

Mr. Wolf received his B.A. degree in mathematics from Chico State College in 1962 and his M.A. degree, also in mathematics, in 1963 from the University of California at Davis. He is a member of the Association for Computing Machinery.

GEOFFREY H. BALL, Senior Research Engineer, Radio Systems Laboratory, received an A.B. in Applied Physics and Engineering Science at Harvard University in 1955, and M.S. and Ph.D. degrees in Electrical Engineering from Stanford University in 1960 and 1962, respectively. During the period of his graduate study, he worked summers at Stanford Research Institute. Dr. Ball rejoined Stanford Research Institute in October 1963. During the first two years he developed, in conjunction with other SRI staff members, a cluster-seeking data analysis process called ISODATA. This technique has utility for the analysis of multivariate data from many fields of research. He is now engaged in the development of a CRT-console-controlled computer system for the analysis of multivariate data, as well as in further research on cluster-seeking techniques.

Dr. Ball is a member of the Institute of Electrical and Electronics Engineers; the IEEE Professional Technical Groups on Information Theory, Automatic Control, Systems Science and Cybernetics, and Computers; the American Association for the Advancement of Science; Sigma Xi; and the Institute of Mathematical Statistics.

His recent publications include "Data Analysis in the Social Sciences," *Proc. of the Fall Joint Computer Conference, 1965*, which is a survey of 50 cluster-seeking techniques, and "ISODATA, an Iterative Method of Multivariate Data Analysis and Pattern Classification," *Proc. of 1966 IEEE International Communications Conference* (with David J. Hall).

San Francisco to have biggest joint computer tech program

Far-ranging coverage of the current scene in computer science and technology to touch on most professional and business interests

Forty-seven sessions, 157 individual presentations and seven panel discussions combine to make the technical program for the 1968 Fall Joint Computer Conference, December 9-11, the most ambitious undertaking in the history of the twice-yearly professional conferences and trade exhibitions sponsored by the American Federation of Information Processing Societies.

The impressive range of subjects covered by the program, completed by a committee headed by Robert H. Glaser, promises three full days of heavy involvement for the more than 6000 registrants anticipated.

Mr. Glaser, who is vice president of Compata, Inc. in charge of Northern California operations, has observed that proceedings of the technical program are expected to fill 1500 pages of two volumes — a likewise heavy record to be made available to all registrants.

Technical sessions run from 10:30 AM December 9 through most of December 11 and occupy meeting rooms in the Civic Center and at several hotel locations in downtown San Francisco.

REGISTRATION

David Katch, vice president of Boole & Babbage, Inc., of Palo Alto, has announced pre-registration hours between 2 and 8 PM on Sunday, December 9, at the San Francisco Hilton. An informal "no host" cocktail party is being held in Continental Parlor Six after 4 PM for early arrivals.

Registration hours at the Civic Auditorium are 8 AM to 5 PM December 9 and 10 and from 8 AM until noon on December 11.

Registration fee for members of sponsoring societies in the American Federation of Information Processing Societies is $20. Non-member fee is $30, but those joining one of the member societies at the conference may have a $10 credit toward the registration fee.

Fee for full-time students is $3. This year, for the first time, there will be a $5 admission fee for those wishing to visit the exhibits only. There will be no "one day" fee, as in previous years.

Full registration includes the two-column proceedings of the conference to be published by Thompson Book Company, National Press Building, 14th and F Streets, N.W., Washington, D.C.

COMPUTERS IN EDUCATION

Recognizing the continuing need of educators, school officials and advanced students to be kept abreast of developments in the computer sciences, daily seminar sessions will be held geared to the interests of participants from 14 Northern California counties.

Robert J. Andrews of IBM Corp., San Jose, who has led development of the FJCC education programs in recent years, is again chairman and has announced particulars for the daily events at Del Webb Town House on Market Street, near the main conference activities at the Civic Auditorium and Brooks Hall.

Mr. Andrews reports plans to accommodate between 400 and 500 students each of the three days and 200-250 school administrators and board members on each of December 10 and 11.

No charge is made for the programs and participants will be bussed to San Francisco by their respective county school districts.

MIT PRESIDENT KEYNOTER; HARDIN LUNCHEON SPEAKER

Two distinguished educators involved with the impact of computer technology on today's society are featured speakers for signal sessions.

Dr. William H. Davidow of Hewlett-Packard Co., general chairman, has announced Howard W. Johnson, president of Massachusetts Institute of Technology, as keynoter for the opening session.

Dr. Garrett Hardin, professor of biology at the University of California, Santa Barbara, addresses the conference luncheon December 10.

Mr. Johnson has been president of MIT since 1966, after being dean of the Alfred P. Cloan School of Management there beginning in 1959. He was formerly on the faculty of the School of Business and the Division of Social Science at the University of Chicago. He is a member of the President's Advisory Committee on Labor-Management Policy and the National Manpower Advisory Committee.

Dr. Hardin, has degrees from the University of Chicago and Stanford, and numerous scientific honors. He is widely known as a lecturer. Among his books is *Nature and Man's Fate.*

SID Activities

CALENDAR OF PROPOSED *SID* TECHNICAL MEETINGS AND NATIONAL SYMPOSIA

1968	Dec. 11	FJCC—*SID* Sponsored Session—San Francisco Hilton/Imperial Ballroom (Bay Area Chapter)
1969	Jan. 13-17	Information Display Exhibition—London
	May 27-29	M.E.D.I.A. — 10th National Symposium — Marriott Twin Bridges Motor Hotel, Washington, D.C. (Washington, D.C. Chapter)
	Fall	Technical Conference—San Francisco, California (Bay Area Chapter)
1970	Fall	Technical Meeting — Minneapolis, Minnesota (St. Paul/Minneapolis Chapter)
1971	Spring	National Symposium — 12th (Delaware Valley Chapter)
	Fall	Technical Conference — Dallas, Texas (Southwest Chapter)
1972	Spring	*SID* National Symposium — 13th —San Francisco, California (Bay Area Chapter)
1973	Spring	*SID* National Symposium — 14th —Dallas, Texas (Southwest Chapter)

Further information may be obtained from *SID* National Office, 654 North Sepulveda Boulevard, Los Angeles, California, 90049 — (213) 472-3550.

WASHINGTON, D.C. CHAPTER

In the past, Information Display technology has often advanced through the "school-of-hard-knocks." Too many multi-million dollar computer driven display projects have resulted in compromise, stalemate, or decommission. The reasoning for such failures can be traced to the complexities of the interdisciplinary sciences of engineering, optics, psychology, physiology, behavioral, and computing. *SID* has had a significant part in bringing the multiplicity of the interdisciplinary sciences together. *SID* has accomplished this through cooperative exchanges of information at local meetings, technical committees, *Information Display*, and National Technical and Symposia meetings. Information Display is now a well defined science and as such, is recognized by many universities as an elective subject.

From the above build-up, one might jump to the conclusion that Information Display today is "old hat" requiring only a textbook and a little practical experience. Not so. Our job at *SID* is just well under way. Now is the time for practical growth with successful systems. *SID* will continue to be the common denominator for the meeting of the interdisciplinary sciences. The chapter is responsible for meetings to promote professionalism, maintain personal contact, and perpetuate the society's goals.

Program of the September meeting featured:

The Home Of The Future: A motion picture produced by Philco-Ford that has merited outstanding notices by the critics. It shows the impact of electronics in our future homes with a special emphasis on the many applications of Display.

Coding Techniques for Visual Communications, by Dick Schaphorst of Philco-Ford's Communications-Electronics Division.

Introduction of the National *SID* officers to members, friends and guests.

Discussion of M.E.D.I.A., the Tenth National Symposium of SID to be held in Arlington, Va. on 27, 28 and 29 May 1969.

BAY AREA CHAPTER

The September '68 technical meeting featured a tour of FAA Oakland Air Route Traffic Control Center, and included a description of operations and viewing of the film "Air Traveler Meets Air Traffic Controller."

Subject for the October meeting was the Air Force Low-Visibility Landing Program.

SID WELCOMES THE FOLLOWING NEW MEMBERS:

Alburty, William H., McDonnell-Douglas; *Allen, Richard W.*, IRA Systems, Inc.; *Anderson, Odean D.*, Control Data Corp.; *Anderson, Robert J.*, Optics Tech. Ctr.; *Ball, Lloyd*, Tasker Industries; *Batchelder, George R.* (The Bendix Corp. — Mosaic); *Bauer, Paul A.*, TYCO Labs.; *Beckwith, Paul D.*, Venus Scientific, Inc.; *Binkley, Kenneth M.*, Sanders Associates; *Bjerstedt, William R.*, IBM-FSD; *Bonin, Jr., Richard V.*, Control Data Corp.; *Brewer, III, John A.*, Louisiana State University; *Brusselars, Donald J.*, Grumman Aircraft Eng'g. Corp.; *Casarow, Jr., Lawrence*, Litton Industries; *Cochran, Gary*, KMS Industries; *Cole, John A.*, Sperry Gyroscope Co.; *Cooley, David B.*, Westinghouse Elec. Corp.; *Crandell, Frank F.*, Northrop Nortronics; *Curry, William C.*, Sanders Associates; *Davis, C. Jane*, U.S. Army; *Davis, Joseph A.*, Purdue University, (Student); *Desens, Robert B.*, Naval Postgraduate School, (Student); *Duck, Sherman*, Bell & Howell.

