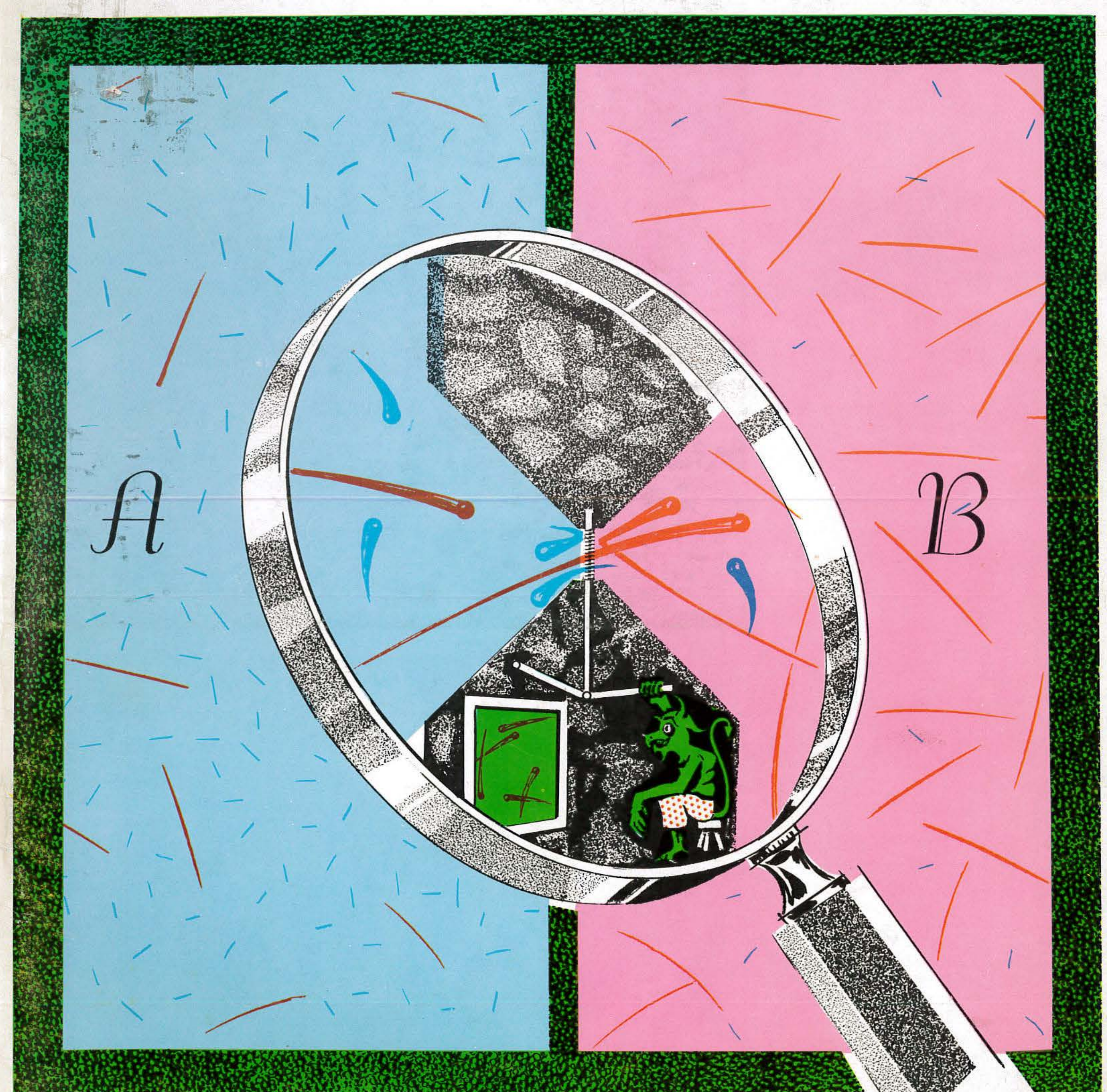
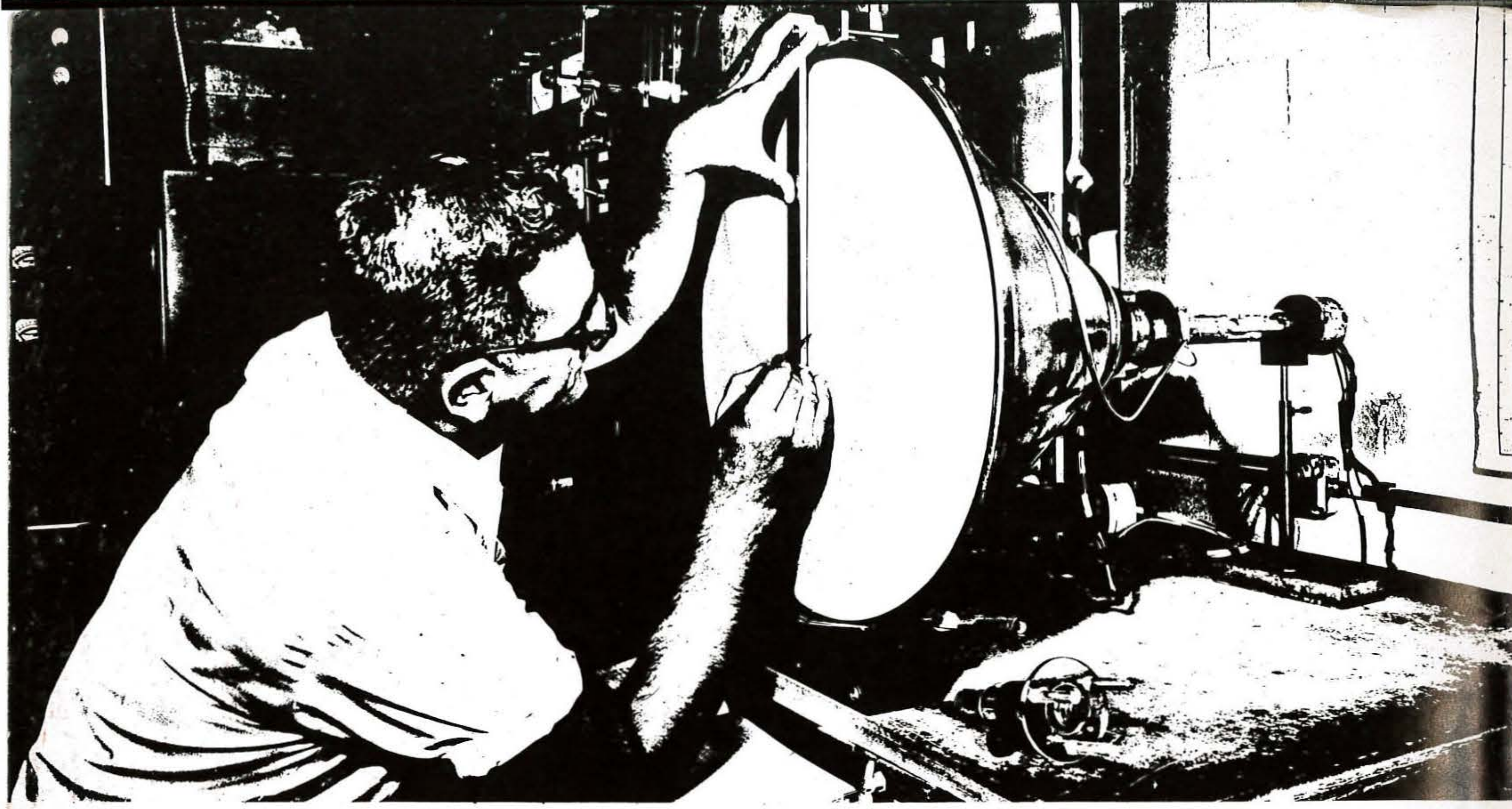
Volume 5 Number 1 January/February 1968

Information Display

Journal of the Society for Information Display





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Volume 5 Number 1 January/February 1968

Information Display

Journal of the Society for Information Display

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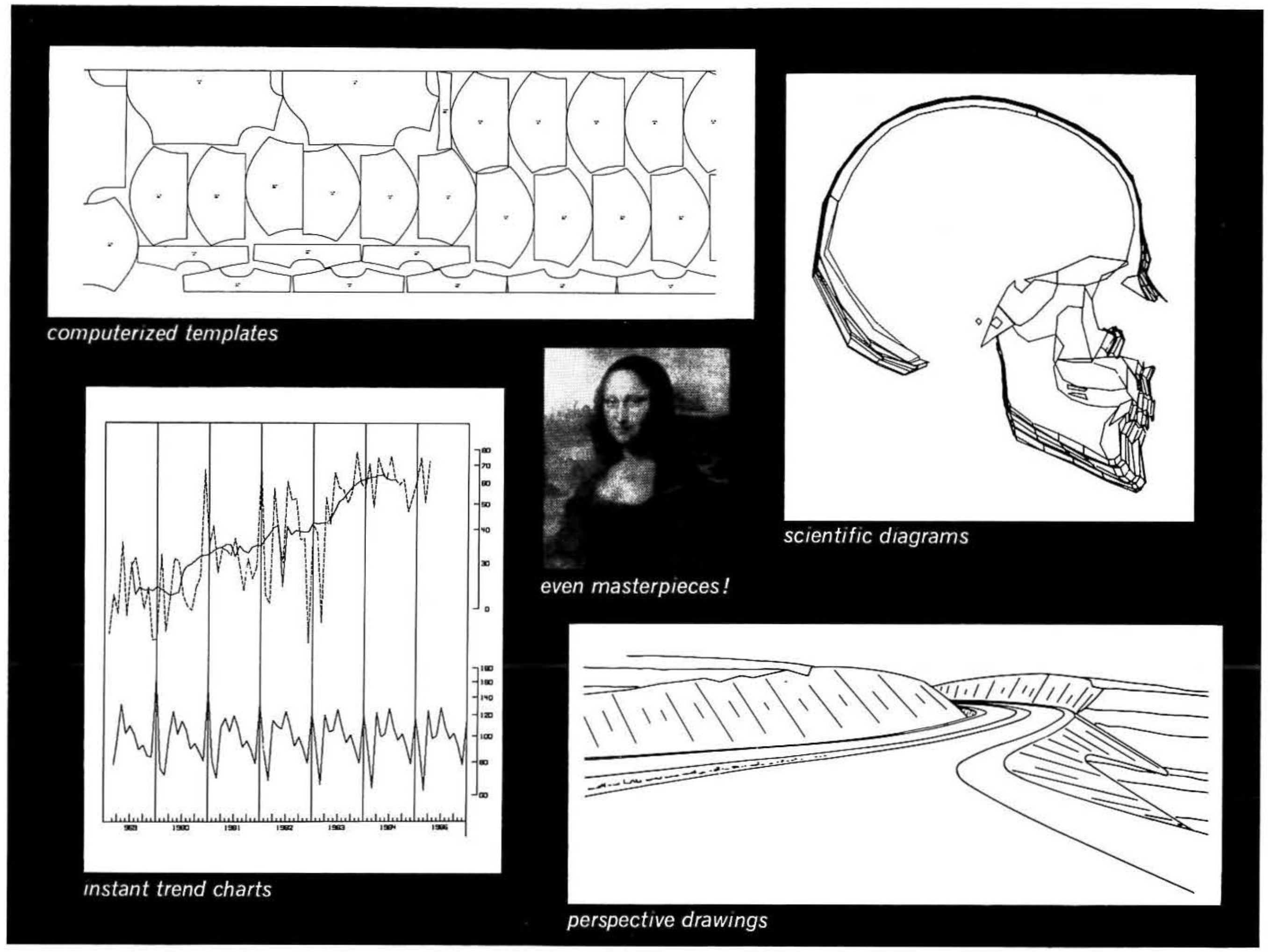
the cover

The total thermal energy in the enclosure represented by the fast and slow moving molecules of air cannot be made to do work unless there is a difference in temperature. Maxwell's "Demon", drawn by Harold R. Bonnet, Illustration Group Supervisor of Burroughs Defense Space and Special Systems Group, determines the precise moment when the valve in the partition should be opened to allow hot molecules to move from A to B and cold molecules to move from B to A. This theme is developed in Display With Entropy, beginning on page 20.

Do you know what it takes to make your computer draw like this?



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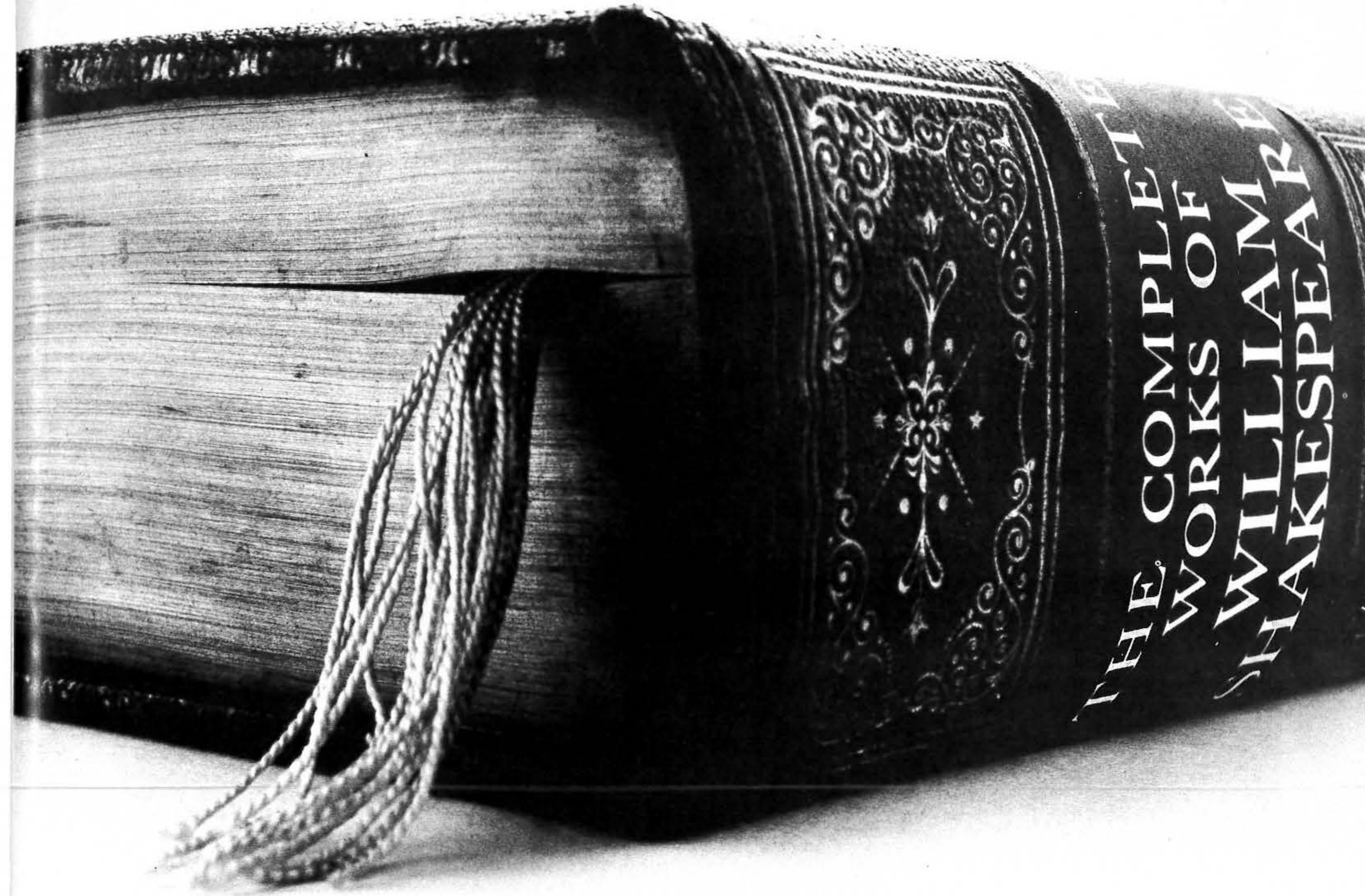

We could print it in 158 seconds.

Our new 2″-monoscope (Fig. 1) can generate over 30,000 characters per second. And our cathode-ray printing tube (Fig. 2) can print them just that fast by an electrostatic printing technique.

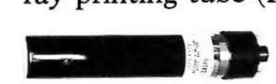

Fig. 1. Sylvania 2″ monoscope Type SC-4648.

At that rate, we could print an amount of text equal to the complete works of Shakespeare, some 950,000 words, in about 158 seconds, based on an average of 5 characters per word.

The secret of the monoscope's unique character-generating capability is in the metallic character screen (Fig. 3), electronically opaque except for the open characters. To generate a character, the electron beam scans only one character location, not the entire target. Since a single character occupies less than 1/100 of the full screen, the monoscope generates a character in 1/100 of the time of a full raster scan.

Fig. 2. SC-3154 high-resolution electrostatic printing tube with useful screen area of 0.16″ x 8.6″.

Fig. 3. Stencil character screen from 2″ monoscope can be custom-designed to your requirements.

The stencil target screen shown has 64 alphanumeric and mathematical symbols. But it can be made with additional character symbols *to meet your individual specifications* including other languages, in any given character style.

We recommend the monoscope as a character generator for: computer data display, airline status boards, stock quotation boards, teaching machines, address-label printing, command control center displays, racetrack tally boards . . . anywhere a high-resolution information electronic readout system is required. Sylvania Electronic Components, Electronic Tube Division, Seneca Falls, New York.

SYLVANIA

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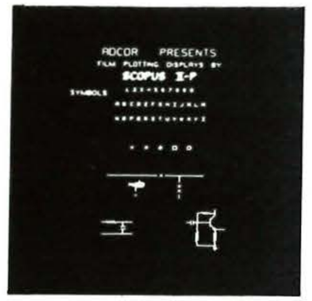
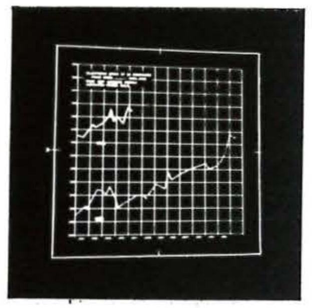
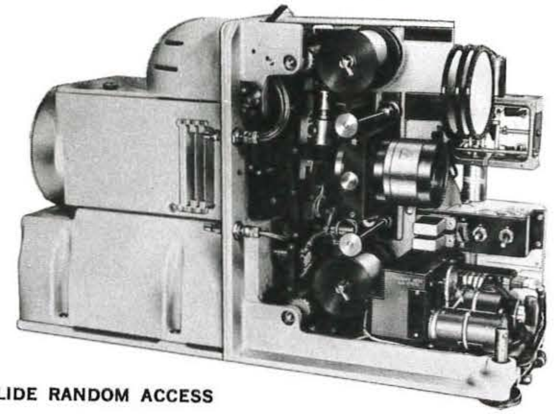
A unique concept in high speed film plotting
for front or rear projection

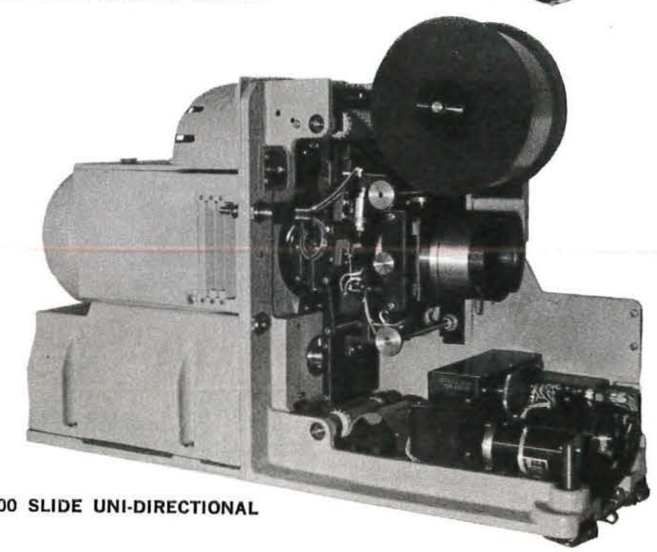




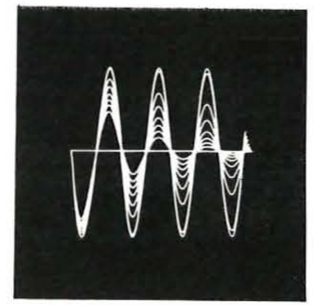
Actual photos taken of 7 foot by 7 foot display screen.

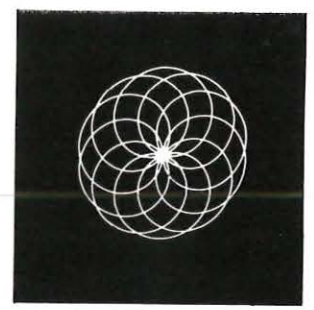


100 SLIDE RANDOM ACCESS



2000 SLIDE UNI-DIRECTIONAL





Actual photos taken of 7 foot by 7 foot display screen.

The new SCOPUS II offers:

. . . Plotting on 70 mm stabilized polyester film
. . . Low logistics cost
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INFORMATION DISPLAY SYSTEMS
APPLIED DEVICES CORPORATION
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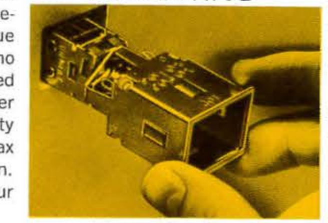
Circle Reader Service Card No. 8

There are sound reasons why. Unimax Series 9 lighted pushbutton controls meet the requirements of MIL-S-22885. They feature unique front-panel mounting with a single screw — no need for sleeves or hardware. Internally bussed lamp circuits get rid of line jumpers and solder connections — and that means more reliability and much lower installation costs. With Unimax LPB's, relamping is just a push-pull proposition. And our exclusive spring loaded sockets end your usual terminal-to-lamp continuity problems.

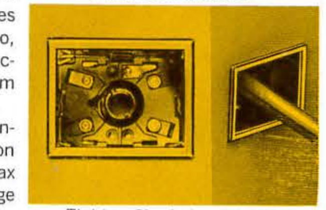
More good news: you can specify custom messages from a wide range of display styles and color coding. Choose your switching — two, three or four pole, momentary or alternate-action. Design your own complete assembly from our modularly-designed snap-on components.

Before you turn to any more illuminated controls, why not turn on Unimax LPB's? The coupon at right offers you, free, your personal Unimax "Think Twice" button, and our detailed 12 page color catalog #50-1.

MOUNTING



Place Unit in Panel



Tighten Single Leadscrew

RELAMPING

Pull ¼" — Push ⅛"

Remove Lens from Unit

Think Twice

Unimax Switch. Dept.
Division Maxson Electronics Corporation
Wallingford, Connecticut 06492

☐ Yes, I would like to turn to Unimax LPB's before I turn on any more illuminated controls. In addition to my free, personal "Think Twice" button, I would like to receive your detailed 12 page color LPB catalog 50-1.
☐ I can't wait for the mail. Please have your representative contact me immediately to discuss a particular need.

NAME ____________________
TITLE ____________________
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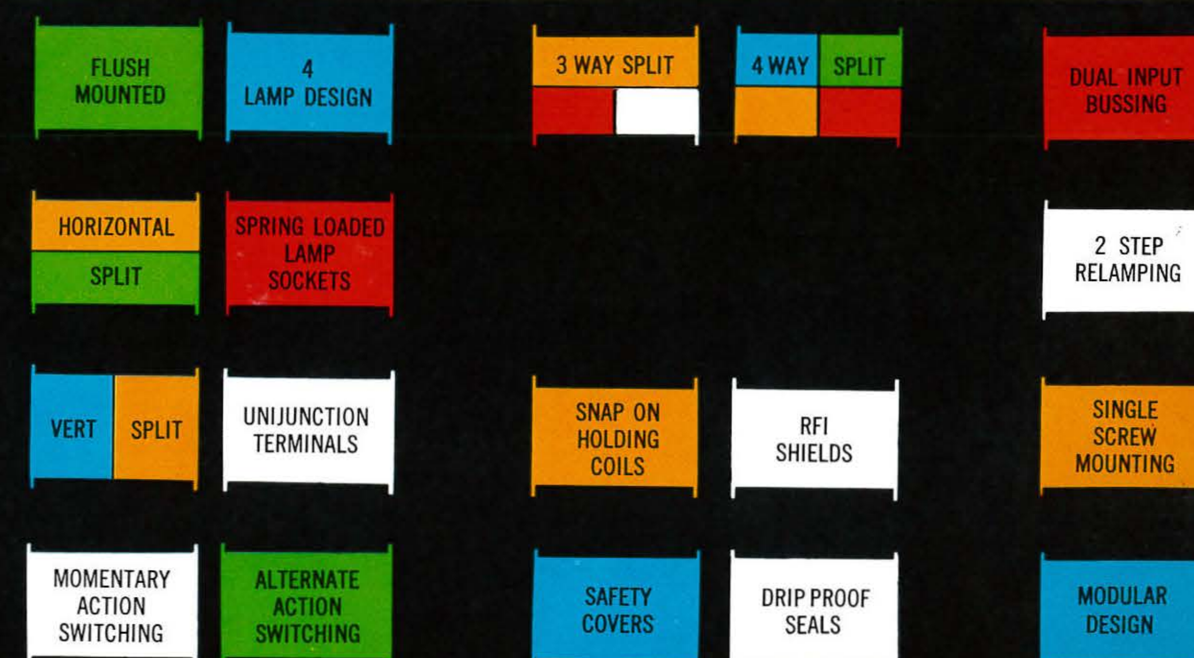
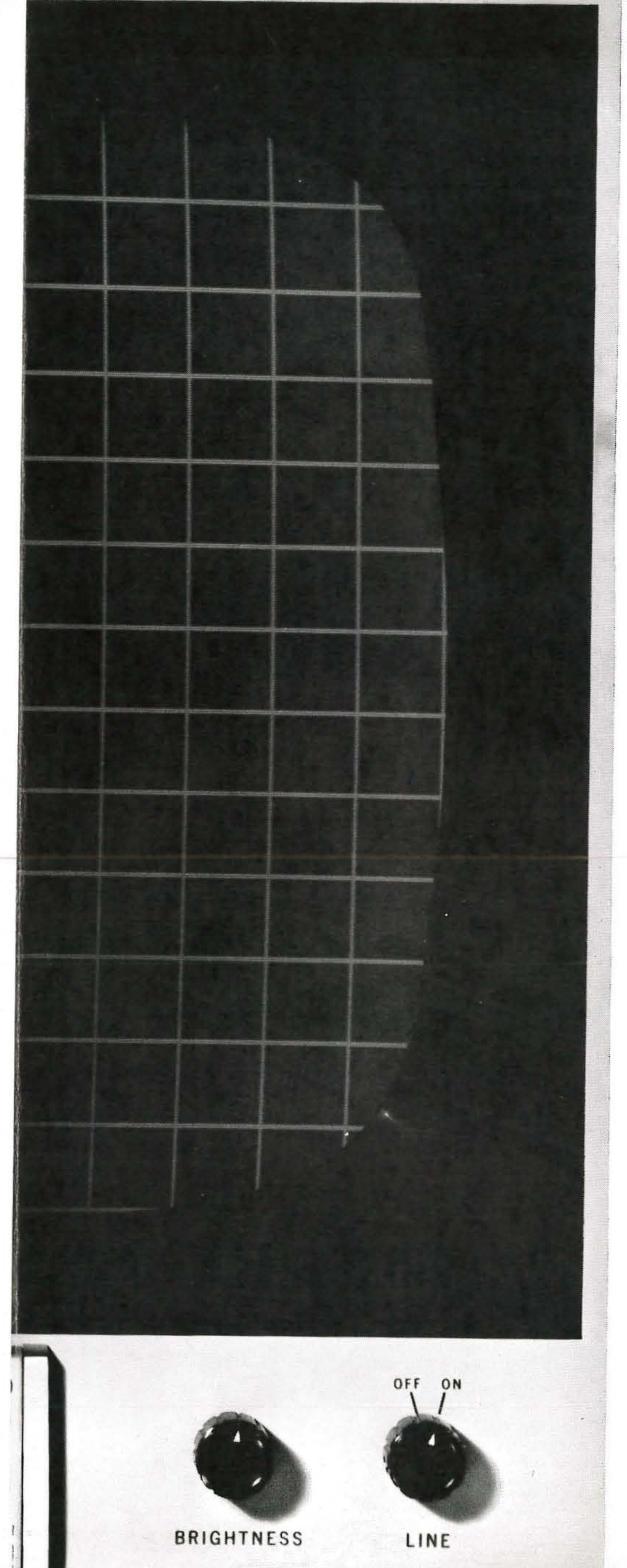
New Unimax LPB's turn Design Engineers on!



Unimax Switch

Circle Reader Service Card No. 9

DIVISION MAXSON ELECTRONICS CORPORATION • WALLINGFORD, CONNECTICUT



OFF ON
BRIGHTNESS
LINE

Directly Heated Laser Cathods

Philips Metalonics, Mt. Vernon, N.Y., offers a new version of the Philips Impregnated Cathode for use in gaseous lasers. Tungsten matrix is machined into a helical coil shape which allows it to be heated by passing current directly through the turns; eliminating need for a separate heater and heat shielding arrangement. The hollow helix may be mounted on the axis of the laser without blocking the beam.

Circle Reader Service Card No. 33

Fast System Designing With IC's

Cambridge Thermionic Corp., Cambridge, Mass., has announced availability of a plug-able and patchable integrated circuit card as an addition to its expanding line of digital products. These new boards (P/N 705-0147-1) feature cabion's exclusive cage-jack and each board can handle up to 8 dual in-line circuits at a time. Integrated circuit and the patchwork are on the same side of the card, permitting the engineer or technician to see exactly what he is doing.

Circle Reader Service Card No. 34

IBM 1130 Interface

Computer Communications Inc., Inglewood, offers an interface to an IBM 1130 Computer System permitting use of a CC-30 Communication Station as a low-cost, powerful, remote communications and display link. Designated CC-7011, the Channel Adapter attaches to the storage access channel of the 1131 central processor.

Circle Reader Service Card No. 35

Counter Measure 1

A high reliability decade counter has been introduced by Quasar Microsystems, Inc. Valley Stream, N.Y. All silicone circuitry is

combined in a compact modular design. The firm claims a configuration which substantially simplifies installation is achieved by use of a Nixie tube readout. The device is capable of counting at a rate of 0 to lmc per second; the unit, which measures 3 x 5.8 x 1 in. is packaged in a Lexan case.

Circle Reader Service Card No. 36

Solid State Digital Clock

A solid state digital clock to furnish accumulation of real time or elapsed time for display purposes and/or the time tagging of digital data is offered by Datatron Inc., Santa Ana. Model 3350 utilizes from 6 to 9 Nixie indicator tubes for visual output; digital output consists of binary coded decimal information with resoultion available down to one millisecond. The instrument is operated from an internal crystal oscillator, an external frequency source, or 60 Hz power line.

Circle Reader Service Card No. 37

Numerical Readout Tubes

National Electronics Inc., a Varian subsidiary, Geneva, Ill., has announced a series of short, side view readout tubes. They are considerably shorter than existing types, have flat tops and fit existing sockets. NL-900 series are side view, long life display tubes with .610 in. characters and a dynamic operating life in excess of 200,000 hours. Max. over-all length is 1.635 in. and max. seated height is 1.375 in. Max. dia. of .750 in. allows less than .800 in. center to center spacing.

Circle Reader Service Card No. 38

Digital Computer

Elbit Computers Ltd., Haifa, Israel, has announced the ELBIT 100, a digital computer selling for a single quanity price of less than $5,000. It is designed for integration into a system or control loop. Basic price includes a 1024 twelve bit core memory with 2 μsec cycle time, a 256 word fixed memory with 400 nsec access time, control panel, all power supplies and interface with any standard Teletype or mechanical tape reader. Using all IC construction, machine is microprogrammable for optimizing speed of read time operations.

Circle Reader Service Card No. 39

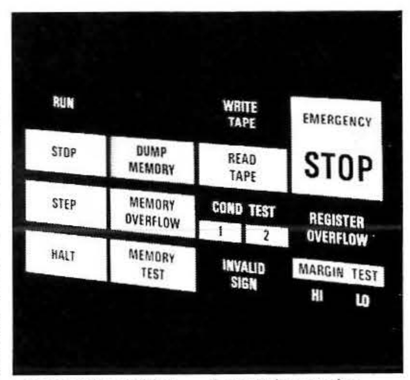
YES, YOU GET THE BOLDEST BRIGHTEST MOST READABLE CRT DISPLAY AVAILABLE TODAY.

Actual photo of DATA-SCREEN Display Terminal characters — shown actual size.

but TEC's DATA-SCREEN Display Terminal also gives you . . .

Interface flexibility—compatible with most EDP and communication systems, transmits and accepts any 8-level code including ASCII, IBM, and EBCDIC. Electrical interface signal level options include 5-volt current sink I-C logic and EIA Standard RS-232B.

Keyboard flexibility — optional input keyboards offered in standard or special key arrangements. Special keys for control functions, indicators and switches can be located anywhere on the keyboard. A variety of key styles are offered with legends to order.



Display flexibility — in addition to the CRT data display, up to 144 fixed messages can be displayed behind the black screen using TEC's DATA-PANEL® Display System. Invisible when off, messages such as FAULT, OVERFLOW, ON LINE, STOP, etc., become instantly visible when illuminated.

Without a doubt (our competitors admit it) this display terminal has the largest . . . ¼″ minimum . . . most readable, rock steady characters available in its field. Stroke-written messages appear in brilliant contrast to the black screen of TEC's DATA-SCREEN Display Terminal.

Three completely self-contained models with keyboard, character generator, refresher core memory, solid state logic and power supply are offered with 128, 200 and 512 character display. Everything else you'd expect in a completely flexible CRT display is offered: full character repertoire; flashing cursor with positioning controls; editing features; character size and slant adjustments; modern cabinet or rack panel mounting option.

Send for 6 page brochure that tells all about TEC's DATA-SCREEN Display Terminal — the flexible, readable CRT.