Emile, Jr., Philip, Monsanto Co.; *Eveleth, Jason H.*, Andersen Labs., Inc.; *Feigenbaum, Stan A.*, Houston Fearless; *Fender, F. G.*, Zenith Radio Corp.; *Fleming, William H.*, Sterling Institute; *Foster, Raymond F.*, Control Data Corp.; *Foy, Nancy S.*, Time-Sharing News; *Frauman, Burt*, Frauman Associates; *Freeman, Herbert*, New York University; *Gaynor, Albert H.*, L. F. Rothschild & Co.; *Gearheart, Glenn L.*, Douglas Aircraft; *Godbey, James A.*, Electro Fiberoptics Corp.; *Gordon, Ernest P.*, Ash M. Wood Company; *Guest, John E.*, IBM Corporation; *Harding, Paul A.*, Raytheon/Equip. Div.; *Hauser Jr., Arthur A.*, Cybex Assoc., Inc.; *Hedden, Geoffrey M.*, Raytheon Co.; *Helbig, Walter L.*, Control Data Corp.; *Herrmann, Robert L.*, Honeywell, Inc.; *Hockenberry, Jack K.*, Syracuse Univ. Res. Corp./CDL; *Hudson, Kenneth C.*, RCA; *Humphries, Donald E.*, Nat'l. Bureau of Standards; *Hutchings, John E.*, U.S. Army; *Inman, David*, Univ. of Texas at Austin, (Student).

Jannery, George E., Time, Inc.; *Janse, Edward A.*, E. A. Janse Assoc. Inc.; *Johnson, Bertrand H.*, Bell Telephone Labs.; *Johnson, Gordon K.*, Honeywell, Inc.; *Judisch, James Mann*, HRB-Singer/Dec. Sci.; *Kamnitzer, Peter*, UCLA School of Architecture & Urban Planning; *Kegelman, Thomas D.*, Computer-Optics, Inc.; *Kovach, Roger P.*, Univ. of Calif.-Data Proc. Ctr.; *Leland, Thomas*, EMR-Computer; *Luciano, Ambrosia*, Selenia, s.p.a.; *Lurcott, Eugene G.*, RCA; *Martin, Richard H.*, George Washington Univ., (Student); *Matle, Calvin C.*, Bendix Corp.; *Mauceri, Robert J.*, Tech. Operations Eng.; *Meador, Donald X.*, Sperry Rand Corp./Remington Rand/OSD; *Meister, Roland P.*, Itek Corp.; *Melchior, Gerard G.*, CGE — DEL; *Milinowski, Arthur S.*, Perkin-Elmer; *Monay, Eugene R.*, Dept. of Defense, NSA; *Mulley, William G.*, Johnsville Naval Air Dev. Ctr.; *Pesner, Sanford M.*, Loral Elec. Sys.; *Prives, Joel M.*; *Pullin, Jr., William Thomas*, Johns Hopkins Univ.; *Puthuff, Robert H.*, Conrac Corp./Conrac Div.

We welcome the following sustaining members:

INFORMATION DISPLAYS, INC., Mt. Kisco, N.Y.—*K. L. King; David Peltz; A. Pestone; A. Vollenweider; B. Walder.*

PERKIN-ELMER CORPORATION—*M. Rosenau; B. A. Ross; Margaret D. Wood; Paul Yoder.*

SID Sustaining Members

ADAMS ASSOCIATES
Bedford, Massachusetts

AEROSPACE CORPORATION
San Bernardino, California

BUNKER-RAMO CORPORATION
Canoga Park, California

BURROUGHS CORPORATION
Defense, Space & Special Systems Group,
Paoli, Pennsylvania

CBS LABORATORIES
227 High Ridge Road
Stamford, Connecticut

CELCO
(Constantine Engineering Labs. Co.)
Mahwah, New Jersey

COMMUNICATIONS & ELECTRONICS DIV.
Philco-Ford Corporation
A Subsidiary of Ford Motor Company
Willow Grove, Pennsylvania

CONRAC DIVISION
Conrac Corporation
600 North Rimsdale Ave.
Covina, California 91722

ELECTRONIC COMPONENTS GROUP
Div., Sylvania Electronic Products Inc.
Seneca Falls, New York 13080

GENERAL ATRONICS CORPORATION
Electronic Tube Division
1200 East Mermaid Lane
Philadelphia, Pennsylvania 19118

GRAPHIC SYSTEMS DIVISION
Computer Industries Inc.
14761 Califa Street
Van Nuys, California 91401

HUGHES AIRCRAFT COMPANY
Culver City, California 90230

HUGHES AIRCRAFT COMPANY
Vacuum Tube Products Div.
Oceanside, California

IBM CORPORATION
Armonk, N.Y.

INFORMATION DISPLAYS, INC.
Mt. Kisco, New York

NAC INCORPORATED
7 - 1 Ginzanishi
Chuo-Ku, Tokyo, Japan

THE PERKIN-ELMER CORPORATION
Optical Group
South Wilton, Connecticut

RADIATION INC.
Melbourne, Florida

STROMBERG CARLSON CORP.
Data Products, San Diego, California

SYNTRONIC INSTRUMENTS INC.
100 Industrial Road, Addison, Illinois

THOMAS ELECTRONICS, INC.
100 Riverview Drive
Wayne, New Jersey 07470

TRANSISTOR ELECTRONICS CORPORATION
Minneapolis, Minnesota

ID Readout

TRW DEPARTMENT TO DEVELOP ELECTRONIC DISPLAYS

A team of physical scientists, electro-optical engineers and human engineering specialists have been brought together to establish a new Display and Imaging Department in the Sensor Systems Laboratory of TRW Systems Group.

The department has been established because of the growth in electronic systems requiring sophisticated displays and advanced man-machine interface capability. The new organization will research, design and develop equipment and perform system and human engineering of electronic display for avionic and aerospace systems. This will include coordination of the application of new technology advances, according to Don M. Culler, Manager of TRW's Sensor Systems Laboratory.

Peter G. White has been appointed Manager of the new department. He was formerly Manager of the Electronic Systems Department in the Systems Laboratories, where he was responsible for a variety of display and imaging activities.

Dr. David J. Blakemore, who has been named Assistant Department Manager, was formerly Manager of the Systems Analysis Section of the Electro Optics Department of the Sensor Systems Laboratory, involved with the development of electro-optical data processing techniques.

Dr. Alex A. Weiss will be responsible for directing the display and human engineering activities of the new department. He was formerly Assistant Department Manager for Displays in the Control Systems Laboratory of Electronic Systems Division.

GRAPHIC DISPLAY SUBSYSTEM

A "second-generation" man-machine communication system, featuring the first announced commercial digital deflection technique in graphic displays, was introduced and demonstrated recently by the UNIVAC Division of Sperry Rand.

Designated the UNIVAC 1557/1558 Graphic Display Subsystem (a 1557 Display Controller and a 1558 Display Console), the system is designed for direct interconnection with a large-scale computer system or for remote operation with connections to a central processor via voice grade or wideband communication facilities.

The all digital techniques in the 1557/1558 System enable speed and accuracies, in excess of what has been available to date, to be achieved. This capability is high enough to design integrated circuits and detailed drawings of complex mechanical parts. Other suitable applications would be automotive design, architectural drawings, mathematical models and drawings of animated cartoons on-line.

The deflection system on the 1557/1558 is fully electromagnetic, as opposed to electrostatic.

By using a digital technique, the process of converting digital inputs into analog signals and then amplifying them to high current levels is eliminated. Instead, the Univac digital deflection system permits a digital representation to drive the deflection system directly, eliminating the differential amplifiers and feedback loops and their attendant adjustments.

The digital technique also provides more stability of image position. Although the theoretical speed of the electron beam is not quite as high as in an electrostatic deflection system, the practical speed is faster because of the precise positioning control that can be achieved.

Equipped with a keyboard containing standard alphanumeric and 40 function keys plus a light pen for operator input, the 1558 Display Console has the capability of plotting randomly positioned points, vectors, and tabular mode alphanumeric data.

ILLUMINATION BY SINGLE LIGHT THROUGH GLASS FIBER OPTICS

Glass flexible fiber optics will provide illumination for several home entertainment systems slated for introduction in 1969.

Peter D. Davenport, senior market specialist in the Communications Products Department of Corning Glass Works, stated that fiber optic applications in radios, phonographs, televisions and consoles are planned by several manufacturers in 1969 models.

Most impressive applications, according to Davenport, is a movable point of illumination to indicate the position of radio dial pointers. "This," said Davenport, "represents a desirable sales feature with no attendant replacement problems."

Another application is to provide a point of cold light near the needle in a phonograph arm. This enables accurate manual selection of desired bands on long-playing records, Davenport said.

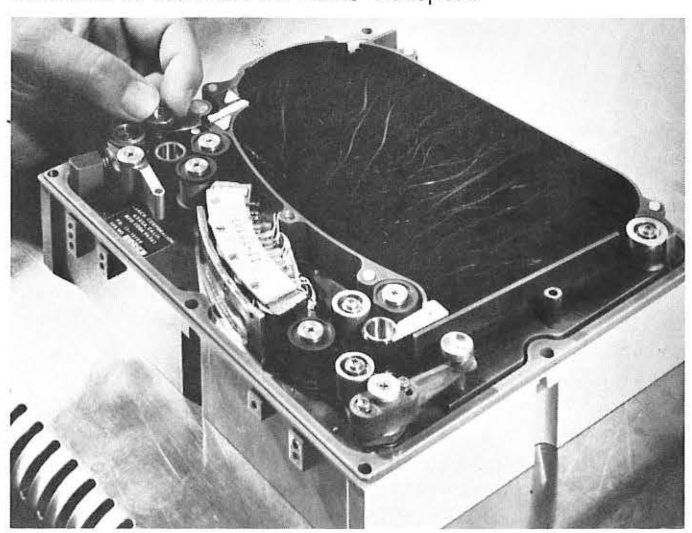
Chief advantage of fiber optics is that they provide service-free illumination to a variety of points from a single low-voltage bulb. The one bulb can be easily replaced by the set owner.

Standard bundles of glass flexible fiber optics of varying lengths can be fitted with colored lens caps to serve as pilot lights. They may also illuminate function switches on consoles to show the user at a glance the mode (AM, FM, TV, Phono), attitude (bass or treble), or balance (left or right speaker) of the set.

Cost of using glass flexible fiber optics is comparable to using standard bulb assemblies, Davenport said. Unlike incandescent bulbs, however, the fiber optics have an unlimited life. Corning provides finished pieces in varying lengths ready for installation by the manufacturer. Pricing depends on length and volume.

C-5A TO BE EQUIPPED WITH RECORDER

What is believed to be the first successful use of a random-bin tape loop in airborne recorders meeting MIL-E-5400 environmental specifications has been developed by the Leach Controls Division. These units are being supplied to Lockheed Aircraft Service Co., Ontario, Calif., for use as the crash recorders in the C-5A Air Force Transport.



Use of the random-bin loop technique enables continuous recording and does away with cumbersome tape handling. Further, the elimination of tape reels reduces power consumption and problems created by vibration.

Four channels of voice, and three channels of digital instrumentation data are recorded at 15/16 inches per second on the 150-foot loop of ½-inch magnetic tape.

After the first 30 minutes of data is recorded the loop starts another pass across the heads; old data is erased and new data is recorded continuously. In this manner the 30 minutes of information immediately preceding a crash is always on the recorder.

The electronics assembly is mounted in the air frame of the C-5A, while the tape transport goes into an ejectable airfoil.

Environments through which the tape must survive are—sea water immersion for 48 hours; impact shock of 1500 G for one millisecond; temperature to 125°C for five minutes.

These units record and reproduce at 15/16 and 5.62 inches per second. The faster speed enables a complete system checkout in five minutes.

They also incorporate BITE circuitry to isolate failures to the subsystem level. Illuminated indicators on the cockpit control panel alert the pilot to any system failure. Additional indicator lights on the equipment isolate the failure to either the electronics assembly or the tape transport. Maintenance personnel can then remove and replace the proper assembly.

WESTINGHOUSE ISSUED PATENT ON OPTICALLY PUMPED LASERS

The United States Patent Office has issued Westinghouse Electric Corporation a patent covering optically pumped lasers that use solids or liquids to produce their remarkable beams of light.

The patent recognizes that Westinghouse first invented a mechanism termed optical pumping of materials, which is basic to lasers that use rubies and other crystals, glasses, liquids, or plastics. About half the lasers manufactured today are of these types.

The newly patented invention was made in the late 1950's at the Westinghouse Research Laboratories by Dr. Irwin Wieder, a physicist, who is presently affiliated with Carver Corporation, Mountain View, Calif. Issue of the patent awaited completion of procedures necessary to review, clarify and support the claims.

"This patent is perhaps the most important issued to Westinghouse since that granted to Dr. Joseph Slepian in 1937 for the ignitron," Dr. W. E. Shoupp, Westinghouse vice president for research, said in announcing the patent.

"The ignitron patent laid the foundation for electronic control of electric power; the patent just issued forms the basis for electronic generation of light."

HEADS UP

Pilots flying the A-7D tactical fighter and A-7E attack bomber will utilize a computer driven head-up display unit to simplify flying the plane during ground attack, inflight navigation, terrain following or during landing, according to LTV Aerospace Corporation.

Instead of having to scan the plane's instrument panel to determine such things as altitude, airspeed, heading and climb or dive angle, the pilot will have this information presented on a transparent mirror located directly to his front at eye level. The AN/AVQ-7 head-up display set, built by Elliott Brothers, Ltd., of Rochester, Kent, England, provides the pilot with continuous, accurate solutions to problems of day and night visual attack, radar bombing, all-weather navigation and approach and landing.

The head-up system is linked to the A-7's digital computer. It supplies visual information stored in its memory and on current information received from sensors in the plane.

Weapons information is stored in the computer before the flight. Current data from the plane's instruments on air speed, climb and bank, gravity, air density, cross wind and other variables all are fed in, giving the pilot information on flying and when to deliver his weapons.

CINERAMA IN THE SKY

Without leaving the ground, today's pilot can visually land or take-off from any airport in the world.

Working in a ground-based simulator which duplicates his airborne cabin, he sees through his windshield all the landmarks surrounding the runway, the runway itself, and all the activity in and about the airport. The key to the out-of-the-window realism is a flight simulator visual system similar to Cinerama films.

The optical projection system, built by Applied Optics and Mechanics Division, of Electro-Optical Systems, Inc., is designed to be coupled with VAMP, a variable anamorphic visual system developed by the Link Group of General Precision Systems, Inc., Binghamton, N.Y.

VAMP is General Precision's trade name for Link flight simulators and more sophisticated versions of the Link Trainer first conceived in the early 1930's.

For the pilot in the simulator cabin, it is not unlike attending a Cinerama movie. He is viewing a much more sophisticated system at work, however. Projected through his windshield is a 70mm motion picture film of the runway and its environs taken during an actual aircraft approach, landing or take-off. The picture, however, moves right along with him and changes as he directs the simulator. If he turns in one direction, a banking effect is produced optically. If he climbs or dives the earth either diminishes or rushes up to meet him. The horizon moves accordingly in a realistic manner. As the pilot makes his simulated approach watching the VAMP motion picture, he "flies" the simulator accordingly. A computer within the simulator accepts the movement of his controls, translating them into commands to the simulator and the VAMP projector which retains the airport and surrounding area in perfect perspective.

So comprehensive is the VAMP system that the pilot has the illusion of flareout and touchdown. He can complete the landing by taxiing to the terminal.

The optical projection portion of the VAMP "represents the state-of-the-art lens design, combined with precision optical component manufacture," said Paul Richartz, AOM division manager.

TV PICTURES FROM SPACE IN REAL-TIME

Television pictures, live from a reconnaissance satellite, can now be seen immediately and stored in a computer for study—both at the same time.

The reason: the first video-to-digital converter that operates in real-time—so fast there is virtually no delay between receiving and converting the data. It does in one minute what it takes other converters ten hours to do, according to International Business Machines Corp.'s Federal Systems Division. It changes TV pictures from analog to digital form so they can be more securely transmitted to Earth.

The converter operates in real-time by using a parallel conversion technique—all the bits are determined at the same time—and current mode switching in the comparator circuits.

Analog voltage signals are generated by the light and dark areas of the TV picture. The signals are converted, transmitted to Earth, stored in a computer and reconverted to analog form for viewing.

Conversion to digital form for transmission is desirable because digital signals can be coded into patterns easily recognized on the ground. The digitized TV pictures are less susceptible to electrical or atmospheric interference.

The unit converts analog data in parallel to six bit resolution. It consists of a comparator, which compares the analog input voltage to reference voltages; an encoder made up of high-frequency ferrite cores; tunnel diode detectors, which determine the current in the ferrite cores and produce voltage outputs, and pulse amplifiers, which amplify the diode pulses to levels compatable with computer logic.

NADGE COMPUTER DISPLAY LINKED FOR FIRST TIME

Tests are under way involving the first link-up of two different pieces of equipment built by separate companies for a $300-million electronic air defense system under development for the NATO nations of western Europe.

NADGE, for NATO Air Defense Ground Environment, is regarded as the biggest electronic undertaking in Europe.

The milestone event involves a general-purpose computer, built by Hughes Aircraft Company here, and a data display console, built by Selenia S. p. A. of Italy.

"It is the first interface between two pieces of NADGE equipment built by two different firms," J. C. Evans, NADGE project manager at Hughes, said.

The Hughes computer has been shipped to Selenia's plant in Rome to assist that company with the development of its NADGE displays, he said.

The computer (designated H3118M) has 48,000 words of memory and eight input-output channels, Evans said. It was built as part of a contract Hughes received from NADGECO, Ltd.

Hughes and Selenia are two of six international firms that collectively own the London-based corporation, NADGECO, Ltd., which is responsible for building the overall NADGE system. The other four are Marconi Company, Ltd., Great Britain; Thomson Houston-Hotchkiss Brandt, France; AEG Telefunken, West Germany; and N. V. Hollandse-Signaalapparaten, The Netherlands.