TEC LITE® INFORMATION DISPLAY AND CONTROL DEVICES

TRANSISTOR ELECTRONICS CORPORATION

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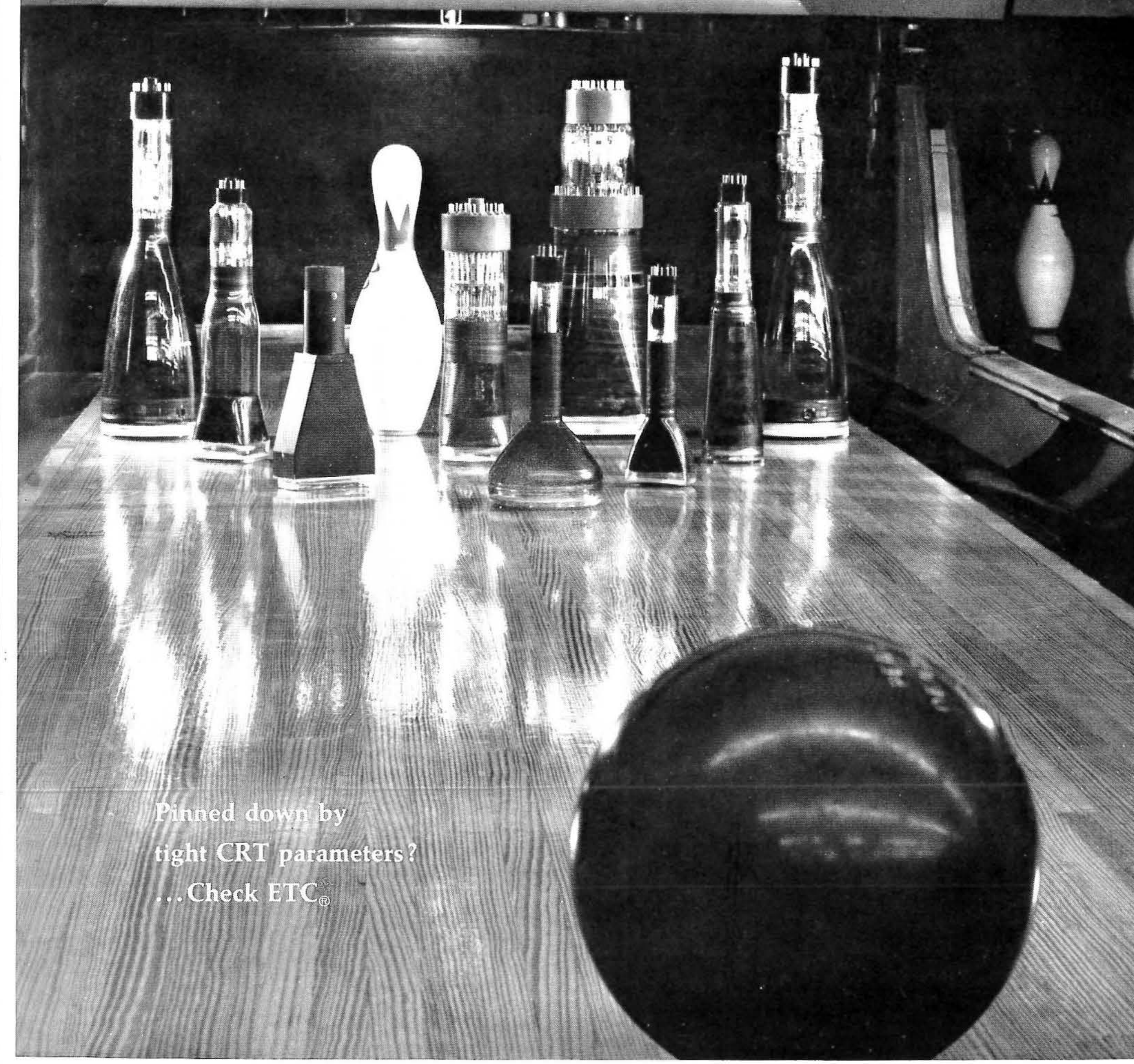

Tube capability is right down our alley

Challenge has been our game for nearly 30 years... the challenge of designing, engineering and producing new CRT's for special applications.

We meet this challenge continually, and from our modern R & D and manufacturing facilities have come many "firsts" in CRT development. Our contributions to industry, science and the military have earned us a reputation for solving the particularly difficult display problem.

Today, as a result of our 3-decades of pioneering activities in tube technology, we offer one of the largest lines of off-the-shelf CRT's in the industry. Each has undergone the quality-controlled product engineering and stringent testing required as a custom fabricated item. And each will provide more performance per dollar in the application for which it was designed.

Try "pinning us down" to your individual CRT needs, whether they involve multi-gun displays, multi-layer phosphors, special bulb shapes, or ultra-high resolution.

You'll find us "right down your alley" when it comes to meeting your specs. Why not call us today ... or write for our complete capability catalog.

GENERAL ATRONICS
ELECTRONIC TUBE DIVISION
PHILADELPHIA • PENNSYLVANIA 19118

Info 68 Gets Ahead

When Lou Seeberger approached me to do this mini editorial on just what the INFO 68 logo means, I was surprised. After all, doesn't it immediately come over to all who see it? Obviously, it doesn't. As a matter of fact, I ran a little experiment among some friends of mine to discover what it symbolized to them. Unfortunately, I can't repeat their replies in a professional journal, but it did clarify one thing. I had better write that editorial — and fast. I can't guarantee that after reading this little tome you'll have any better idea of what it symbolizes, but you may have gotten a chuckle or two.

First of all, let me absolve the rest of the Symposium Committee from any responsibility for the logo's creation. I was responsible. However, the design of a graphic symbol did involve the Planning Committee's sanction, even though they may be loath to admit it.

We might consider what it isn't. It isn't a Greek with a home permanent, and it certainly isn't a bust of Ceasar (or Cleopatra, for that matter).

Seriously, for a moment, INFO 68 was the outgrowth of a Planning Committee discussion in which a "catchy" keynote for the symposium was sought. INFO 68 is an outgrowth of Expo 67 — *SID* style. Once this phrase was adopted, a logo was required to graphically relate it to the whole area of information display. One of the problems that confronts any graphic designer is to try to express his theme in a form that is not trite. One of the ways is to deal only with essentials. For information display, there can be no more basic symbol than the eye, and its information storage and therefore bank, the brain.

The graphic or artistic quality of the imagry is no less important. For this reason, I selected a head (brain) that contains some interesting graphical qualities. If you inspect the head closely, you will discover a series of little vignettes that illustrate certain qualities once thought to be the main structure of the mind (Victorian phrenology). These little pictures will become much more visible when the May/June issue containing a large-scale version of this logo is published.

The eye provides us with a lot more today thanks to the "explosion" of information technology. This explosion is not going off inside the logo's "head," as one of my less-than-generous friends remarked upon reviewing the symbol, but in the vast spectrum of activities that comprise 20th century man. This is one of the reasons that the symposium will endeavor to point up information display in a variety of non-military fields such as medical applications and civil uses, entertainment and the burgeoning field of education.

If the preceding rationale for the logo eludes you, a more basic explanation can be supplied. Symposium general chairman Lou Seeberger tells me he recently saw a huge replica of the logo head in Hollywood (where else) with an arrow underneath and a sign stating "THIS WAY TO THE HEAD."

I believe you, Lou, but will the Society??

JAMES BELCHER
Publicity Chairman
9th Annual Symposium
Society For Information Display

Display with entropy

by CHARLES HALSTED,
Mgr., Display Technology
Advanced Development Division
Burroughs Corporation
Defense, Space and Special Systems Group
Paoli, Pennsylvania

Material included in this paper was originally prepared for the symposium for the Advisory Group for Aerospace Research and Development (AGARD) of the North Atlantic Treaty Organization and presented at a display symposium held at Munich, Germany on Nov. 8, 1966, under the title "A Study of the Relationship Among Special Symbol Fonts, Electronics and Subjectivity." The paper in its entirety, however, is published here for the first time.

INTRODUCTION

The influence of electronic data processing equipment has infiltrated nearly every area of human endeavor. Solving routine accounting problems was such a blessing to so many that the computer has already justified its existence for just that purpose. It has become obvious to computer manufacturers and many users that the use of computers and data processors will continue to grow at a very fast rate. The computer's most ardent champions are quick to admit that no matter how big and capable the electronic computer, it still falls far behind the human in many areas. On the other hand, the computer can do some tasks much better than the human. It seems only logical then, that there must be a large class of problems which could best be solved if the human and the computer could pool their best talents and solve the problem together.

Cathode ray tube (CRT) display systems are being continually refined by manufacturers, with the recommendations of users, for the purpose of optimizing the man-machine relationship. This paper deals with one facet of the cathode ray tube display and develops a concept which it is hoped will be useful in other areas. This concept of "entropy" was first used in the science of thermodynamics but it has been extended into other fields. In this paper, entropy is used in its "information theory" sense as applied to character generation.

To develop this concept of entropy, a description of the information capacity (as opposed to actual information supplied) as a function of basic display features is necessary.

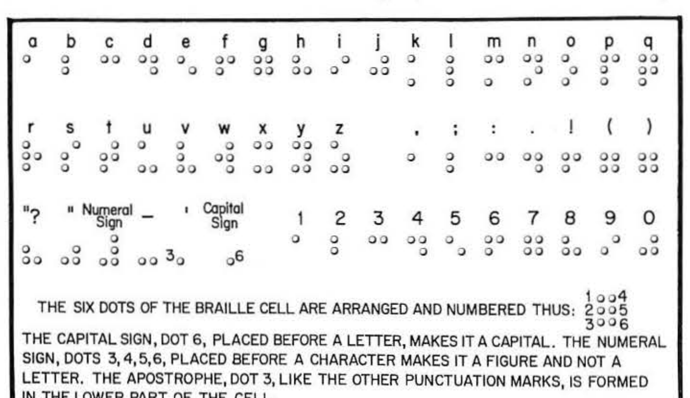

FIGURE 1: Braille Alphabet

The following alphabet factors will be considered in this paper:

1. Character sets
2. Character font
3. Recognition and Esthetics

The thermodynamic concept of entropy and its relation to information capacity and consequently entropy as applied to character generation is discussed. This discussion is followed by several examples of character sets which exhibit various relative values of entropy and the tradeoffs necessary to obtain the entropy desired. The object of this paper is to suggest the concept of "entropy" as it applies to character generation.

CHARACTER SETS: FROM BRAILLE TO CHINESE

One of the simplest alphanumeric sets in use today is Braille. It is a 6-bit code which is read directly (See Fig. 1).

If Braille, or its equivalent, were to be displayed on a cathode ray tube the character generator (CG) required would be a very simple device. It would consist of the small amount of electronics required to display, in dot form, the six input bits (a six bit to six bit code converter may be required). An example of a message displayed in Braille form is shown in Figure 2.

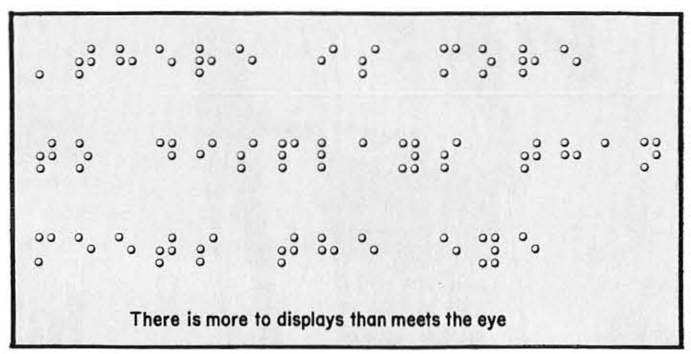

FIGURE 2: Message Displayed in Braille Form

Most sighted people have never had any reason to learn the Braille code. If the application for which we are going to use an alphanumeric display could justify teaching a new alphabet to the operators, the following is suggested simply to illustrate a different coding method. A useful character set not quite as simple as Braille but certainly not as complex as more familiar sets is shown in Figure 3. In this set, characters are made up of three vertical cells; each cell filled with one of three symbol designators, or left blank. The designators selected were the colors red, green and yellow. An alternative, in a set limited to black and white, might be a horizontal line, a vertical line and a plus sign which would be a combination of the two lines. Most of the displays that will be described in this paper have two states (the dot or stroke is there or it is not). This character set has four states (red, yellow, green and not). Thus the versatility of this character set, as compared to the braille set, is due to the number of available states per bit rather than the number of bits available (in fact, there are only half as many bits per character available as the braille set). During the development of this particular set, certain constraints were assumed. All of the vowels contain red and

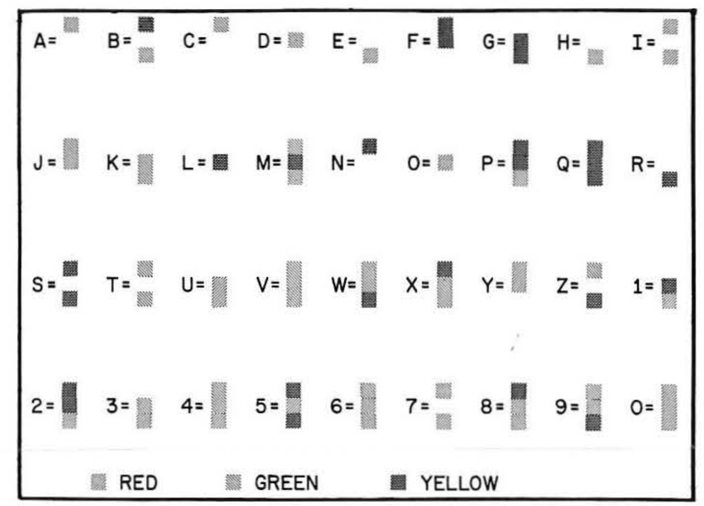

FIGURE 3: Three-Color Character Set

blank squares only, while the often used consonants contain yellow or green only. The little used consonants contain yellow and green combinations. The numerals contain red and at least one other color. These rules were selected because they would help the operator learn the code while costing nothing in hardware. It is obvious that a more complex code could be selected which would provide for special symbols and that other rules might be selected which

FIGURE 4: Northwest Orient Message

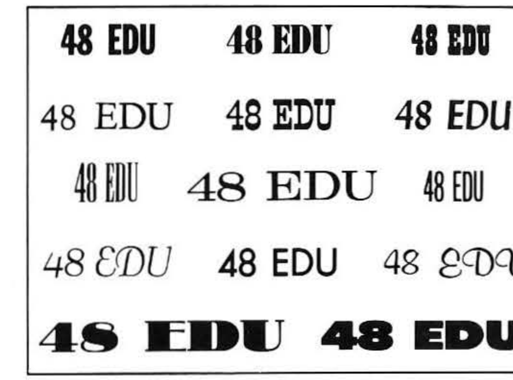

FIGURE 5: Printing Fonts

would aid the operator even more or be more applicable to the code selected. The number of characters available in this set is 4 (possible combinations) to the 3rd (number of squares) power or $4^3 = 64$ (a standard number of characters in use in present data displays). Since this character set is simply a translation of Roman letters and Arabic numerals, the English speaking operator would need approximately the same level of training as an operator learning semaphore or Morse code.

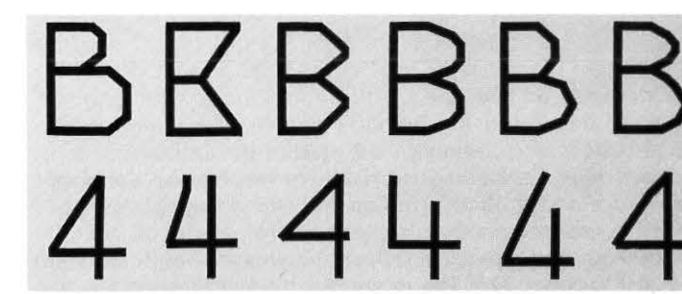

FIGURE 6: Various Fonts That May be Made by Character Generation

Now let us consider a more complex character set. Figure 4 is a message, in several languages, to some Northwest Orient Airline passengers. In the oriental character sets in the figure, the individual characters are complex and difficult to draw with most CG equipment in use today. Depending on the use of the display, it is possible that as many as 2000 to 5000 different characters may be required in the character set. The input character word from the refresh memory could be 11 or more bits. The decoder by itself would be large and the total quantity of information to be stored would be staggering. The designer would certainly be forced into finding the most efficient technique for information utilization.

CHARACTER FONT

Webster defines "font" as: "in print, a complete assortment of printing types of one size and style." In printing,

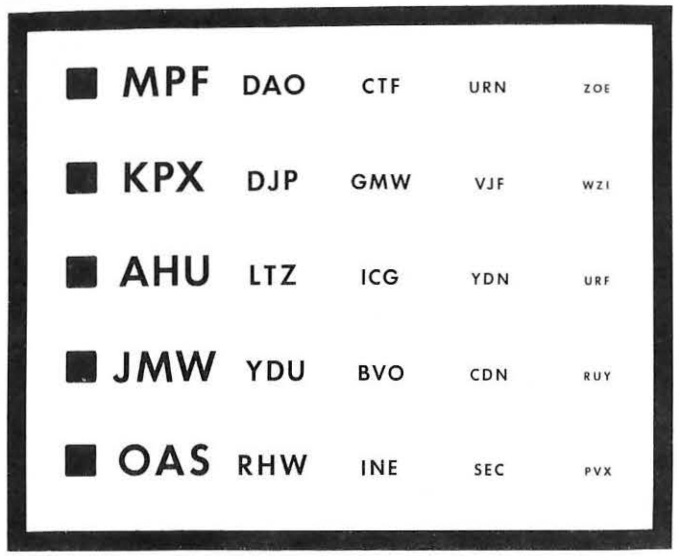

FIGURE 7: Contrast versus Resolution

sets of characters of different sizes but the same style require a different print type, but on a cathode ray tube the size is easily changed electronically. Thus, when the word font is applied to electronically generated characters it usually only refers to the selected style.

Figure 5 illustrates a number of different fonts used in printing or on posters.