Additional equipment is being produced for NADGE by companies in other NATO nations in direct proportion to the financial contribution of each country to the project.

Business News

BUNKER-RAMO's Defense Systems Div., Canoga Park, has introduced a new information system, the BR-700, which provides a self-contained system that is an ". . . economical solution to the problems of source data automation and local data management and control . . ." according to Div. vp E. E. Bolles . . . An $842,000 development contract for airborne signal processing and display equipment for the carrier-based Grumman A-6A Attack Bomber has been awarded RADIATION INC., Melbourne, Fla. The award is part of a program to equip the aircraft with a full one-way digital data communications system . . . A $454,635 contract for a quantity of 7268B direct-view storage tubes for use in the F-4 Phantom II aircraft now operational in the Armed Forces has been announced by DU MONT ELECTRON TUBES, div. of FAIRCHILD CAMERA AND INSTRUMENT CORP. Procurement was made by the Defense Electronics Supply Center, headquartered in Dayton, Ohio. The 7268B is a five-in. display device furnishing cockpit readout of the aircraft's fire control and navigation system.

CALIFORNIA COMPUTER PRODUCTS INC., Anaheim, has reported a 50% increase in gross revenue and a 20% increase in earnings over a like period a year ago. Net earnings were $759,647 on sales of $11,295,899 . . . RCA has received a $521,00 contract from MCDONNELL-DOUGLAS to provide 32 data display units for use during development checkout and launch on Air Force programs. The displays, to be built by the West Coast Div., Van Nuys, Calif., are for ground-based computer systems used to perform test and checkout functions in the factory during assembly and at the launch area prior to flights . . . TRANSAMERICA COMPUTER CO. and COMPUTER COMMUNICATIONS INC. have signed a leasing agreement wherein Transamerica will supply up to $20 million of lease financing to CCI over the next two years.

INFORMATION CONTROL CORP. announced recently that ICC recorded bookings in the month of August in excess of $1,800,000. Majority of bookings were for the ComRac series Core Memory Systems . . . The Electrographics Div., newest unit of VARIAN, has been formed to capitalize on the success of the company's line of electrostatic writing instruments. The div. will develop, produce and market existing and new models of the firm's line of multi-channel Statos recorders and other devices using the electrostatic technique . . . COMPUTER DESIGN CORP., Santa Monica, and NIPPON CALCULATING MACHINE SALES CO., Tokyo, have reached an agreement for the development of advanced electronic desk calculators. Machines will be manufactured and marketed, world-wide, by 1970 . . . System/360 Compatibility Survey Service is available from PROGRAMMING SCIENCES CORP., N.Y. Service is offered on an individual basis to manufacturers of peripheral devices.

GENERAL DYNAMICS has announced establishment of a wholly owned subsidiary, STROMBERG DATAGRAPHICS INC., to expand activity in the market for information processing systems that convert computer data into readable form. Previously known as the Data Products div. of Stromberg-Carlson Corp., the San Diego-based operation now is itself a separate corporate entity within GD's Electronics group . . . Contracts valued at $2.4 million for information and display systems have been received by LORAL CORP.'s LORAL ELECTRONIC SYSTEMS DIV., The Bronx, N.Y. Prime programs involved include the AN/ASA-59, Integrated Helicopter Display System, and the AN/ASA-66, ASW Pilot Display System.

Acquisition of PRICE BROTHERS, a 45-year-old manufacturer of custom advertising displays for point-of-purchase use, has been announced by LUMINATOR INC., Chicago, producer of transportation lighting fixtures, electric infrared heating and lighting, and switching. Louis E. Price continues as president of Price . . . KOLLSMAN INSTRUMENT CORP. has won a $1.2 million letter contract from the U.S. Naval System Command to produce altimeter-encoders for automatic altitude reporting on military aircraft. Contract is part of Project AIMS, the FAA program which requires aircraft entering major traffic control areas to automatically report their altitude to ground stations. The definitive contract is expected to total about $2.5 million.

INDUSTRIAL ELECTRONIC ENGINEERS INC., has expanded its plant facilities to a total of 85,000 sq. ft., and occupies three buildings in Van Nuys, center of the corp.'s readout and lamp activities. While components manufacturing remains at the present Lemona Avenue plant, components engineering, sales and marketing, as well as corporate research and development operations move to an adjacent building . . . DISCON CORP., Ft. Lauderdale, Fla., has been awarded a contract in excess of $110,000 by the Navy for design and development of an electronic message display system. The system can simultaneously display up to 240 characters, with letters, numbers, and symbols being formed by a pattern of micro-miniature incandescent lamps.

CONTROL TECHNOLOGY INC., has enlarged its Long Beach computation center with expansion of its Milgo 4020 Analog Computer to 400 amplifiers, addition of an 8-channel oscilloscope for real time display of variables, and access to an SDS920 digital computer via a time-sharing terminal . . . INFORMATION CONTROL CORP. has won a $41,000 contract for the manufacture of its new LP-300 series solid state light pens, awarded by the Columbus Div. of the NORTH AMERICAN ROCKWELL CORP. The pens feature response times of under 300 nsec, 2 ft. lambert sensitivity, resolutions of 100 mils or 20 mils, a locator beam for designating the target area, and a touch actuated switch.

A new company has been formed with headquarters in San Mateo, Calif. TECHNOLOGY TRANSFER ASSOCIATES INC., will specialize in the transfer of technology within the key market areas of the world. Activities fall into two major categories: new product research and import/export marketing . . . LEVER BROTHERS CO. has formed a subsidiary designed to provide a wide range of data processing services. LEVER DATA PROCESSING SERVICES, INC., will be headed by Robert W. McGeary as president. Services will include computer time sales, service bureau operations, EDP consulting and recruiting, software and application development, and educational programs.

SPATIAL DATA SYSTEMS INC., will supply its Model 501-3 Three Dimensional Plotting System to NASA, Computer Facility, Manned Spacecraft Center, Houston. Complete, self-contained, the console cabinet will contain plotting mechanism, electronic interface, operating controls and magnetic tape reader . . . KLM Airlines has signed an agreement with TELEMAX CORP., permitting Telemax subscribers to make foreign air travel reservations. KLM is the sixth major air carrier to so contract . . . MARSHALL INDUSTRIES affiliate, MARSHALL COMMUNICATIONS, San Marino, has received a $2,756,835 contract from the Federal Reserve System for a key segment of a nationwide message communications switching system.

New Literature

Chart Paper Bulletin

Houston Instrument Div. of Bausch & Lomb Inc., Bellaire, Texas, announces the availability of a chart paper bulletin. The four page bulletin describes the various Z-fold chart papers that can be used on Complot digital plotters. Blank, linear grids, linear continuous, log-linear and log-log papers are described.

Circle Reader Service Card No. 33

Literature Available

Applied Data Research, Inc., Princton, N.J., has published a 20-page illustrated booklet on AUTOFLOW, the company's computer documentation system. Of interest to both technical and non-technical personnel, the booklet discusses the need for flowcharting generally and more specifically describes the four languages accepted by Autoflow: COBOL, FORTRAN, PL/1 and Assembly.

The new booklet also gives background on several other ADR proprietary software products.

Circle Reader Service Card No. 34

Tube Housings

Pacific Photometric's 16 page catalog discusses the complete line of Photomultiplier Tube Housings. Specifications and dimensions are given for ten separate types of housings which are designed to accommodate all leading photomultiplier tubes. The catalog is illustrated profusely with photos and graphs. Prices are referenced to the photomultiplier tube which is intended for use.

Circle Reader Service Card No. 35

Frequency Counters

Six-page brochure lists all 22 of Hewlett-Packard's electronic frequency counters in a chart that simplifies comparison, making it easier to select the best choice for particular applications. Easily determined are frequency range, input characteristics, time base stability, price, and basic functions (e.g., frequency, period average, time interval, etc.).

Another chart in the brochure also displays graphically the frequency ranges of the company's frequency extender plug-ins, clearly showing the range of each and how they relate to each other. Other sections describe special instruments, such as preset and reversible counters, automatic frequency dividers, and digital-analog converters.

Circle Reader Service Card No. 36

Condensed Industrial Lamp Catalog

A condensed catalog, containing detailed descriptions of popular lamp types for industrial applications, is available from Chicago Miniature Lamp Works, Chicago.

Included in the catalog is information relating to standard industrial lamps, CM8 miniature, thin line and line filament lamps, neon glow lamps, and telephone slide lamps. All lamps are listed in numerical order to facilitate locating a specific lamp type. Each listing indicates design voltage and current, mean spherical candle power, base type, bulb type, filament type, average life, maximum diameter and length. The catalog contains all the pertinent details relating to a wider range of lamps for applications in such areas as aerospace, aircraft, appliance communications, communications, computer, instrumentation, marine, radio, television and transportation.

Circle Reader Service Card No. 37

Quarterly House Organ Covers Lighted Switches, Indicators and Warning Systems

A quarterly external company publication called the MSC ILLUMINATOR has been introduced by Master Specialties Company, Costa Mesa. According to the company, this new publication will provide detailed material on information display and control devices. Products covered will include lighted pushbutton switches, word-indicator lights, and fault warning systems and annunciators. Information will include new product and accessory announcements, application ideas, and specialized technical data.