Figure 6 illustrates a variety of fonts that could be generated by a stroke type character generator. A character generator having a high degree of font flexibility is one which has the capability of being programmed to provide a large number of styles of the same character type (Figure 6). Font flexibility is a very important performance characteristic of a character generator, because a character generator with a large font flexibility is also capable of being programmed to provide a large variety of special characters or symbols.

RECOGNITION AND ESTHETICS

During a war in which friend and enemy may have a large variety of different types of aircraft, a quick recognition of the aircraft type may be very important. Recognition depends on the size of the retinal image, the quantity of image detail and the human's degree of training. When the aircraft is very far away, the size of the retinal image is so small that the human is unable to resolve the detail required for recognition. The quantity of image detail perceived is related to lighting conditions, angle of aircraft, camouflage, fog, specular reflections, image grey scale and/or color content, etc. The degree of training determines the speed with which the human is able to provide an accurate

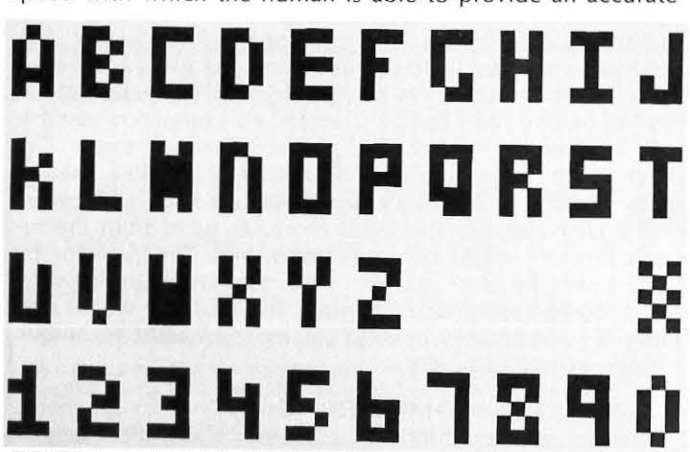

FIGURE 8: 3 X 5 Matrix Dot Characters

THE SENSATION OF BRIGHTNESS IS A FUNCTION OF THE LUMENS <MEASURE OF VISIBLE POWER> PER UNIT AREA IMPINGING ON THE RETINA OF THE EYE. THE NUMBER OF LUMENS COLLECTED BY THE EYE FROM A DIFFUSE SOURCE, AND THE AREA OF THE RETINAL IMAGE BOTH VARY INVERSELY AS THE SQUARE OF THE VIEWING DISTANCE. IT FOLLOWS THAT BRIGHTNESS IS INDEPENDENT OF VIEWING DISTANCE.

FIGURE 9: 3 X 3 Matrix Stroke Character Message

response with the least quantity of visual information (recognition implies accuracy).

The recognition of characters and special symbols in an electronically generated display system depends on contrast ratio, character size, specular reflections, bandwidth, and operator training and light adaptation. If the contrast ratio (ratio of character to background brightness) is very low, the human perception of fine detail falls off, resulting in a poorer chance of recognition (Figure 7). If character size is too small, the human finds it difficult to resolve detail.

Specular reflections (mirror-like) of lights in the room, off of the display surface, confuse and reduce the contrast of the displayed images. Insufficient bandwidth of a deflection amplifier may round off points, causing "B"s to look like "8"s or some special symbols to be confused with others. The speed with which an operator recognizes symbols is related to his familiarity with those symbols, hence his training.

FIGURE 10: 3 X 3 Matrix Alphabet

The perceptual contrast of a display may be a lot lower than the measured contrast if the operator is in a room where his eyes are light adapted because of certain high ambient light. Light from a desk lamp or a window that gets to the operator's eyes but not to the display surface causes this effect. In addition, any ambient light which reflects from the display surface into the operator's eyes will reduce contrast. On the other hand, if the operator is dark adapted and looks at a display having high brightness characters on a dark background, it can be annoying or even painful to the eye.

In command and control, and commercial display applications the audience is usually "captive." That is, the operator is trained to do a job which involves the use of the display device. He learns special symbols and routines as a requirement for getting the job done. It would not be unreasonable to ask him to learn a few changes in the alphanumeric set if it could be shown that faster recognition and lower equipment cost would result. Figure 8 illustrates a very simple alphabet in which a few of the characters would require a little learning; for example, M, N, Q, U, W, X. When composing the 3 by 5 dot characters the rule was that at least 2 out of the 15 dots had to be different when any two characters were compared.

Please read the message in Figure 9. This message was composed using a very simple stroke character in a 3 by 3 matrix. Many of the characters lack esthetic quality but with very little learning no character would be mistaken for any other. The complete alphabet is shown in Figure 10.

An example of a non-captive audience is the pasengers in an air terminal looking for flight information. If the flight posting board were to use a special high-recognition character set which required learning or lacked esthetic quality, the passengers would ignore the board and continually bother the agents. The board must be attractive and require very little learning to achieve the desired goal.

ENTROPY

Entropy has been a useful concept in the field of thermodynamics for many years. Entropy is a measure of the unavailability of heat energy. It follows then that low entropy is desirable because it makes energy more available. For purposes of this discussion it is sufficient to say that entropy is the quantity of heat divided by the temperature difference at which it is available. The natural processes tend to reduce temperature differences and so increase entropy.

Is the concept of entropy really of any value in connection with character generators or displays? Interestingly and perhaps fortunately the concept of entropy can be very useful in the study of displays without requiring any knowledge of thermodynamics. However, before we drop the subject of heat entropy one attempt will be made to bridge the gap.

Assume a closed rectangular box (Figure 11), divided by a partition into two equal parts, with each half containing the same amount of air and the same amount of molecular energy. In the partition there is a little valve just large enough to allow a molecule of air to pass through when it is open. A little demon at the valve control is watching a display which shows both sides of the valve. The input to the display is from tiny cameras, one on each side of the valve. The demon is able to see an image of the molecules as they approach the valve from either side. Whenever a fast (hot) molecule approaches the valve from side A the demon opens the valve allowing it to pass into side B. In the same manner the demon allows slow (cold) molecules to pass from B to A. It is assumed that it takes a "bit" of information each time the demon allows a molecule to pass through the valve. It is this information which is causing the temperature difference between sides A and B to increase.

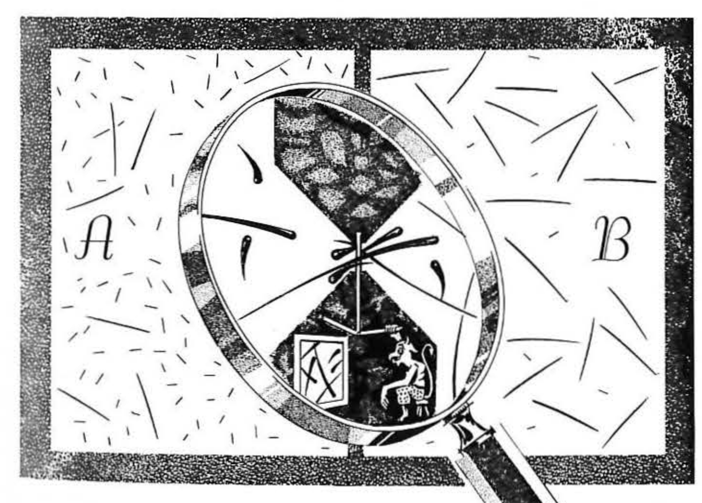

FIGURE 11: Maxwell's Demon (see cover)

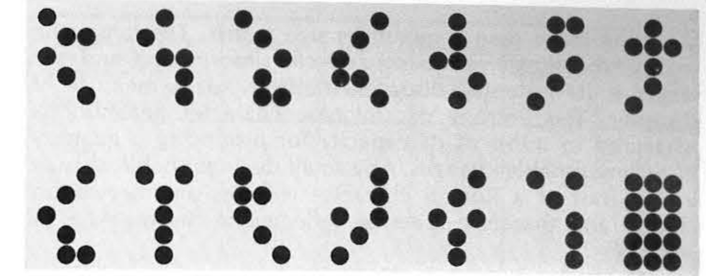

FIGURE 12(a): 2 X 4 Dot Character Set

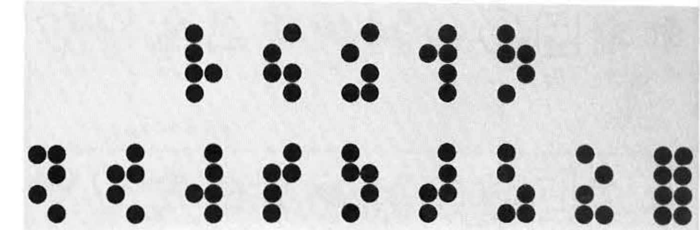

FIGURE 12(b): 3 X 5 Dot Character Set

If the discussion to this point has not been adequate to illustrate the concept of entropy and its connection with information theory a quotation from Grossman[1] is appropriate. "Entropy is one of those very basic and fundamental concepts to have had such a checkered history. Query the general electrical engineering practioner on his understanding of entropy and you will elicit a pained expression and a shudder, as though you had uncovered an ancient traumatic childhood experience."

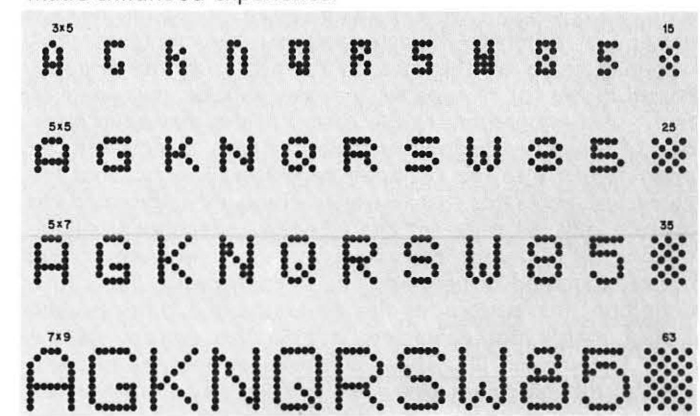

FIGURE 13: Four Dot Character Sets

Entropy can be thought of as a measure of disorder. As Maxwell's demon worked away he was bringing about some order by separating hot and cold molecules. If we now look at a matrix in which characters may be drawn, the order of the dots determines what characters, if any, are created. In Figure 12 two different size matrices are illustrated. If every possible arrangement of the dots was to be considered a different character, the 3 X 5 matrix can provide 128 times more characters than the 2 X 4 matrix. Each location in the matrix has a dot or not (binary) and if there are 15 locations then the number of different possible characters is 2^{15} or 32,768. From a pure information point of view, the 2 X 4 matrix which can provide 256 characters would satisfy most of our needs but the design of a character in the real world must take into account some or all of the following:

a. Minimum viewer training
b. Esthetics
c. Pictorial messages
d. Redundancy

Each of the above items contributes to the requirement for a larger matrix. Each item is somewhat nebulous and difficult to measure. A common denominator could be a measure of how much each of the items contributes to

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requiring more than a minimum size matrix. The larger the matrix, the greater is its capacity for information and the larger is its potential disorder. "Entropy" is a measure of disorder. The entropy of any type character generator is measured in terms of its capacity for producing a quantity of distinguishable changes. Any small distinguishable change in the font of a Roman character requires an information change and therefore must be reflected in the measure of entropy.

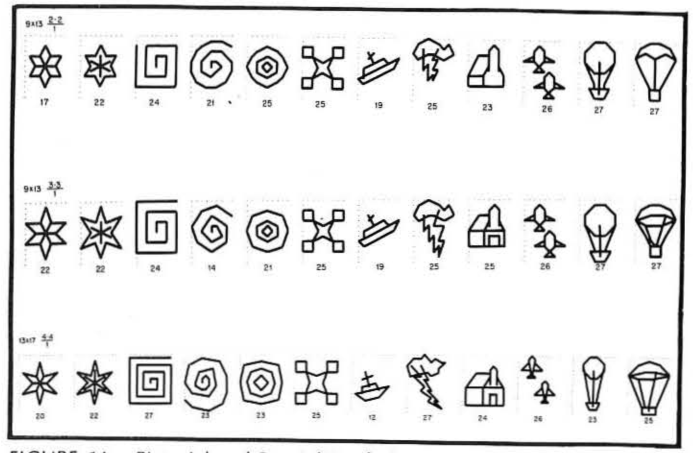

FIGURE 14: Pictorial and Special Symbols

Figure 13 illustrates point (or dot) Roman characters in four matrix sizes. If we are going to talk about the relative entropy of different character sets or character generators we must agree on the method of measuring the entropy. For purposes of this paper entropy will be measured in terms of the logarithm to the base 2 of the maximum number of possible distinguishable characters which can be programmed into the character generator. The fact that the character generator hardware is frequently designed to provide only 64 different characters is independent of the number of different characters that the generator *could* be programmed to provide. In keeping with the above definition, the entropy of the generator that produces the 3 X 5 matrix dot characters is E15. The entropy of the 9 X 13 matrix is E117. These numbers for entropy are valid only if the hardware does not impose any limitation on the presence or absence of dots. In a stroke type character generator usually the number of strokes that could be drawn is so great that the character generator memory limits the entropy as is illustrated later (Table I).

In a 5 X 7 matrix the total number of lines that could possibly be drawn between the 35 points is 35 X 34 X ½ = 595. Each of the 35 points has a line leaving it going to the other 34 points. There are half as many lines as line endings.

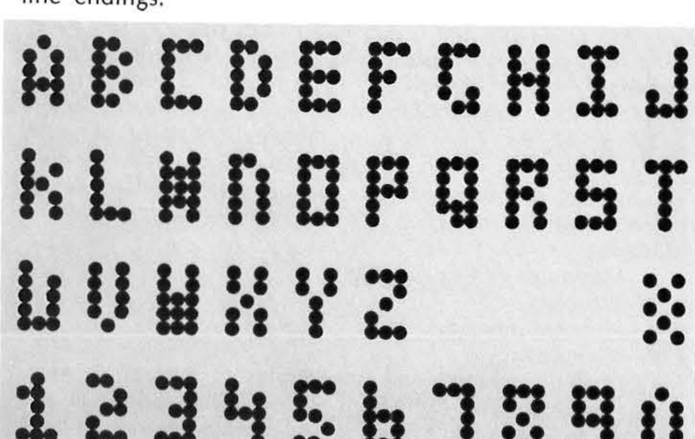

FIGURE 15: 3 X 5 Matrix Dot Characters (Using Circles)

Matrix	Max. No. Lines
3 X 3	36
5 X 7	595
9 X 13	6,786
13 X 17	24,310

The maximum number of lines column is the Entropy of the matrix if the electronics (or a character programming rule) does not limit the strokes that can be drawn. It is very common to have a restriction which limits the unit lines that can be drawn to 1st or 2nd order neighbors.

a. *Resolution and Entropy*

The resolution of a display surface is related to the number of individual elements into which the surface can be sub-divided. The greater the resolution, the greater is the information capacity of the display surface. It follows, that, the resulting entropy of the display is limited by the resolution of the display surface or the electronics driving the surface.

b. *Pictorial and Special Symbols*

In Figure 13 (4 dot alphabets) the entropy ranges from E15 to E63. The esthetic quality of the characters improves as the entropy increases, but the greatest difference is between the 3 X 5 and 5 X 7 matrices. To the extent that legibility depends on familiarity and character redundancy the 3 X 5 matrix is poor. If a small amount of learning is permissible and redundancy is not important the 3 X 5 matrix could prove to be useful.

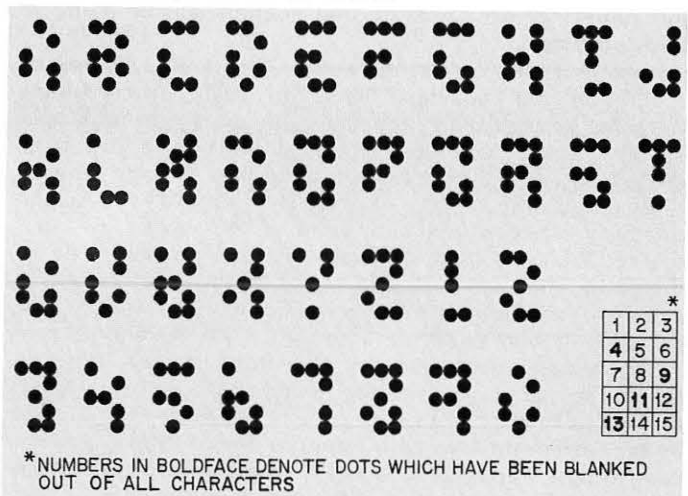

FIGURE 16: 3 X 5 Matrix, Illustrating Redundancy

Pictorial and special symbols are illustrated in Figure 14. The symbols in Figure 14 are the products of stroke generation rather than the dot generation previously described. Attempts to create these special symbols with a matrix of lower entropy produced unrecognizable symbols. It becomes apparent that good quality pictorial symbols require a large entropy generator.

c. *Redundancy and Entropy*

Any feature or features (which may take the form of short line segments or dots) possessed by a character which exceeds that required to identify the character may be considered "redundancy." In the Braille alphabet there cannot be any redundancy because, if just one point is changed the identity of the character is changed to a different character. Since Braille is six binary bits its entropy is E6.

The smallest value of entropy which can be used to make dot Roman letters is E15 in a 3 X 5 matrix (Figure 15). This alphabet certainly lacks esthetic quality and a few of the characters require a little learning such as M, N, Q, U, W, and X. The real test would be, how quickly could a person learn to read using this alphabet making a minimum of errors.