The first issue, just released, details a new audio/visual annunciator system called AVA that combines the standard lighted word-indicator with a corresponding pre-recorded voice message into one, compact package.

Circle Reader Service Card No. 38

Neon Lamp Data Sheet

An illustrated data sheet discussing the replacement characteristics of neon glow lamps for digital readout tubes has been published by Signalite Inc., Neptune, N.J. The bulletin discusses how the Signalite A261 neon lamp is used as a replacement for numeral 1, the plus and the minus readouts. A photograph of a digital voltmeter utilizing the A261 tube is shown as well as a dimensional diagram indicating measurements.

Circle Reader Service Card No. 39

Retainer Plate Bulletin

An all metal O-Ring assembly for ASA/API pipe flange seals is described in Bulletin 969 from United Aircraft Products Inc., Dayton, Ohio. Included is an ordering chart which lists O-ring/retainer plates for each combination of pipe size and flange rating.

Circle Reader Service Card No. 40

Printout Booklet

A 10-page brochure describing its Symbolray alphanumeric generator for cathode-ray display or hard copy printout is available from Raytheon, Quincy, Mass. The brochure describes application of the Symbolray monoscope to reservations control, air traffic control, production line inventory information, remote engineering mathematical computations, stock market quotations, medical consultations, and business report editing. Principles of digital display operations are included.

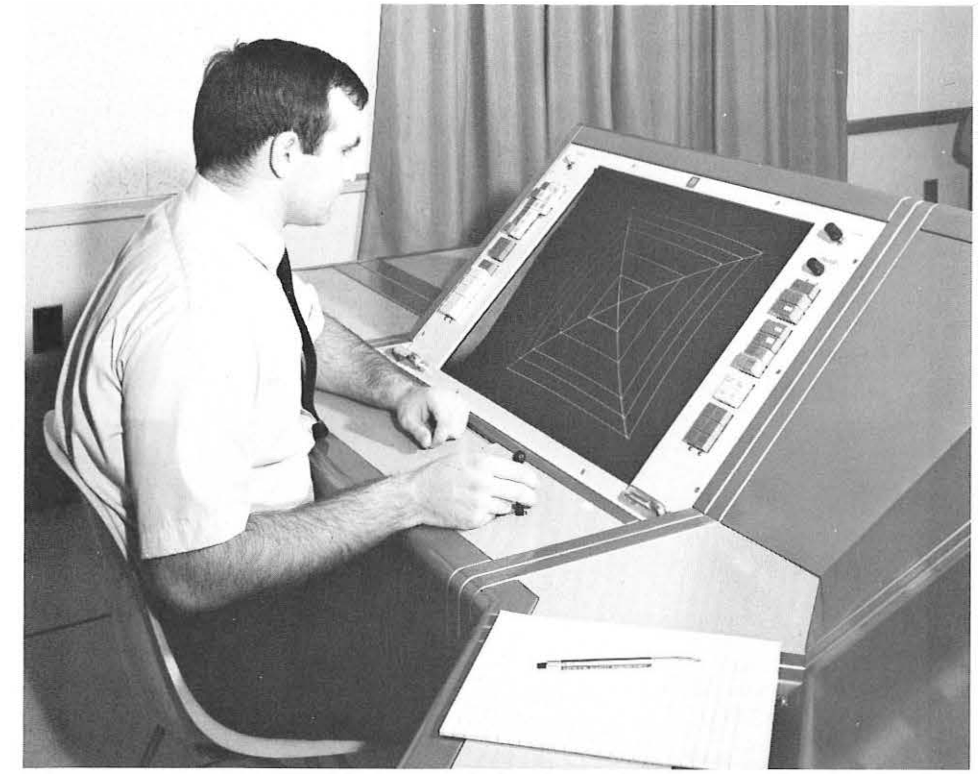
Circle Reader Service Card No. 41

Alloy Catalog

A 16 page catalog from Hoskins Manufacturing Co., Detroit, describes properties and performance characteristics of Hoskins Alloy 750, Alloy 815 and Alloy 875 iron-calcium-aluminum electrical resistance materials. These materials are primarily used as heating elements in portable appliances, electric furnaces and kilns. Technical data presented include a tabulation of the alloys' physical properties, typical life and temperature-resistance curves, mechanical properties at room and elevated temperatures, plus specification tables which list ohms-per-ft. and ft.-per-lb. values for all standard wire and ribbon sizes. In addition, the catalog also contains information and recommendations for designing, fabricating and welding coiled heating elements made of the alloys.

Circle Reader Service Card No. 42

COMPUTER STUDIES BETTER CONTROL OF SHIP WEAPONS



MAN-MACHINE RELATIONSHIPS in future antisubmarine warfare systems. Operator Ken Coulson is seated at cathode ray tube display console in (real-time) experiments at Honeywell's Marine Systems Center in West Covina, Calif.

Computer-driven display equipment is helping to investigate man's role in the next generation of shipboard weapon-control systems, Honeywell Inc. reports.

Design engineers at the automation company's Marine Systems Center (MSC) use a DDP-124 computer to conduct real-time digital experiments in processing, display and control of fire control information, the company said.

This SHIMMS (Shipboard Integrated Man-Machine System) technique "is an advanced concept that makes possible one-man analysis and control of complex tactical combat information and weapon deployment," said Arnold P. Klimke, manager of MSC operations.

Developed primarily to study shipboard fire-control problems, SHIMMS also may be useful in antisubmarine warfare, undersea warfare countermeasures, deep submergence vehicle control and simulation, and shore-based weapon-system simulation and training devices, Klimke said.

"In each case the key problem is essentially the same: to improve the display technique and man-machine interaction so that the right information is presented to the right people at the right time," he said.

Display technology is becoming a critical consideration because battle situations are becoming more dynamic—the weapons system operator no longer has time to sift through a lot of information," he said.

"We must design systems so the operator can grasp what he needs to know in the shortest time and in the most effective form. One way is to use a central control computer to display combat information.

Screen Shows Data

Engineers can display the processed target and weapon data—either alphanumerically or graphically—on a 23-inch cathode ray tube screen that forms the heart of the marine center's new dynamic simulation facility. The screen is "driven" by the Honeywell general-purpose digital computer, which has a 16,000-word memory.

The console operator can draw tactical pictures as well as present numbers letters and other symbols on the screen. A self-contained memory refresher eliminates the need for a larger control computer memory.

"Our ability to create software," Klimke pointed out, "stems from years of development of ASW training systems, giving us knowledge of not only the basic problem but also of how to fit that problem into this kind of simulation program." Honeywell has built more than 12 ASW warfare trainers since the late 1950s.

The trend toward more integrated shipboard displays means a central control computer is needed not only for fire control but also for command control, he said. To accomplish system integration it is necessary to determine how many people should be doing what jobs.

How Much To Display

"The question of the best relationship between the human being and a computerized system is difficult to answer," he said. "The human factors experts know that if you put too much information on the display, the human being cannot absorb it and some information gets lost. But they really can't tell you how much information display is too much. We are running some experiments to give us additional criteria.

"There's great pressure now on the commanding officer of a Navy ship to reduce his manpower requirements. At the same time he's being given more complex equipment and weapons.

"Furthermore, a ship is usually a multi-mission vessel," Klimke pointed out. "There is anti-aircraft, ASW, mine-hunting and missile capability. Quick and correct reaction is of the essence.

"How many people do you need? How many of them must operate at the same time? Which threat has priority?"

Computers Only Help

To solve this problem, Klimke said, it is necessary to employ computers to help people make decisions.

"What we're really aiming at is not just a computerized system but the most intelligent possible computer-aided decision-making system," Klimke said. "Man's sensors still are the best and his brain is a very fine integrator of a variety of information.

"We must allow a man to relax, but alert him at the proper time. We want to take the load off the man by designing helpful equipment that requires him to do only what the machine cannot—make a judgment."

ID Products

Film Reader

The Traid Corp., Glendale, Calif., has announced the production of the Model 660 Precision Film Reader, formerly a product of Richardson Camera Co., an operaton to make semi-automatic measurements of X, Y, and O coordinates and process this data into computer compatible formats. Images recorded on various 16mm, 35mm and 70mm sprocketed film can be reduced with high speed and comparator accuracy using the Model 660. According to Traid, interchangeable pin registered film transports make it possible to convert film handling capability to view various film formats. Film transport controls include single frame, multiple frame, variable cinemotion and fast flow motion, all bi-directional. The system incorporates a low distortion optical projection system with automatic selection of 5X, 10X, and 20X magnifications. Digitization of a joy stick manipulated stage is claimed to coordinate readout accuracies of better than 10 microns. A rotatable reticle and separate light source are used to provide reference for X, Y, and O measurements. This reticle is mounted in the proximity of the movable stage such that the image of the film frame and the image of the reference reticle are both projected through the same objective lens.

Circle Reader Service Card No. 44

Resistron

A Vidicon Tube Type 2000, a television camera tube sensitive in the range from 3,500 to 18,000 Angstroms, is now available from Epic Inc., New York. The tube is suitable both for television camera operation in infrared light and for observing hot bodies at temperatures over 250°. According to Epic the unit has a low photoelectric lag and a high sensitivity to infrared illumination. The electron gun is provided with a separate mesh. The tube camera can be used on any television camera commercially available. The tube is marketed under the name Resistron.

Circle Reader Service Card No. 45

Migi-Lite

Chicago Miniature Lamp Works, Chicago, Illinois, has announced the development of a series of subminiature panel indicators, the T-1 series Migi-Lite. This series provides a substitute for military standard subminiature indicators in the 3-28 volt range. The firm states design characteristics of the Migi-Lite series include mounting on ¼" centers and three termination styles. Strain relieved wire leads are available for soldered connections, pin contacts for quick-disconnect, and special right-angle pins for printed circuit applications. The high-temperature polycarbonate housing is available in a variety of custom and transparent colors to meet a wide range of application requirements.

Circle Reader Service Card No. 46

Data Acquisition

5206 D-DAS (Digital Data Acquisition System), from Vidar, Mountain View, Calif., collects data from 1 to 1,000 data points such as thermocouples, flow meters, strain gages, load cells, and pressure transducers. A built-in data processor analyzes the data, formats reports, and sets control outputs as needed to adjust test devices, processes, or production equipment. The processor is designed to linearize inputs, convert to engineering units, solve equations, make logical comparisons such as limits scanning, and compute results such as efficiencies, moving averages, or temperature coefficients.

Circle Reader Service Card No. 47

Printed Circuit Board Indicator Light

A direct mounted PC board indicator light for circuit status information is announced by Display Devices Inc., Santa Monica, California. The unit is available in two configurations, for use on either double-sided or single-sided PC boards, and incorporates front-relampable long-life T-1 lamps. Additional features are claimed to include small size for high-density packaging, minimum protrusion from edge of PC board; unit also serves as an auxiliary card-pull handle. Lenses are available in the five standard colors, and clear.

Circle Reader Service Card No. 48

Remote Data Terminal

Hendrix Electronics, Milford, N.H., announces its remote Data Terminal. A CRT terminal, constructed of micrologic, MSI and LSI with a

2000 character display capacity, it will operate in full or half duplex mode. Format restrictions for inventory control and retrieval operations are provided.

Circle Reader Service Card No. 49

Display Terminal

Computek, Inc., Cambridge, Mass., introduces its Series 400 family of stand-alone display terminals. The Series 400 features a curve generator for graphics, said to enable curves to be drawn directly rather than approximated by straight-line segments. Model 20 includes a storage-type CRT, an alphanumeric input keyboard, curve and vector generators for graphics, a character generator for alphanumerics, and interfacing for standard data sets.

Circle Reader Service Card No. 50

Radio Remote Control

An all transistor two channel radio-remote control, designed for use with Selectroslide automatic slide projectors, is announced by Spindler & Sauppe Inc., Glendale, California Unit, designated Model 734 Slide Commander, is claimed to provide wireless remote control of two projector functions at distances up to 150 feet. One projector may be operated in forward and reverse, or two projectors forward only. The hand-held radio control is a 2-channel transistorized FM transmitter, powered by a single dry cell battery. The receiver/actuator operates on standard 110 volt, 60 cycle AC current. A fitted carrying case is supplied weighing 6 pounds.

System is designed for use on most of the "SL" series of Selectroslide projectors and adaptable to many other remotely controlled slide projectors.

Circle Reader Service Card No. 51

Three Point Tach Indicator

A tachometer indicator that displays three spread parameters within a single case has been developed by Kollsman Motor Corp., Dualin, Pa. The instrument is currently undergoing environmental and reliability testing in accordance with the latest mil spec, Mil-I-23832 (WP). Called the "Triple Tach", it will be used on military or commercial helicopters to indicate any three combinations of engine or rotor speeds. This new instrument operates from signals supplied by standard two pole tach generators per Mil-G-9398 or Mil-G-26611 and is accurate within 0.5 per cent. The unit is hermetically sealed in an MS 33639 case 5.25 in. long with a 3.25 in. diameter. The firm states options available include: Various ranges, mounting, configurations, and integral lighting per Mil-L-25467.

Circle Reader Service Card No. 52

Character Generator

A seven-segment character generator designed primarily for use with a CRT in the display of numeric information is now available from Fairchild Semiconductor, Mountain View, Calif. The product is the 3250, a MOS/LSI circuit with a single-chip complexity of 150 gates. Offered in a 24-pin Dual In-Line package, the device accepts a four-bit binary coded word and generates four deflection pulses properly synchronized with a serial train of video pulses that subsequently control the beam on a CRT. The deflection pulses sweep the beam through the seven-segment character in eight clock cycles, while the video pulses blank the appropriate segments needed to form numerals.

Circle Reader Service Card No. 53

Data Acquisition System

Applied Peripheral Systems Inc., Houston, Texas, has introduced the DT-1000, digital data acquisition system designed to multiplex various input signals at remote locations over phone lines. It may be used over standard DDD phone lines with automatic telephone answering and coupling built in, and point scan provides a continuous real-time presentation of any remote data point. Interrogation is not required since terminals report their data one-way. The firm claims the DT-1000 will accept data inputs from many sources, analog, digital and manual. A six-digit display provides data readout at the receiving terminal. It is computer compatible for automatic polling. Applications include oil production, electric and water utilities, gas distribution, pipelines, automated production lines, air terminal baggage handling systems, etc.

Circle Reader Service Card No. 54

Neon Indicator Lights

A series of permanent mounted neon indicator lights designated as the E-Lite Series, with and without built-in resistors and including a version of RFI shielded models, has been introduced by Eldema, Compton, Calif. Designed to meet applicable requirements of MIL-L-3661, the E-Lites have aluminum cases with either a black or clear anodized finish, high dielectric insulation and two pin plated turret terminals. Lenses are available in a choice of five colors and a variety of shapes for display requirements. Two basic types are available—The EG group which has only a neon lamp, and the ER group which has a neon lamp and a series resistor packaged within the unit. Special versions of both the EG and EF types with RFI/EMI shielded lens caps are included in this product group, according to Eldema.

Circle Reader Service Card No. 55

Horizontal Deflection Amplifier Tube

Amperex Electronic Corp., Slatersville, Rhode Island, announces the 6LF6, a 12-pin version of the Amperex 6KG6 anti-snivet horizontal deflection amplifier tube that operates at low B+. The 6LF6, like its 9-pin predecessor, is designed around the "cavi-trap" anode. The permeance of the 6LF6 permits it to be used at B+ voltages as low as 280 volts. However, the electrical characteristics of the 6LF6 are also flexible to permit its use as a replacement for the 6LB6, now used in some power-transformer color sets. With the 6LF6 operating at low voltage and high current, the tube elements are at low temperature.

Circle Reader Service Card No. 57

Print-out Media for Computers

A line of precision print-out media for computer data plotters has been announced by Keuffel & Esser Co., Hoboken, New Jersey. COMSTOC papers and films meet professional drafting standards for pencil and ink take, typing acceptance, and easy erasability, the company said. Computer graphics can thus be made compatible with standard engineering drafting practices and reproduction methods, K&E said. The materials, in plain or gridded formats, will be offered on three base stocks — natural tracing paper, transparentized vellum, and polyester-base drafting film. Papers are available in 40 yard rolls, in 12 in. and 31 in. widths. Film has the same choice of widths, in 20 yard rolls. All media are punched and perforated to work with most leading makes of drum-type data plotters, K&E stated. Grids are rotogravure printed in 10x10/inch and 20x20/inch standard formats. Federal Aid Sheets are offered as specials.

Circle Reader Service Card No. 58

Translator/Display Package

A translator-display package with opto-electronic modules for BCD/D readout, function displays identifying the numeric readout, and bezel assemblies for simple panel mounting is now available from Sigma Instruments Inc., Braintree, Mass. The Sigma 7 Model 321, which combines the functions of code translation and numeric display, accepts 6- or 12-volt binary-coded-decimal input and generates 0 through 9 decimal output on an integral 7-bar neon display powered directly from 120 VAC, 60 Hz. Translation is provided by a photoconductor matrix, coupled optically to incandescent lamps controlled by the BCD input circuits. The firm claims signal and output circuits are electrically isolated.

The Model 322 function display identifies the numeric readout in terms of temperature, pressure, volume, or any desired function. The display area may present a single message, or may be segmented to provide up to four messages of four symbols each. Translator and function displays are panel-mounted in standard AT421 bezel assemblies which will accommodate two to eight modules. Special assemblies can be supplied for more than eight modules.

Circle Reader Service Card No. 59

ID Correspondence

Sir:

In the article by Kinney and Showman (*Information Display*, Sept./Oct. 1967) the following statement occurs: "Crook, Hanson and Weisz . . . found that 'Capitals could be read more readily than lowercase when occupying the same printing area' . . . Unfortunately, they used one kind of task for lowercase and another kind of task for uppercase, which makes a direct comparison depend upon a weighted 'legibility score' they developed." (referring to our report: Crook, M. N. Hanson, J. A., and Weisz, A. *Legibility of type as a function of stroke width, letter width, and letter spacing under low illumination.* WADC Tech. Rep. 53-440, March 1954.)