Let us assume a 3 X 5 matrix of light bulbs in which four of the bulbs have burned out (Figure 16). Bulbs 4, 9, 11 and 13 are out. How much additional training and how many more errors would result using this alphabet? Twenty-seven percent of the bulbs are out and some greater difficulty in reading has resulted. The fact that the alphabet can still be read (by a trained operator) means that 27 percent of the matrix is "redundant" information. There is not an abrupt cut off, if one more bulb was out it would be more difficult to read the characters. However, there is a trade off between training and working bulbs in the matrix. As the number of working bulbs decreases the training must increase because the characters are looking less like Roman characters.

FIGURE 17: 7 X 9 Matrix, Illustrating Redundancy

For distant or flash viewing the redundancy in Roman characters helps in the recognition process. On the other hand if six lights were set up in a Braille type code a trained operator would have no difficulty reading even though there would be no redundancy per character.

Figure 17 illustrates that the greater the entropy used for making Roman characters, the better the esthetic quality and the greater the redundancy. Forty-one percent of the bulbs are out in Figure 17.

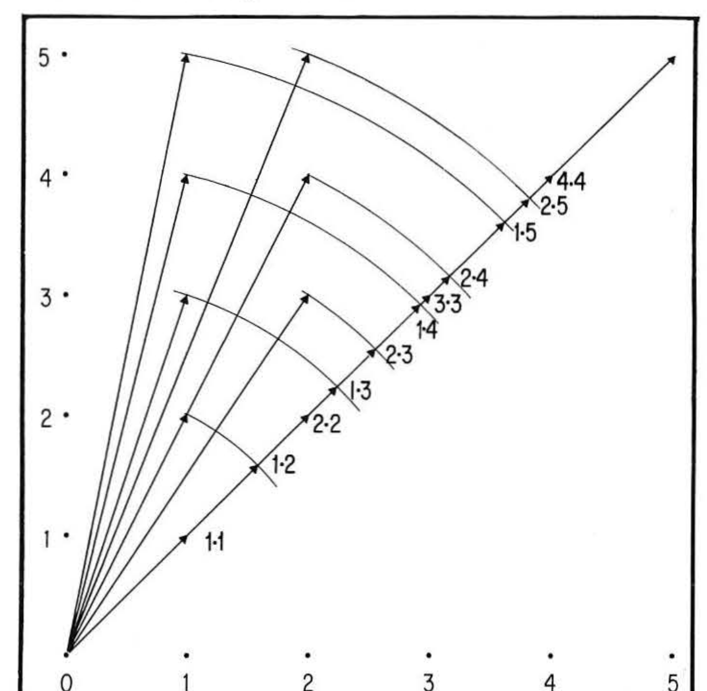

FIGURE 18: Line Lengths Compared

MATRIX CHARACTERS ARE DRAWN IN (COUNT POINTS)	STROKE X & Y DISTANCES WITHIN MATRIX	LENGTH OF PAINTED STROKE MAX.*/MIN.	RATIO OF MAX. TO MIN. LENGTH PAINTED LINE	NUMBER OF CHARACTER MEMORY OUTPUT LINES X Y Z	MAX. NUMBER OF STROKES	MEASURE OF ENTROPY
3x3	1	1·1/1	1.4	2 2 1	9	20
5x7	1	1·1/1	1.4	2 2 1	21	105
5x7	1,2,3	2·2/1	2.8	3 3 1	14	98
9x13	1	1·1/1	1·4	2 2 1	44	220
9x13	1,2,3	2·2/1	2.8	3 3 1	23	161
9x13	1,2,3	3·3/2	2.1	3 3 1	18	126
13x17	1 Thru 7	4·4/2	2.8	4 4 1	28	252

*THIS IS A VECTOR SUM.

TABLE I: Table of Character Sets

CHARACTER GENERATORS

Monoscope

Today there are many different types of generators used for painting characters on a cathode ray tube. One method possessing a high degree of font flexibility is the monoscope. In the monoscope character generator, the character memory consists of characters drawn on a target inside of a CRT. The characters and the background have different secondary emission ratios. The electron beam is gross positioned to some particular characters and then the beam is made to scan the desired character. The video which is produced at the target terminal is sent to a display CRT. The same waveform which scans the character in the monoscope is also used to scan the display CRT. When the entropy of the monoscope character generator is specified it should include the limitations imposed by the display CRT and deflection system. There is little point in generating a much higher entropy character in the monoscope than the output CRT can display. A measure of the entropy of a monoscope display system would be a function of the finest detail (maximum number of squares) in a checker board pattern that could be transferred from the monoscope to the output CRT with acceptable quality.

The spot size, brightness and writing speed trade offs impose limitations on the display CRT being driven by a monoscope or by any type character generator. With a monoscope each character is scanned with a small saw-tooth (or sinewave) one after the other until all characters in the frame are covered. The total linear distance traveled per frame is greater with a monoscope than with a stroke generator for a given number and size of characters. For a given CRT and brightness the spot size is usually larger because of higher beam current. While the monoscope does provide very high quality symbols its entropy is a function of circuit bandwidth and CRT limitations as is the case with other type character generators.

Charactron

The Charactron achieves high quality symbols by extruding the electron beam through a mask. The entire character is created at once as opposed to scanning or a sequence of strokes. The brightness is related to the current density and the duration of on time for a given refresh rate. For a given beam current if the characters per frame increase, the on time per character and brightness decrease. The high quality of the characters is mainly because of the very sharp black to white transitions made possible by this technique. The charactron provides very high entropy characters. It does, however, have a practical limitation imposed by economic and electron optical considerations.

Dot and Stroke

A set of rules must be established if an alphabet is to be designed. The first step is to establish the size of the matrix in which the characters will be drawn. Next, will dots be placed at appropriate points in the matrix or will lines be drawn between appropriate points in order to form the desired characters? Figure 15 is an alphabet in a 3 X 5 matrix using dots arranged such that there are at least 2 dots out of the 15 which are different when any two characters are compared.

When a stroke character is designed, the length of strokes must be defined. The electronics will be designed to deflect the electron beam from one point in the matrix to another point one or more points away in the X and Y directions (second column in Table I). The third column of Table I specifies the maximum and minimum lengths of painted (brightened) strokes such that the fourth column can be calculated. (Figure 18 shows a comparison of line lengths for various lines or vectors.) In a constant time per stroke character generator the longer the stroke the less its brightness. The number in the fourth column is the ratio of the brightest to the dimmest painted line without brightness compensation. When this ratio exceeds 2 to 3 brightness compensation is desirable if not required, depending on character quality desired. One bit in the Z column determines paint or blank. If brightness compensation is required, the X and Y values may be decoded to obtain a Z value.

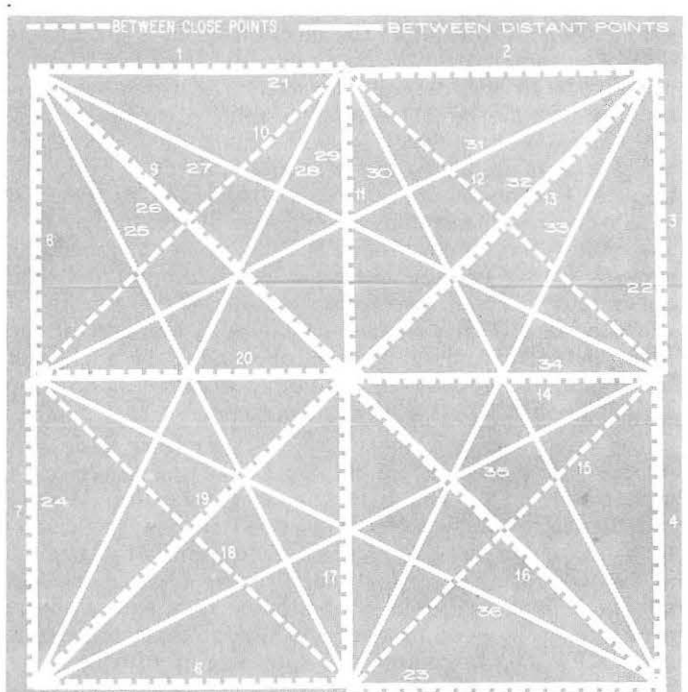

FIGURE 19: Possible Lines in a 3 X 3 Matrix

A numeral 1 in the second column requires two bits in the X and Y columns because a sign bit is required. The next step is to lay out the complete alphanumeric set using the rules laid down. Every effort should be made to make each character or symbol using a minimum of strokes.

The total number of individual lines which can be drawn in the given matrix with line length restrictions considered, is the entropy of the matrix. There are 20 nearest neighbor (1st order) and 16 2nd order neighbor lines possible in a 3 X 3 matrix, Figure 19. Two 1st order lines which fall under one 2nd order line cannot be included in the total character count.

When the matrix becomes larger than 3 X 3 it becomes desirable to have a general formula from which the total number of lines that can be drawn can be calculated. Fig-

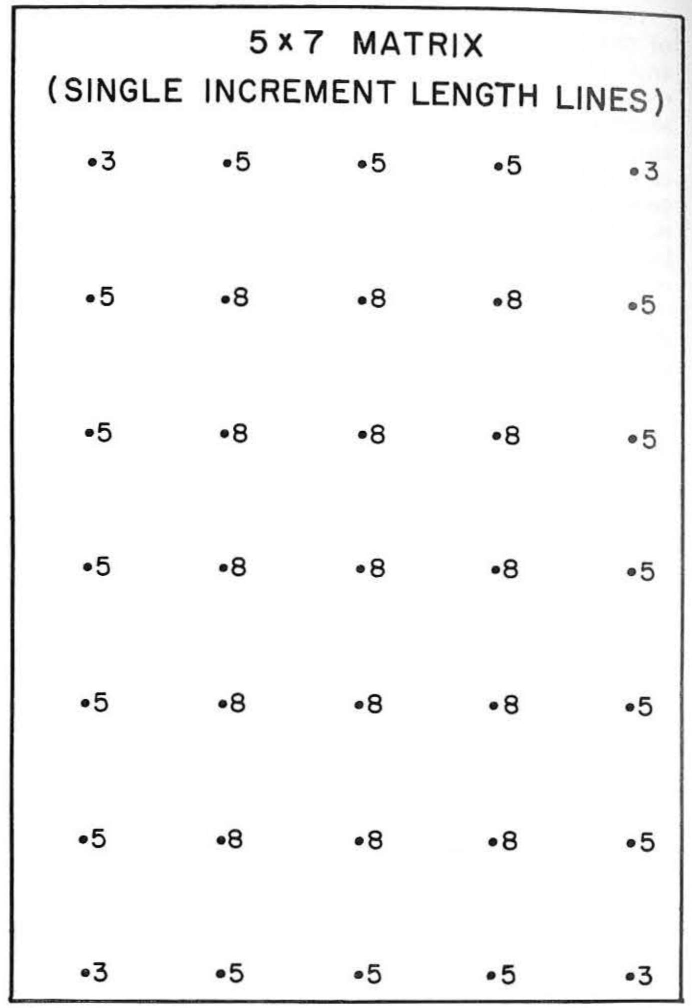

FIGURE 20: Technique for Deriving Number of Possible Lines in a Matrix

ure 20 suggests a technique which may be employed for deriving a general equation. Nw is the width and Nh is the height of the matrix in number of points. The number by each point in the 5 X 7 matrix in Figure 20 is equal to the total number of lines which can be drawn to that point. The total of all 35 numbers is the number of line "ends." The total of all possible nearest neighbor lines in the matrix is equal to one half of that number since there are two ends per line. The general equation can easily be derived from examination of the figure.

FIGURE 21: Seven Stroke Character Sets

$$N_{total} = 5\,(N_w + N_h) + 4(N_w - 2)(N_h - 2) - 14$$

The entropy of the matrix for nearest neighbor lines is equal to the total number of nearest neighbor lines which can be drawn. The entropy for a number of matrices for dot and stroke (1st order neighbor) characters is given in the following table.

Matrix size	Entropy Dot	Entropy Stroke
3 X 3	9	20
5 X 7	35	106
9 X 13	117	404
13 X 17	221	796

The entropy is the logarithm to the base two of the total number of characters that can be made in the matrix even though most of them may have no practical value.

The information which goes into making the character in the matrix must come from the character generator memory. It follows that both the matrix and the memory have information capacity. The smaller of the two must be given as the entropy of the character generator. Figure 21 illustrates Roman characters from several different size matrices and Figure 14 illustrates special symbols from various size matrices.

In the 3 X 3 matrix discussed in Table I the max. stroke length is 1-1 and the total number of lines is 20. It follows that the entropy for this case is limited by the matrix in which the character is drawn rather than the memory which stores the information required. It should be pointed out that there are many ways in which the information may be coded and stored and decoded. The number of memory output lines and strokes given in Table I may not be optimum but they suggest a starting point. It is hoped that the concept of entropy will motivate some workers to find more optimum techniques for generating characters and special symbols.

The entropy of the character generator memory is a function of the product of the total output lines and the maximum number of strokes. The object is to achieve the desired character quality and symbol complexity with the lowest value of entropy.

CONCLUSIONS

This paper has attempted to explain and illustrate the concept of entropy as it may be applied to character generation. No matter what technique is used for generating characters there must be a practical and economic limit to the detail (font flexibility) which can be obtained. This application of entropy is an attempt to provide a common denominator which can be used as one means of comparing different character generating techniques. Some of the techniques will require further study before a number for entropy can be given.

Room for further investigation includes, but is not limited to:

1. Obtain entropy number for Charactron, Monoscope and other character generators.
2. Derive entropy for stroke generators having lines drawn to 2nd and greater order neighbors.
3. Further study of entropy of CRT graphic displays.

A reasonable first step for an engineer whose assignment is to design a character generator is, determine the font of the alphanumerics and the number and complexity of special symbols which will satisfy the application. If a number of approaches are under consideration, an entropy figure for each would be one reasonable basis for comparing. In most character generating techniques there is a trade-off between the entropy and the speed of generating the character and both of these related to cost.

The concept of entropy is certainly not limited to character generation. Character and finger print recognition are two applications. The entire display surface has a limited information capacity and consequently entropy. The entropy of a display surface is related to the maximum number of character spaces and the number of different type characters or symbols which can be drawn in each space. Line drawing capability increases the possible entropy by a very large amount.

If a particular display system could place any one of 64 different characters in any one of 1000 character spaces on the display screen, the entropy would be at least E6000 $(2^6)^{1000}$.

The display can be thought of as part of the communication channel which is carrying information from a computer to a human. Entropy is a tool that may be used to help measure the performance of the display system.

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Mr. Halsted has five patents. One of them is the Burroughs Polar Programmed, *high entropy*, stroke Character Generator used in a number of display systems built by Burroughs Another one is for a radar data processing automatic clutter elimination system used by Burroughs. He is vice chairman of the Delaware Valley Chapter of the *Society for Information Display* and a Senior Member of the IEEE.

Simplified methods for determining display screen resolution characteristics

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RCA Service Company
White Sands Missile Range,
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INTRODUCTION

The increasing requirements for small and large screen display systems have emphasized the need for simplified techniques for determining display screen resolution characteristics. This paper presents some useful relations to aid the systems designer in determining display screen sizes, resolutions, and viewing distances and areas.

This study first develops the relations for determining display characteristics of the small screen display which utilizes the cathode ray tube. The discussion covering large screen displays then extends the small screen rationale and develops additional relations to include a three-dimensional audience volume and thus oblique viewing conditions.

The Small Screen Display:

The small screen display of particular interest uses the cathode ray tube (CRT) for electronically displaying information by either a "deflection" or "raster-scan" technique. It is principally used by only one viewer. Briefly,

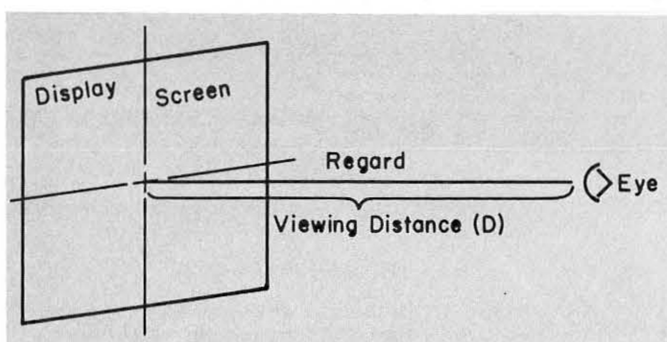

FIGURE 1: Regard for small screen display.

in the deflection technique, an electron gun emits a stream of electrons that strike the phosphor screen of the CRT. Magnetic deflecting coils or electrostatic deflecting plates are then used to deflect the electron beam in such a manner as to sweep out the various symbols and vectors. The deflecting technique is generally used for displaying computer generated (digital) data. A digital-to-analog converter provides the interface between the digital data and the analog deflection voltages. The raster-scan technique (used principally for television) uses sequential scanning with a modulated beam for displaying data. Picture detail is reproduced on the phosphor screen of the CRT by variations in the beam intensity. The video signal that modulates the beam may be either camera or computer generated. Digital-to-video converters provide the interface between the computer-driven digital data and the video signal.

Screen size selection in the design of a display system is dependent on the viewing positions and viewing conditions desired. For the small screen display, a single viewer is assumed who is typically situated directly in front of the display at viewing distances from 12 to 30 inches in a console-type or similar working environment. Thus, for all practical purposes, viewing is dependent on the legibility requirements along the normal distance from the center of the display. (See Figure 1.)