We want to correct a failure of communication between us and Kinney and Showman which is reflected by this statement. We did Experiment 4 for the specific purpose of comparing uppercase and lowercase not only in the same area but on the same task. With these variables controlled, we found uppercase to be better than lowercase, and that is the conclusion that our write-up was intended to convey.

It is possible that we did not give this point sufficient emphasis in our report, and as communicators we are willing to share the blame with the communicatees.

Mason N. Crook
John A. Hanson
Department of Psychology,
Tufts University

Sir:

In our article we stated, "Unfortunately, they (Crook, Hanson and Weisz) used one kind of task for lowercase and another kind for uppercase, which makes a direct comparison depend upon a weighted 'legibility score' they developed." As pointed out above, we were mistaken in stating that their comparison of uppercase and lowercase used different tasks. An oral reading task was used in their Experiment 2 for uppercase, and in their Experiment 4 for lowercase. A rereading of their report has not revealed to me why I made the mistake; their procedure seems clear enough now.

The reference to a "weighted legibility score" (I should have said scores and ratios) was intended to convey my doubts that their Experiments 2 and 4 had demonstrated the superiority of uppercase over lowercase. Since I was not convinced that their speed and accuracy scores and ratios were suitable comparatives, I included their report in a group of others that left the issue of uppercase versus lowercase in some doubt. Small differences in procedure and sample sizes in the two experiments added to my not being convinced that uppercase was shown to be superior to lowercase.

My issue of the scores and ratios, however intended or conveyed, is a small one, probably a matter more of personal preference than of technical adequacy, and not a good reason for my wanting to debate it. I apologize to Crook, Hanson and Weisz for any disservice to them, and to *Information Display* readers for being inaccurate about the similarity of tasks in their comparison of uppercase and lowercase printing.

Glenn C. Kinney
Digital Systems Departmen
The Mitre Corp.

Sir:

The July/August and September/October issues of *Information Display*, containing my article, *True Stereoscopic Movie System Without Glasses*, were extremely well done. I should like the following corrections noted for purposes of clarification:

PART I

page 28—column 2, line 2—"P_i" should be "P_i'"

page 29—column 1, paragraph 1. "An alternate method is to permanently install several lenses in front of the cylinders, as in figure 6b.

page 31—column 1, paragraph 3, line 3 "intersects the screen at P_{ix}'" (not P_{ix})

page 31—column 1, paragraph 3, line 4 "screen at P_{iy}'" (not P_{iy})

page 31—column 2, paragraph 3, line 6 "unobstructed" (not obstructed)

page 33—column 2 "Description of Parameters in Figures 16, 17 and 18"
under D_n = "O_f" should be "O_n"
under D_f = "O_n" should be "O_f"

page 36—column 2—after $N = 2\pi R/S = 4520$, the following was left out: "The total quantity of capture points or cells/120° is then approximately 1500".

PART II

page 29—DC Resistance Between Plate, 1st line, $R = pd/LI$, not p^d/LI

page 29—Generator Power Required to Charge Slit Capacity—line 3 of Column 2, remove "t=" formula for E should not have dividing line under 0.477 watt-seconds; Resistive Power Dissipation, $P = V^2/R'$ not $P = VV^2/R'$

page 29—Final Stereoscopic Illumination Available to Audience—line 3—"glossy" should be "lossy"

page 30—Column 2, line 11—remove "rate" after "illumination"

ROBERT B. COLLENDER

on the move

HAROLD W. POPE has been elected to the newly created post of executive vice president of Sanders Associates Inc., Nashua, N.H. The company also announced the appointment of RICHARD F. BARNEY, assistant manager, Marketing Services Dept.; JOHN S. TODMAN, engineering manager for the firm's United Kingdom operation; and PETER KELLETT, general manager of the European Headquarters.

JOHN D. POFFENBARGER JR. is operations manager for Linear Ferrite Operations, Saugerties, N.Y.

POFFENBARGER

LEE

EDWIN K. LEE has joined the Houston Fearless Corp., Westwood, Calif. div., as director of marketing.

F. WILLIAM SHRIVER directs communications for Atar Computer Systems Inc., Los Angeles.

Promoted to the post of radar and display laboratory manager at the Chicago Center of Motorola's government electronics div. is JACK R. PENDLETON.

Elected vice president, western region, for Computer Applications Inc., New York, is DONALD G. MALCOLM.

G. D. SPEAKE is now general manager of telecommunications for Marconi Co. Ltd., Essex, England.

Appointed to the post of manager of the display and imaging dept. of the Sensor Systems Lab at TRW Inc., Redondo Beach, Calif., is PETER G. WHITE.

DR. MARVIN P. PASTEL has joined Zenith Radio Corp., Chicago, as chief engineer of the government engineering div.

PETER O. CIOFFI and DONALD F. COTE were elected vice presidents of Keydata & Adams Associates Inc., Watertown, Mass.

United Electronics, subdivision of General Electronics Inc., Newark, N.J., announces the appointment of ROBERT W. DEUTSCH as president.

WILLIAM L. MOORE is development engineering manager for Philco Houston Operations of Philco-Ford Corp. He succeeds B. P. GARDNER, now manager of information systems of the National Alliance of Businessmen, Washington, D.C.

Newly appointed sales manager, western region, for the Display Div. of Data Disc Inc., Palo Alto, Calif., is CHARLES T. MASTERS.

THOMAS F. DEAHL has been named managing editor of *Graphic Processing Reports*, published by Auerbach Corp., Philadelphia.

WILLIAM E. STANDRING JR. has been promoted to general manager of the newly formed Fiber Optics Div. at Optics Technology Inc., Palo Alto, Calif. Other promotions at the company include ROBERT J. APLIN, vice president, marketing; GERALD W. OLMSTED, director, manufacturing; HAL L. SOWERS, assistant director of research; and BRIAN G. PHILLIPS, manager, applied optics research.

Warnecke Electron Tubes Inc., Des Plaines, Ill., announces the appointment of DR. OSKAR DOEHLER to the position of chief scientist.

ROGER J. KELLY and ALLEN J. FLITCRAFT were elected to newly created vice president positions at Computer Technology Inc., Chicago.

The appointment of ANTHONY M. CATALINI as manager of the Princeton, N.J. branch has been announced by Computer Sharing Inc.

Mark Systems Inc., Cupertino, Calif., has been separated into two divisions: Mark Instruments, under the management of CHARLES ASKANAS; and Mark Technology, managed by MALCOLM R. MALCOMSON.

ROBERT FRIEDMAN has been appointed director of marketing of the TNT Electronics Div., New York.

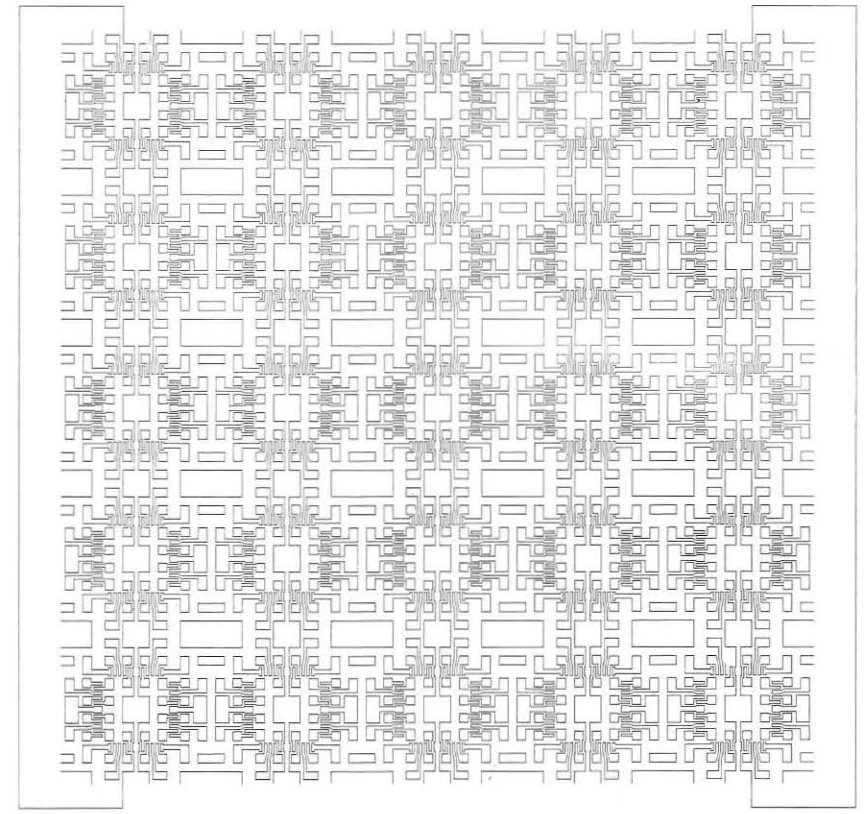
HOMER G. TASKER, founder and chairman of the board of Tasker Industries, Van Nuys, was named chairman emeritus by the board of directors.

FRANK WAGNER has been appointed sales engineer and KENNETH G. HARPLE has been elected vice president at Systems Engineering Laboratories, Fort Lauderdale, Fla.

Stromberg Datagraphics Inc., San Diego, Calif., has made two new appointments. FRANK M. SINGER is now program manager for A-NEW Airborne ASW Avionics Systems, and ARTHUR C. SCHMITT is eastern regional manager.

Serving as general manager of Intelligence Systems Research and Enginering for CBS Laboratories, Stamford, Conn., is JAMES T. FULTON.

Computer-aided program adjusts plotting path



This intricate pattern of a highly miniaturized circuit chip was plotted automatically with a light beam directed by an experimental computer program.

"Not drawing the correct line is one way to improve accuracy in computer-aided graphics," said William L. Dunne, of I.B.M., at the annual SHARE-ACM-IEEE Design Automation Workshop.

Artwork produced by a high-precision plotter driven automatically by computer commands is examined by draftsmen. The mask—used to make miniaturized encoder discs for circuit clocking—is one of many diverse applications of the experimental program.

"Charting a path different from the line described to the computer keeps the plotter within critical tolerance limits."

Such an approach is part of an experimental computer program called Graphic Applications Subroutine Package (GASP). It is designed to meet the demand for automated high-precision graphics and handle a broad range of artwork typically found in a production drafting room.

Tested and refined under actual working conditions, the experimental graphics package has been applied over the past two years at IBM's Systems Development Laboratory in San Jose, Calif., to such diverse jobs as comparator charts for manufacturing inspection, encoder disks for circuit clocking and precision artwork for chemical milling of machine parts.

Program commands written in FORTRAN language for IBM System/360 computers drive a small plotter or produce a tape for a large precision drafting machine that can "draw" images with a light beam on photographic film or glass. The program is easily adapted to graphic display on a CRT scope or to other computer output devices.

To initiate action, the user enters "call" statements into the computer with x-y coordinates describing his drawing. A single command, "CALL LSEG" followed by coordinates for two points, will cause the plotter to draw a line segment. Similar commands produce circles, arcs, ellipses, arrows, splines, or letters.

Special program routines allow the user to manipulate these graphic elements individually or in groups and perform calculations that increase accuracy and relieve the designer of tedious detail.

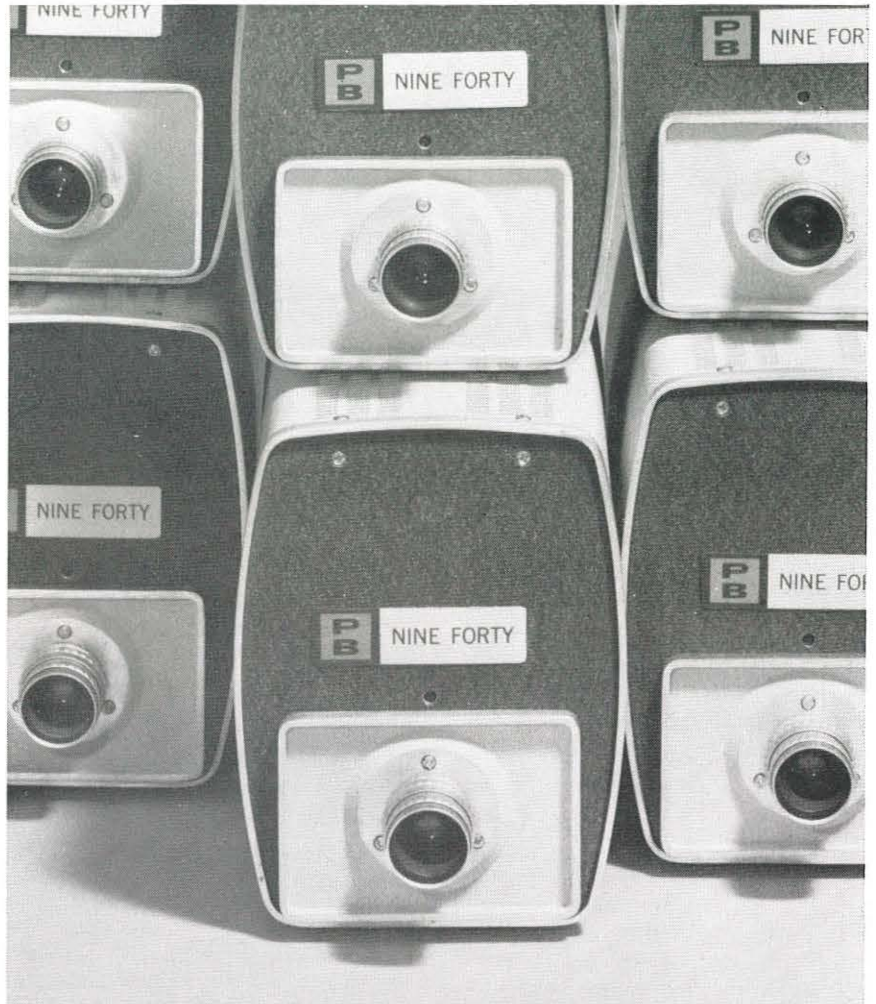
One such routine compensates for the diameter of the pen or light beam by offsetting it from the specified line. This feature is particularly useful in making precision masks for highly miniaturized integrated circuits where a line only a few thousandths of an inch wide can exceed tolerance limits between circuit paths. The offset routine calculates a new path for the plotter that keeps the resulting line from overlapping a critical dimension.

Other routines add flexibility to the program by moving and rotating graphic elements or sections of the drawing, scaling them to any size, and repeating them hundreds of times if necessary.

Lines and other graphic elements can be plotted as a series of dots, dashes, or other special line-types by merely setting an indicator. This removes the need to independently describe each segment of the broken line. Another set of commands can be invoked to add dimensional lines, arrows and numerical quantities associated with engineering drawings.

These routines—besides expanding the state-of-the-art in precision capability—have significantly reduced typical job turnaround time. The experimental program has been especially effective in speeding engineering changes in artwork since only those commands affecting the modifications must be changed before automatically reproducing the entire drawing.

A production mask for a machine part—drawn on film by a light beam automatically controlled by computer commands—is checked by draftsmen at the IBM Systems Development Laboratory in San Jose, California. The path of the beam is directed by an experimental computer program for high-precision graphics.



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Resolvable Elements/Diameter	1700	2100	3400
Maximum Spot Size	0.0025	0.002	0.00125
Settling Time	10 usec	12 usec	20 usec
Small Signal Bandwidth	1 mhz	1 mhz	1 mhz

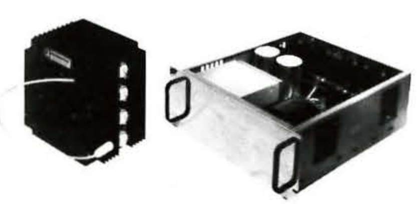
±35 VOLT DEFLECTION AMPLIFIERS

The models DA223, DA224 and DA225 are dc-coupled, all-silicon, solid-state modular packages capable of supplying up to ±2.0, ±4.0 and ±6.0 amperes of deflection current respectively to each axis of a directly-coupled deflection yoke. A unique method of damping optimizes the amplifier for the particular yoke being used by means of an adjustable potentiometer. The amplifiers also feature extremely fast settling time and high bandwidth. The user has the choice of operating the amplifiers Class A for achieving nonlinearities of ±0.02% maximum or Class AB for minimum power consumption.

MODULAR CRT BUILDING BLOCK COMPONENTS

Individual, compatible plug-in circuits such as: DF2050 Dynamic Focus Generator; DF347 Dynamic Focus Amplifier; LC1784/1785 Precision Linearity Correction Circuit; LC916/918 Linearity Correction Circuit; VA2076 Video Amplifier (10 mhz); VA2075 Gamma-Corrected Video Amplifier (10 mhz); VA2077 Video Amplifier (30 mhz); SG1190 Sawtooth Generator; PP529 Phosphor Protection Circuit; DA341 Deflection Amplifier (±200 ma); DA1340 Deflection Amplifier (±0.75 amperes); EDA800 Electrostatic Deflection Amplifier (350 volts plate-to-plate positive or negative); EDA1504 Electrostatic Deflection Amplifier (500 volts plate-to-plate positive or negative); FR1882 Static Focus Regulator; BA1714 Blanking Amplifier. All Beta circuitry features silicon semiconductors and temperature stable metal-film resistors throughout.

HIGH & LOW VOLTAGE CRT POWER SUPPLIES



SERIES HV provides regulated high voltage outputs for CRT electrodes — anode, focus grid, G2 and filament.

Model No.	Anode Output Range
HV8	1-8 kv
HV20	5-20 kv
HV30	15-30 kv

SERIES PAK provides regulated low voltage outputs for Beta modules — ±35 volts, ± 20 volts, G1 and filament.

Model No.	±35 volt (deflection) Output
PAK7	7 amperes
PAK16	16 amperes

PRECISION TUBE AND COIL MOUNTS

Flexible combinations of standard assemblies for the precision mounting and alignment of CRT's, yokes and coils: CRTM Basic CRT Mount includes removable bezel, rods and neck end clamps; DSTM Dual Gun Recording Storage Tube Mount, includes rods and neck clamps both ends; MCM Micropositioner Coil Mount allows 6 independent motions and positive lock; FYM Fixed Yoke Mount for application where micropositioning is not required; FYMS Fixed Yoke Mount for servo-type mounted yokes; CCM Centering and/or Alignment Coil Mount; MS983 Magnetic Shield Enclosure.

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