Studies indicate that good symbol legibiilty requires a symbol dimension that subtends at least 12 minutes of arc to the eye, and a symbol structure that is composed of a mosaic of 7 x 7 or more elements (5 x 7 elements, width to height, is acceptable). (For discussions of alphanumeric symbol structure and legibility, see References 1, 2, 3, and 5.) Figure 2 illustrates a 7 x 7 mosaic structure describing the letter "E".

Legibility of graphical data, which may be composed of any number of elements, is more difficult to determine. However, typically, each element should be at least resolvable to the eye, or be of such a dimension as to subtend an arc of one minute or greater to the eye. Dimensions of two to three times this value will tend to prevent eye strain during prolonged viewing periods. A common reference between graphic and symbol legibiilty can be found by introducing the term "resolution viewing factor, F." If the element dimension, e, of which two adjacent elements of dimension e can just be discriminated for a viewing distance, D (line of sight normal to the screen), is given by

$$e = 0.0003D, \qquad (1)$$

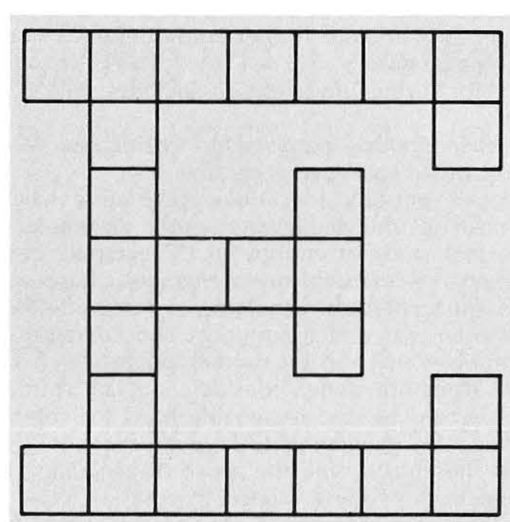

FIGURE 2: A 7 x 7 mosaic representation of the letter "E".

then the resolution viewing factor, F, can be defined as the ratio of a selected element size to the element size that subtends one minute of arc to the eye, or

$$e = 0.0003FD. \qquad (2)$$

A symbol of dimension, L, composed of a 7 x 7 element matrix is related to Equation (2) by

$$L = (0.0003)\,(7)FD$$

or

$$L = 0.0021FD. \qquad (3)$$

Good legibility of both symbols and graphics can usually be achieved by selecting a resolution viewing factor value of two to three. At values above five, the symbol structure may become objectionable because the element spread increases in direct proportion to the letter dimensions. (See Reference 3.)

To relate legibility to display screen size, the ratio between the dimensions of the area to be viewed and the smallest element within this area should be defined as indicated in Figure 3.

This ratio, display capacity, K, defines the system resolution requirements. For example, if it is desired to view symbols with a 7 x 7 mosaic element structure and with minimum dimensions of 0.1 inch and 0.1 inch area (width and height) within a 7 inch by 9 inch area (width x height),

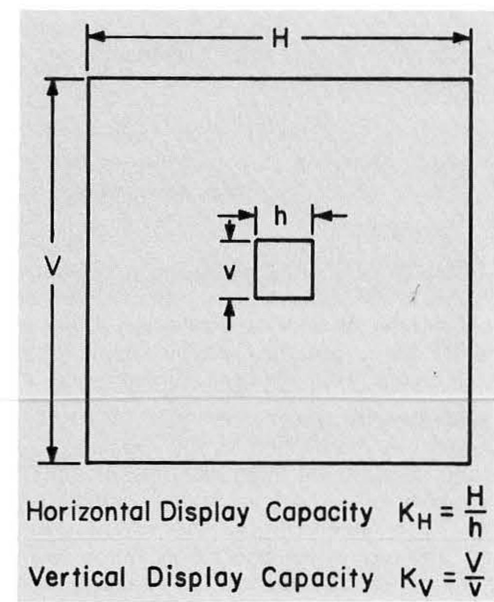

FIGURE 3: Display capacity.

resolutions of 490 elements (7 x 7/0.1) or lines in the horizontal dimnsion (K_H) and 630 elements (7 x 9/0.1) or lines in the vertical dimension (K_v) are required.

It should be noted that in displays of the raster-scan type, the number of lines resolution as seen by the viewer on the CRT is not equal to the actual number of TV scanning lines. (See Reference 6.) The actual TV scan line requirements must compensate for losses occurring in the camera or computer generating video systems. For camera generated video, the number of TV scanning lines is typically greater than the lines resolution required by 30 percent; for computer generated video, the number of TV scan lines is typically greater only by 10 to 12 percent.

The display screen size, E, can now be expressed as a function of the resolution viewing factor, F, the viewing distance, D, and the display capacity, K:

$$S = 0.0003FDK \qquad (4)$$

Equations (5) and (6) below relate Equation (4) in terms of the tube diagonal, T, for the rectangular tubes of aspect ratios 4:3 and 3:4 (horizontal to vertical) and the vertical display capacity, K_v.

$$\text{For 4:3,} \quad T = 0.0005FDK_v \qquad (5)$$

$$\text{For 3:4,} \quad T = 0.00038FDK_v \qquad (6)$$

Figures 4 and 5 show vertical display capacity plotted as a function of CRT sizes (diagonal) and the product of the viewing distance and resolution viewing factor for the two aspect ratios 4:3 and 3:4, as determined from Equations (5) and (6). Thus, once the vertical display capacity and viewing distances are established, the required tube size can be obtained for any particular viewing condition.

For example, suppose it is desired to design a display system to satisfy the following requirements:

(a) Display vectors of minimum dimensions 0.05 inch by 0.05 inch over a 9 inch by 12 inch (width to height) area.

(b) Display symbols of minimum dimensions 0.12 inch by 0.12 inch over a 7 inch by 9 inch area.

(c) Accommodate viewers located at normal viewing distances of 26 and 42 inches for prolonged viewing periods.

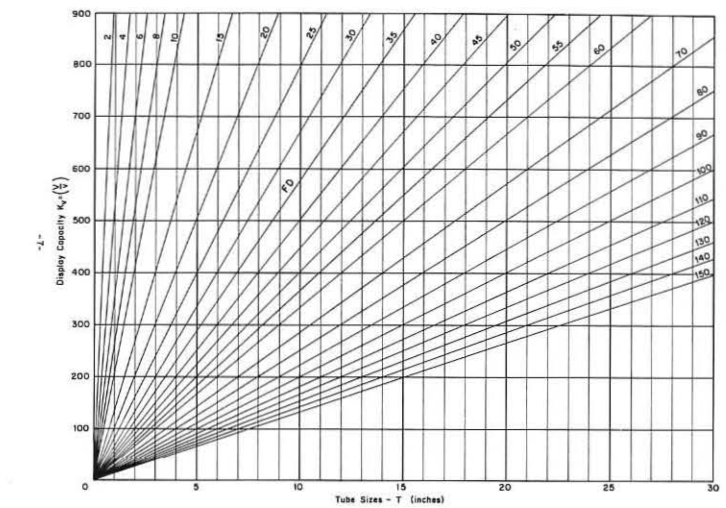

FIGURE 4: Display capacity as a function of CRT tube sizes and viewing conditions (4:3 aspect ratio).

Solution: For adequate legibilty, a minimum mosaic symbol structure composed of 7 x 7 square elements is selected. The display capacity or resolution required for both vectors and symbols may be determined as follows:

For vectors $K_v = 9/0.05 = 180$ lines
$K_H = 7/0.05 = 140$ lines

For symbols $K_v = 9 \times 7/0.12 = 525$ lines
$K_H = 7/0.12 = 408$ lines.

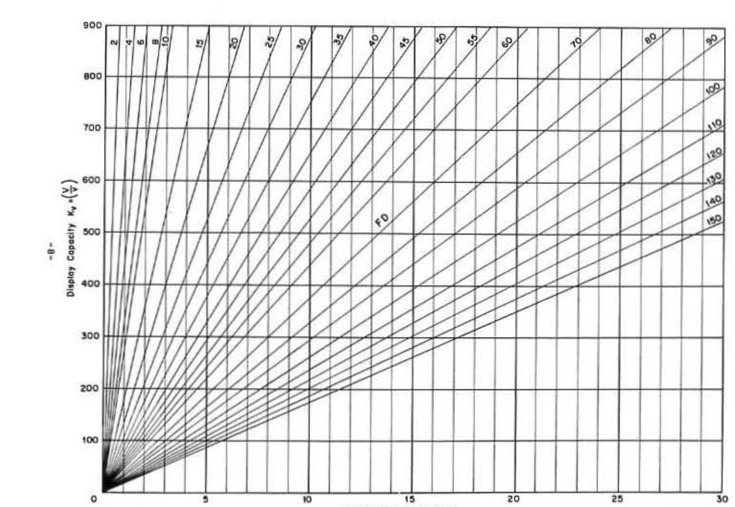

FIGURE 5: Display capacity as a function of CRT tube sizes and viewing conditions (3:4 aspect ratio).

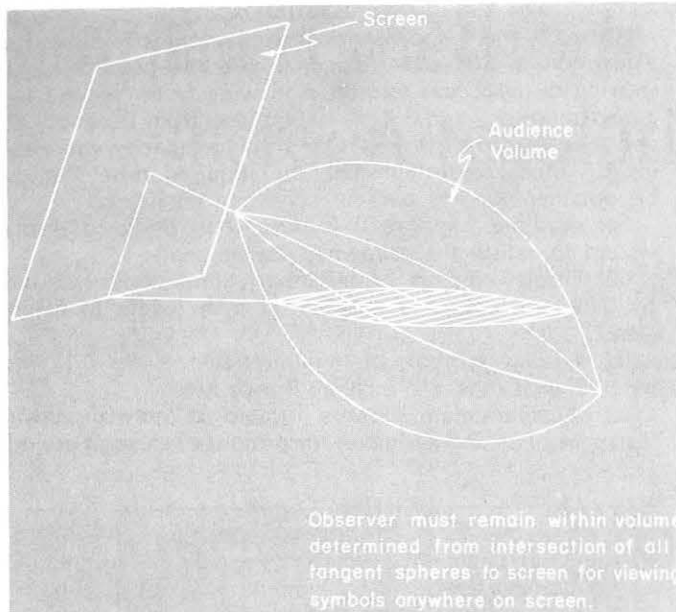

FIGURE 6: Audience volume.

Thus, the system must provide a vertical resolution of at least 525 lines and a horizontal resolution of at least 408 lines. For a raster-scan type display system, camera generated video would require typically 750 scan lines or more, and computer generated video, 600 scan lines or more to provide the resolution desired. If the area to be viewed will always be of greater height than width (in particular, by a ratio of 3:4 — horizontal to vertical dimensions), the 3:4 aspect ratio tube size should be used. For adequate legibility an F of no less than 2.0 is selected. Then, from Figure 5, tube sizes of no less than 10.1 and 16.8 inches are required for the given viewing distances of 26 and 42 inches, respectively.

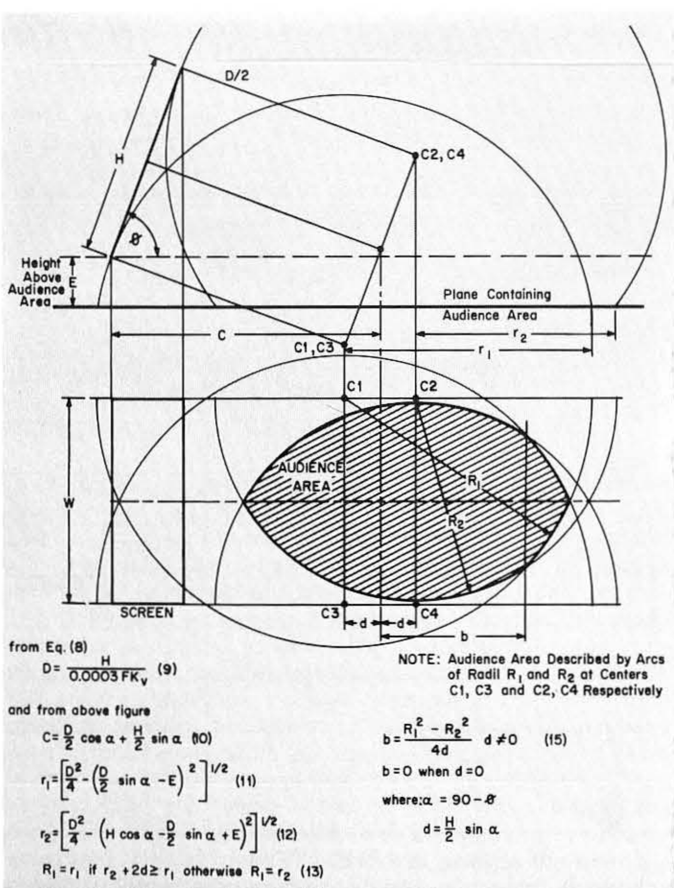

FIGURE 7: Large screen display area geometry.

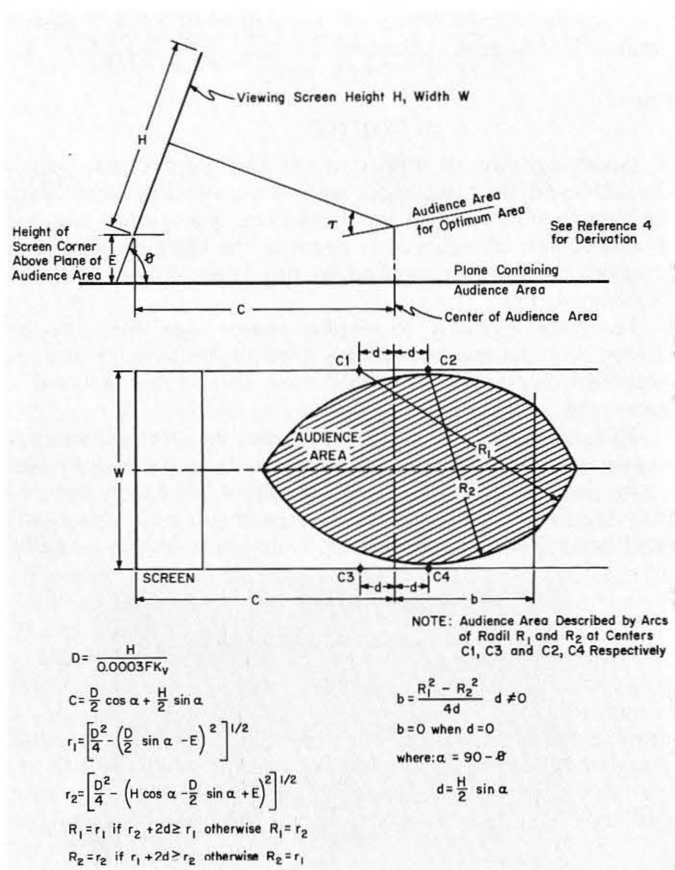

FIGURE 8: Guide for determining large screen display area characteristics.

The Large Screen Display:

The definitions established in the preceding section will be used in determining the relationships of screen size, display capacity or resolution, and resolution viewing factor for the large screen display system. These display characteristics, however, must also be extended to include the viewing region (three-dimensional audience volume) and thus oblique viewing conditions. The large screen displays of particular interest are the video projection and film projection displays which are primarily used for group viewing. Because the screen sizes of the CRT are somewhat limited (usually not greater than 28 inches), video projection equipment was devised for displaying televised information on large screens. The most common TV projection system is the Eidophor. Film projection equipment includes all equipment that projects onto a screen the information stored on a photographic film. In these systems, light passed through the film projects the film image onto the screen. Computer control of film selection from files as well as etching (usually via servo control or analog generators) of vectors and/or alphanumeric symbols on the film provide additional flexibility for real-time functions. Mixing of background and dynamic changes on a single screen is possible by using multiple projectors.

In Equations (1) through (6) a regard perpendicular to the plane containing the viewing element was assumed. For oblique viewing of isotropic symbols, the viewing range is reduced in proportion to the cosine of the angle of obliquity. (See Reference 4.) Equation (4) becomes

$$e = \frac{0.0003FDK}{\cos\theta} \qquad (7),$$

where θ is the angle of obliquity.

Thus, for viewing isotropic symbols, the viewer is constrained to the three-dimensional volume or sphere of diameter

$$D = \frac{S}{0.0003FK} \qquad (8).$$

The sphere is tangent to the viewing plane at the point of symbol location. For viewing symbols at any location on the screen, the viewer is constrained to the football-shaped volume determined from the intersection of all possible tangent spheres, (described by the intersection of the four spheres tangent to screen corners) as shown in Figure 6. The eye-level intersection of this volume is referred to as the audience area. As described in Reference 4, the largest audience area is obtained when the angle between the screen and audience area is tilted so that the center of the audience volume intersects a line normal to the screen at the screen's center, as indicated by the cross-hatched area in Figure 6. The equations derived in Reference 4 provide the relations for determining the audience area and screen size for this special case. The equations relating the audience area for the general case of variations in screen dimensions, height of screen above the floor, the angle between the planes containing the audience area and the screen, the resolution viewing factor, and the display capacity or resolution requirements may be obtained from Equation (8) and from Figure 7.

Figure 8 provides a summary of the calculations of Figure 7 and can be used to determine screen sizes, viewing areas, and viewing conditions for any particular system. The screen may be slanted with respect to a horizontal floor and audience area or perpendicular to a horizontal floor with the plane containing the audience area inclined above the floor.

Suppose, for example, that it is desired to interface a large screen video display with the small screen display system in the previous example. The screen is to be 12 feet by 16 feet (width to height) four feet above a horizontal floor, and perpendicular to the floor. The audience area lines in the same horizontal plane as the floor. The peripheral dimensions of the audience area can then be determined as folows (See Figure 9).

From the previous example, $K_v = 525$ lines.

Thus, from Figure 8

$$D = \frac{H}{.0003FK_v} = \frac{16}{(.0003)(2.)(525)} = 50.8 \text{ ft.}$$

$$\alpha = 90 - \theta = 0^{\circ}$$

$$d = \frac{H}{2}\sin\alpha = 0$$

Thus,

$$C = \frac{D}{2}\cos\alpha + \frac{H}{2}\sin\alpha = 25.4 \text{ ft.}$$

and

$$r_1 = \left[\frac{D^2}{4} - \left(\frac{D}{2}\sin\alpha - E\right)^2\right]^{1/2} = 25.08 \text{ ft.}$$

$$r_2 = \left[\frac{D^2}{4} - \left(H\cos\alpha - \frac{D}{2}\sin\alpha + E\right)^2\right]^{1/2} = 15.66 \text{ ft.}$$

$$r_2 + 2d = 15.66 \quad \text{thus} \quad R_1 = 15.66 \text{ ft.}$$

$$r_1 + 2d = 25.08 \quad \text{thus} \quad R_2 = 15.66 \text{ ft.}$$

Then since d = 0, b = 0

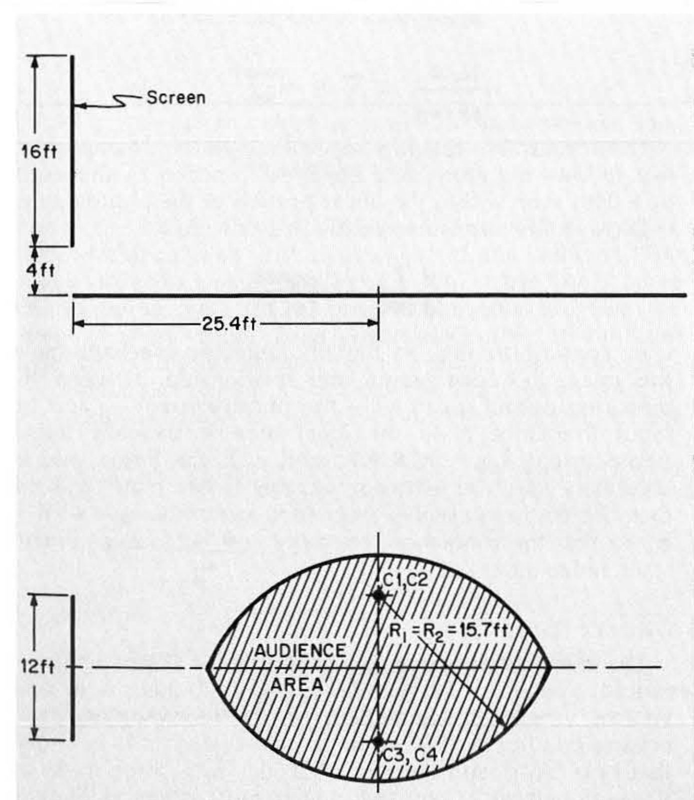

FIGURE 9: Determination of audience area for screen perpendicular to audience area.

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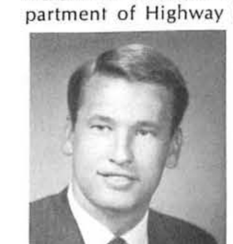
THE AUTHOR



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Comparison of image degradation in photographic and image orthicon systems

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INTRODUCTION

For the recording and processing of optical control and surveillance data on space objects, increasing use is made of image tubes as receptors in place of photographic materials. The main reasons for this are the high quantum efficiency, the real-time and digital signal processing potential of the scanning image tube, and the greater radiometric accuracy of photoelectric over photographic methods. The following short remarks are intended to compare critically the various image degrading effects associated with either receptor type, as well as to point out calibration requirements.

ANALYSIS OF THE PROBLEM AREAS

The two selected receptors are being compared in the following performance areas which affect image quality:

1. The radiometric-sensitometric response
2. the dynamic range
3. the point spread function
4. the line spread function
5. adjacency effects
6. the modulation transfer function
7. contrast rendition
8. dimensional distortions
9. information storage capacity.

The merits and demerits of either receptor may be judged from the summary evaluation.

Sensitometric-Radiometric Response

The photographic material responds to the integral effect of irradiance Hλ and time t in the general form

$$\int_\lambda\int_t H_\lambda s_\lambda \, d_\lambda \, dt$$

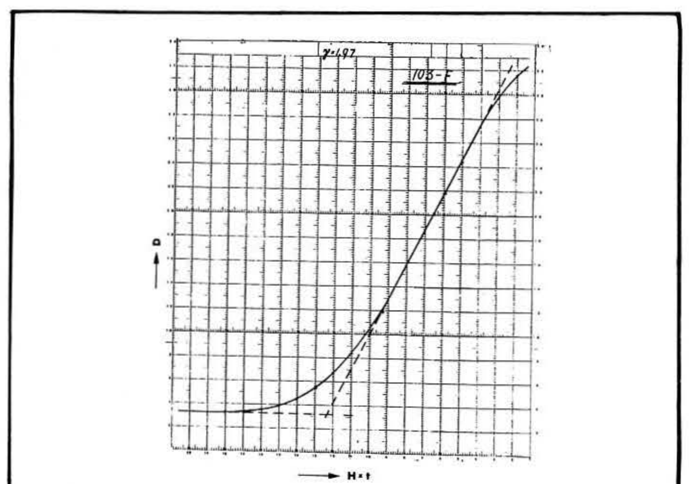

FIGURE 1: Density D vs. exposure H t for an Eastman Kodak Spectroscopic plate type 103-F developed = 1.97, Maximum density above gross fog = 2.9; log scale for Ht.

The measured response is normally expressed as photographic density D versus exposure (H X t), and exposure is plotted either in arithmetic or logarithmic scale (See Figure 1).

D is defined as D = −log T,

T = transparency of the developed emulsion

In photographic photometry the photographic effect is measured with a photoelectric cell in a microphotometer, or microdensitometer, so that

$$i_{photo} = f(D) = \varphi(T) \ldots, \text{ and } T = \frac{I_{tr}}{I_{inc}} = \frac{i_{ph\text{-}tr}}{I_{ph\text{-}inc}}$$

For the linear portion of the photographic characteristic curve we have, with C = a constant:

$$D = C \times \log(Ht) = C \times (-\log T) = C \times \left(-\log \frac{i_{ph\text{-}tr}}{i_{ph\text{-}inc}}\right)$$

From this it follows:

$$\log \frac{i_{ph\text{-}tr}}{i_{pa\text{-}inc}} = C \times (-\log(Ht), \text{ and}$$

$$\frac{i_{ph\text{-}tr}}{i_{ph\text{-}inc}} = T = \frac{const}{Ht}$$

The measurable quantity expressing the photographic effect follows therefore as a nonlinear function of the exposure (Ht), even within the linear portion of the photographic H-D curve. The exposure sensitivity is

$$\frac{dT}{d(Ht)} = \frac{const}{(Ht)^2}$$

In contrast to this, in the photoelectric mechanisms of the image orthicon sensor the relationship between the measured output quantity — the photo current — and the input irradiance H in the ideal tube is basically linear: photocurrent $i_{ph} = a'H + b'$, and with the linear gain by secondary electron emission at the target plate and the dynodes of the multiplier, the video current is $i_v = a'H + b'$, so that the irradiance sensitivity $\frac{d\,i_v}{d_H} = a'$ is constant, independent of H.

Dynamic Range

The dynamic range, in which useful — if not linear — output effects can be measured, and calibrated, is in both systems very much dependent on the recording and processing conditions. For photographic materials it is known that one can obtain a range of 1000:1 with some materials if developed to a very low γ. For most practical applications, however, the emulsions are developed differently; for instance, the Kodak 038-01 plate is developed to a

density of about 2.0 above gross fog, with a γ of 1.2. This gives a useful dynamic range of 46.4:1. A Kodak 103F emulsion, developed to a useful density of 2.9 above gross fog, and a γ of 2.0, has a dynamic range of 28.2:1. For the benefit of target discrimination, these higher values have to be used. The ways to obtain the desired γ need not be discussed here, they are to be found in pertinent texts.

The image orthicon receptors — image tubes with S-10 or S-20 photoemissive surfaces — do not have a dynamic range of greater than 100:1 at most, unless special feedback circuitry is employed which automatically optimizes the scanning electron beam current in the tube. This is a new development which has just recently become available for field use under an Air Force contract to G. E. Company. With this point-to-point feedback a range of 3000:1 seems possible, if the irradiance over the whole field changes by this amount. If irradiance steps in the field are used, the controlled range is more near 500:1. The image tubes used for these tests are type GL 7967/S-20 low light level image orthicons; they have to be specially treated for this application. Figure 2 shows a recent recording of a target — a grid plate, which had neutral density filters #1.0 and #2.0

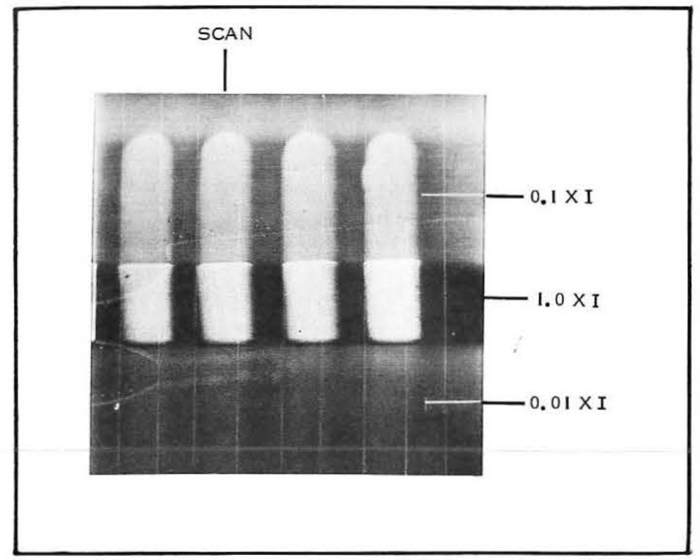

FIGURE 2: C-scope photograph of parallel slot image transfer. Relative luminance steps of 1, 0.1, 0.01; GL 7967 image orthicon. Scan lines across the slots.

across the open slots; it provided a target with a 100:1 step irradiance ratio within the field of the orthicon. The image orthicon was a standard GL 7967 tube. The γ curve has to be set very flat in order to be able to make the range of steps visible. Edge effects noticeable at the same time will be discussed later. Figure 3 shows the corresponding microdensitometer scan, Figure 4 is a contact print of the gridplate made for comparison. If we choose to rate

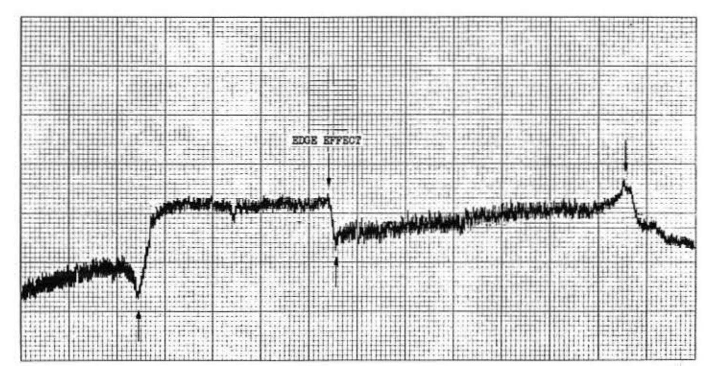

FIGURE 3: Microdensitomer scan of negative of Fig. 2; scanning slit dimensions 125 X 125 microns.

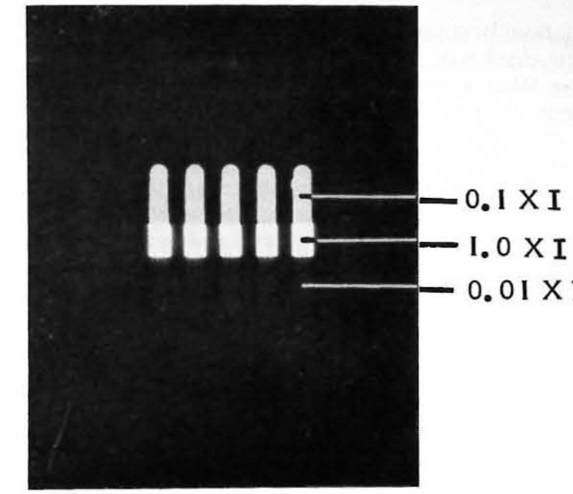

FIGURE 4: Contact print of slot plate of Fig. 2, showing dimensions and photographic modulation response. Polaroid film type 57, ASA speed 3000.

image sharpness according to Higgins and Jones[1], as the product of the mean of the square of the density gradient at the edge, with the density difference at this point we see that the image rendition for this grid is rather poor. Admittedly this has been an extreme case with a maximum of image degradation, including degradation due to the amplifier.

The Point Spread Function

Images from discrete point sources such as astronomical objects, space objects at larger distances, and in selected cases by point emission on reentry bodies, have normally an opacity distribution which is different from the intensity distribution in the original object point due to the spread function.

In the photographic emulsion, the light patch entering it is dispersed due to turbidity and halation; in addition, the opacity develops as a nonlinear function of the exposure and is subjected to edge effects. The grain-to-grain scattering reduces the contrast response for fine detail and affects the spatial modulation transfer. This loss in contrast cannot be reconstituted directly without digital image processing.

The point spread function describes the two-dimensional distribution of the flux density in the image of the point object, I(x,y), or I(r), where the radius r is equal to $(x^2 + y^2)^{1/2}$. As we cannot specify in detail the mechanism of the image spreading, it is adequate to assume a Gaussian flux distribution and denote I(x,y) in the usual way by

$$I(x,y) = \frac{1}{2\pi\sigma^2} \exp\left(-(x^2+y^2)/2\sigma^2\right)$$

The quantity which can be measured is the total flux

$$P(r_0) = \int_0^{r_0} I(r) \times r \times dr.$$

The above description is related to the density distribution in the photographic image by means of the H-D curve.

In the case of the photoemissive surface, turbidity and scattering are not effective as the photosurface is transparent. However, in the process of liberation of secondary electrons at the target plate by the photoelectrons which come from the point image patch at the photosurface, and in the charge transfer process across the magnesium oxide target membrane, the point information becomes basically a Gaussian charge distribution. Now, the scanning electron beam on the read-out side of the target has an electron density distribution which is also Gaussian, so that the video response is the product of two distribution functions.

The situation becomes difficult if in highlights, due to incomplete discharge of the target charge pattern, charge spreading takes place resulting in "blooming" of the point image, e.g., when we have the image of a very bright star. In this case the condition cannot be described anymore by a simple relationship, it can be compared to the photographic image growth due to internal scattering or halation.

Outside this condition, though, the video response to the flux density distribution in the assumed image of the point source can be approximated by a Gaussian type spread function.

Line Spread Function

The practical case of line images is present in a line spectrum or in structural detail of a target. The irradiance across the line is considered the dependent variable. Mathematically, a relation

$$L(x) = \int_{-\infty}^{+\infty} I(x.y.)\, dy$$

describes the total flux if the line image is made parallel to the y coordinate. As a measured response we can describe the knife edge response, with the edge parallel to y and at a point x_0 within the line image; the response is

$$K(x_0) = \int_{-\infty}^{x_0} L(x)\, dx$$

For the photographic medium, again turbidity and adjacency effects determine the amount of spreading from the geometrical image. Spectroscopists know the effect on the profile of spectrum lines, and the limitations to the resolving of fine structure. It is difficult to calibrate for these distortions.

In the case of the image tube, a charge situation similar to the point image exists in one direction; however, the electron distribution is affected by the extended charge "ridge" on the image orthicon target surface, and the beam modulation, and hence the image transfer is different if the scan goes along the line image or across it. Therefore the effective spread function, or modulation response, can be variable. However, keeping the image tube parameters constant, it is possible to calibrate the identical receptor area to a standard irradiance input, and normalize the modulation reponse obtained. It is also important, that the frequency response of the amplifier processing the video signal, covers the edge gradients present in the line image when scanning across the line. High frequency peaking will also relieve the image of the low frequency noise components which are particularly troublesome.

Adjacency and Edge Effects

In the photographic emulsion, these effects are present at the borderline between areas of high and low exposure, and are caused by a higher concentration of active agents in the less exposed parts during the processing, causing diffusion of the agents into the parts with higher exposure. The typical appearance of the edge effect and Eberhard effect is sketched in Figures 5 and 6; the highlight area

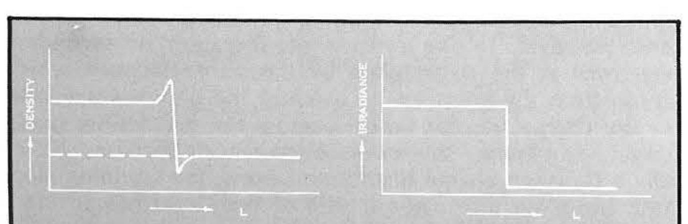

FIGURE 5: Illustration of the photographic edge effect.

shows a density peak close to the border, the low exposure area has a corresponding depression of the density curve. In this way, the edge gradient is falsified and often displaced; for two adjacent images, like double star images, the distance between the centroids is changed and misinterpreted; the profile of spectral lines is falsified. For more information on the mechanism pertinent texts may be consulted. An estimate of these errors can be deduced from recorded square wave grid patterns. The image orthicon sensor has similar effects, though based on different mechanisms. The transparent photoemissive surface should not introduce any effects due to variations in active centers; however, at the target electrode, the photoelectrons originating at the photosurface, release secondary electrons upon their impact, and the impact point remains with a positive charge. The target material in the type tube used is a thin film magnesium oxide membrane with narrow spacing of the target mesh. The anisotropic properties of this material prevent lateral charge dissipation to a large degree, but there is always some spread on the reading side of the target so that the charge density distribution (spread function) is approximately Gaussian as stated before. If, however, the object has adjacent high and low intensity areas with high contrast edge gradients, the scanning beam is affected by the field of these neighboring areas and beam distortion and beam bending misrepresent the true edge configuration — like in the photographic adjacency effects.

The magnitude of these distortions can be best judged

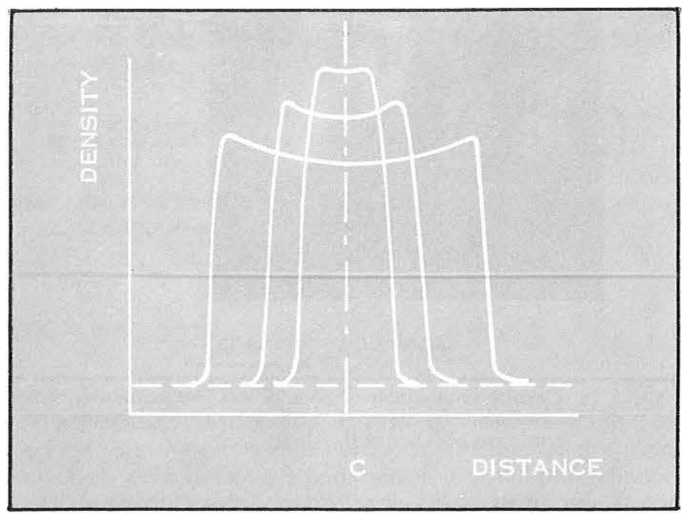

FIGURE 6: Illustration of the photographic Eberhard effect. The smallest image has the highest density, irradiances being equal.

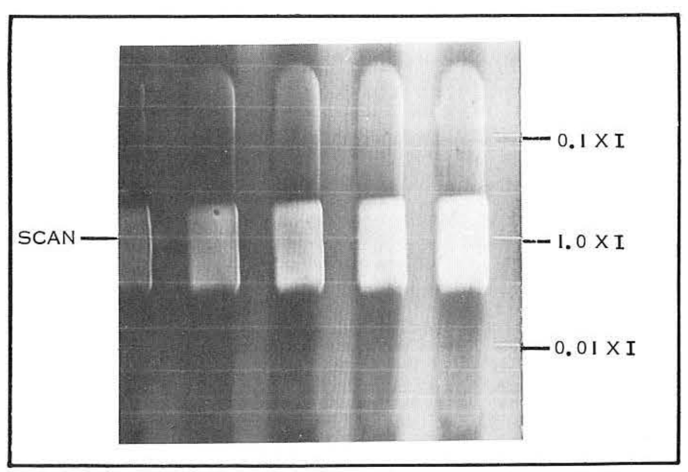

FIGURE 7: C-scope photograph of parallel slots as in Fig. 2. TV scan lines along the slots; illuminance steps 1, 0.1, 0.01; strong edge effects.

from carefully designed calibration tests. These can also bring out — and help to overcome — additional distortions due to insufficient amplifier frequency response. Once more, Figure 7 and Figure 8 show as an example, the recording of the grid plate which had steps of uniform luminance of 1, 0.1, and 0.01. Figure 4 shows the contact print of this plate. This test shows quite obviously that automatic beam current control with extended dynamic range of the orthicon and high frequency amplifier response are mandatory in order to obtain linear intensity information transfer and small adjacency disturbances.

Extreme low-noise preamplification as has been mentioned under Dynamic Range is an additional requirement and has been accomplished with new, field effect transistor input stages.

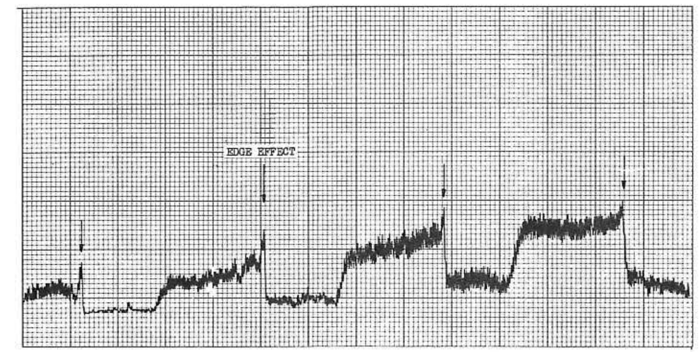

FIGURE 8: Microdensitomer scan of negative of Fig. 7. Scan aperture 125 X 125 microns.

The Modulation Transfer Function

Within the Fourier methods of optical image evaluation, the spactial frequencies of the intensity distribution in the image are the Fourier components. The modulation transfer function τ (ω), describes the grade of response of the considered system to a spatial sine wave input at each spatial frequency ω. Mathematically, the modulation transfer function can be expressed as the Fourier transform of the line spread function L(x).

$$\tau(\omega)_x = \int_{-\infty}^{+\infty} L(x) e^{-2\pi i \omega x}\, dx$$

It can be measured directly by using precision sine wave test objects.

Comparing the two receptor systems considered here, we see that in the average sensitive photographic emulsion the granularity — or photographic noise — limits the response to spatial frequencies not higher than about 100 1/mm. In addition the turbidity reduces the contrast transfer from the incident aerial image to the recorded image in the photographic medium. It has been shown elsewhere[2] that the theoretical treatment of the photographic image analysis is not so direct as the Fourier treatment of the lens transfer function; the scattering process within the emulsion is not completely incoherent as assumed for the theoretical treatment. The result of the Fourier treatment in this case is a relation between the contrast function, the modulation transfer function, and the modulation response.[2]

We can try to apply a similar analysis to the image tube sensor. As mentioned before turbidity does not enter here; however, the charge pattern on the target plate, the scanning beam diameter, and the noise level determine the line cut-off frequency — if we use the concept of Fourier sine wave components as the basis of image formation. Now, in the image orthicon, it is possible to apply noise cancellation and background suppression by electronic means; in addition, if we do digital signal processing, digital computer integration over a convenient sampling period can be employed which improves the signal-to-noise ratio in the final image reconstitution. In this way the tube transfer function can be greatly improved up to its theoretical limit given by the scanning beam.

A computer program handling the image information can include features like contrast enhancement, signal sharpening, and corrections for edge effects and non-uniform sensitivity. A matrix of calibration patches has to be recorded for this purpose. This very general statement does not want to distract from the difficulties still inherent in the analog-to-digital conversion with high sampling rates, which is associated with fast scan, high resolution image tubes.

Contrast Transfer

The contrast of the incident aerial image is, in general, reduced by the receptor medium: in the photographic emulsion by turbidity scattering, in the image orthicon by charge spreading and near-field action. Both receptors can be operated at will for a higher or lower Y value, the photo emulsion by forced processing (temperature, time), and the image tube by selection of the operating voltages and amplifier gain factor. In both cases, a wide dynamic range requires a low Y factor, which decreases contrast discrimination. The advantage of the image tube, as already mentioned, is its capability of electronic contrast enhancement — if the signal is detected properly above threshold.

Dimensional Distortions

Dimensional stability of the photographic material is critical when accurate measurements are to be made from photographs. Image shift can cause noticeable errors in the interpretation of spectral lines and position coordinates. Forced processing at higher temperatures in particular causes non-uniform differential shrinkage. It has been measured that shrinkage increases with the age of the emulsion after processing. Plate emulsion distortions, in general, are about one tenth of film emulsion shrinkage, except for Estar base. The average amount of Estar base shrinkage is in the order of 0.03 percent under average humidity conditions.[3] Latent image gelatine shifts on plates in the amount of 9μ have been observed, and up to 20μ in developed images, with probable error of 2μ.[4, 5]

Other causes of displacement of image contours and centers are the turbidity effect, and edge and adjacency effects mentioned before. The latter causes errors mainly if the distances between two closely spaced point or line images are to be measured. The amount of the described dimensional distortions cannot be accurately anticipated or corrected by calibration as they may vary from place to place and between plates or films.

If the image orthicon performance is compared with the effects just described the following typical conditions are found:

Dimensional image distortions are mainly caused by the effects of deficiencies of the electric and magnetic fields used for the operation of the image orthicon. They start in the image section (See Figure 9). Here we have the simultaneous action of an electrical and a magnetic field. The photo-electrons which leave the photo surface with varying velocities and angles are accelerated by the electrical field and bent into a helix by the magnetic field, so that a true image point is obtained at the target plate. They have to pass through the secondary-electron collecting target mesh which is close to the target plate. Ideal imaging and focusing can be impaired by this mechanism. On the reading side, beam bending due to close-by peak charge densities, and scan deviations between image reading and image reconstitution are the causes for image distortions. The scan

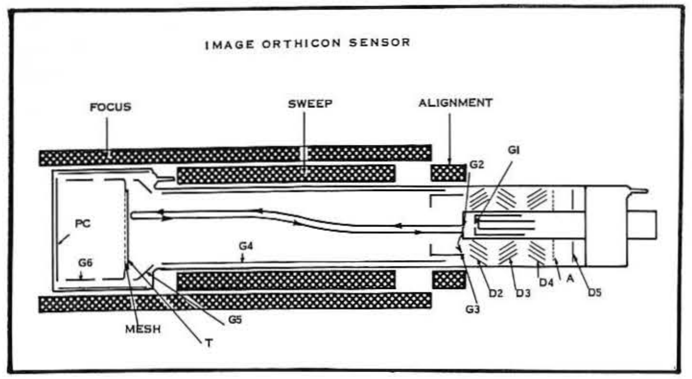

FIGURE 9: Schematic functional arrangement of image orthicon tube.

deviations can be caused by field imperfections and by nonlinearity of the sweep current; to make these as small as possible, a considerable effort has been expended at various laboratories to develop deflection circuitry with greatly improved linearity. The standard reached in this domain provides 0.2 percent linearity for the horizontal scan, and 0.02 percent for the vertical scan. In general, it is possible in image tubes to account by calibrating for the amount of distortion in the frame. A mastergrid is imaged onto the tube retina and the amount of distortion measured in the output image or in the digital coordinate information obtained if digital read-out of the video location is used. If adequate precautions are taken, if temperature stability has been reached, and the tube parameters have been maintained, reliable calibration can be obtained within the linear response range of the tube. If a digital master wave form generator is employed, a precision internal grid can be injected into the circuit and used to monitor possible distortions. If digital signal processing is used, the application of the corrective calibration matrix can be incorporated in the data reduction computer program.

Information Storage Capacity (Information Contents)

As loss of information content of an image is a degradation, this item enters our comparative analysis. The difficulty is that information contents cannot simply be expressed by the number of image points which geometrically can be registered per unit area of the receptor. If this would be the case, we simply would have to state that the photo-emulsion can register about 10^6 image points per cm^2 (elements with 10μ side length) whereas the image orthicon registers about 40,000 elements per cm^2, with an assumed 50μ (approximately 0.002 inch) scanning beam diameter, with a scanraster of 500 lines per frame, and 500 elements per line.

The quoted 10^6 image points per cm^2 for the photographic emulsion is an upper limit set by the photographic "noise," which is an expression for the statistical fluctuations of the developed grains called granularity (ΔD). It supposes low contrast in the object, and approximately linear relationship between the density variations (D −D) and the variations in exposure (E −E) in the exposure distribution E(x, y), (D is the mean density level, E the mean exposure level).

These conditions are not necessarily present, and the effective modulation response of the photographic emulsion may reduce the figure quoted as information contents considerably. In practical applications, the 10μ point size may not be reached at all, as point spread occurs during the longer exposure times necessary for the photographic receptor. On the other side, with the image orthicon, external storage and digital integration can be employed, so that the signal-to-noise ratio can be increased considerably — thus providing sufficient information contents particularly for low signal operation.

SUMMARY AND CONCLUSIONS

The preceding comparative analysis of the photographic and the image orthicon sensor appears to underline the advantage which image orthicon tubes have over photographic emulsions in certain task areas. This means to say that besides the known advantages connected with the high quantum efficiency and the signal generating scan mechanism, image orthicon receptors give less non-accountable, or noncorrectable image degradation.[6]

The following factors are quoted in support of this contention:

1. The relationship between the measured effect and the incident quanta is linear; this in itself gives uniform and smaller error quantities.
2. The modulation transfer function can be greatly improved by electronic means.
3. Contrast rendition can also be greatly improved by electronic means.
4. Inherent random dimensional distortions can be corrected by calibration and digital signal processing and clean-up.
5. Image blur due to image movement can be greatly reduced by the possibility of short exposures.

Other effects are more or less similar in their influence on data accuracy, and have to be judged according to the prevailing conditions. A detailed analysis must be based upon precision laboratory tests under controlled conditions, which would provide quantitative figures. The distinct advantage which the photographic sensor has, is its large information storage capacity. The unique advantage of the image orthicon is its signal-generating mechanism and the digital processing capability with real time data output associated with it.

ACKNOWLEDGEMENT

The data and conclusions presented here have been obtained from the operation of a special sensor system at the Air Force Missile Development Center, the "Facet-Eye Camera System."

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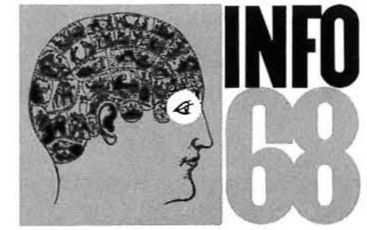
THE AUTHOR

WALTER E. WOEHL has been with the Air Force Systems Command's Missile Development Center since 1956 as optical Research Physicist. He is primarily engaged in the development of optical and electro-optical sensor systems and their application to tracking and Celestial Guidance programs. Prior to this assignment he was a consulting Optical Physicist with the British Ministry of Supply, Armament Research and Development Establishment, Royal Arsenal Woolwich, and as a staff member with the German Air Force Academy at Berlin-Gatow. Mr. Woehl received his MS degree in Physics from the Technical University of Berlin, Germany. He is a member of the Optical Society of America, the society of Photo-optical Instrumentation Engineers, and the German Physical Society.



Ninth Annual Symposium Planning Report

INFO '68, the Ninth Symposium for the *Society for Information Display* now appears on the horizon. As readers of the Journal noted in last month's edition, a great deal of planning and activity have already gone into INFO '68. However, the best of plans cannot be put into action unless there is a group of interested Society members dedicated to achieving the symposium goals. In this regard, the committee members are actively soliciting people in the Los Angeles area to assist in the actual operation of the symposium. These jobs entail helping in registration, assisting in the preparation of publicity releases, and other tasks. Anyone interested is requested to call the *SID* Headquarters at 472-3550 for further information or to contact the following committee members if interested in helping in a specific area:

Tom Curran—Arrangements	785-8361, X-3075
Sam Davis—Registration	781-8211, X-4381
Les Haining—Finance	391-0711, X-2240
Dave Morgan—Audio Visual	849-6741, X-256
Bob Woltz—Program	626-1456
Sharon Satterfield—Ladies Program	472-3550
Jim Belcher—Publicity	887-4214
Erwin Ulbrich—Papers	(714) 897-0311, X-4525

PROGRAM NOTES . . .

According to Program Chairman Bob Woltz, a keynote speaker has been selected. The Society is fortunate to have secured Mr. Harry Davis, Deputy Assistant Secretary of the Air Force, DOD, who is well known for his dynamic speaking ability and thought provoking comments. Other speakers are actively being solicited.

AUDIO VISUAL . . .

Chairman Dave Morgan reports that he has added Pete Vlahos and Al Landsperger to his staff. Pete will handle projection duties and Al will assist in the TV monitor area. Don Olker has also recently joined the committee staff.

LADIES' PROGRAM DEFINED . . .

Ladies' Program Chairman Sharon Satterfield has selected the Beverly Convention Bureau to assist in the ladies' activities. At present, the tour will include a trip to Farmer's Market, CBS Television City, and an MGM studio. Also included is a fashion show and luncheon at the Beverly Hills Hotel. Sharon has recruited a committee to assist her in future activities.

PAPERS COMMITTEE . . .

Erwin Ulbrich reports that the quality and variety of papers received thus far has been very high. A tentative outline for the program includes sessions on *civil, business,* and *military* display applications. This arrangement represents a minor restructuring of the original program in an effort to more fully integrate the papers in a meaningful way.

ARRANGEMENTS PLANNING TO HELP THE DRIVERS . . .

That old bugaboo, parking, is being looked at by Tom Curran in order to lighten the parking load for attendees at the Ambassador. Tom also indicated that exhibitor booth sales have been going very well.

JIM BELCHER
Publicity Chairman INFO '68

SID Activities

The *SID* Board of Directors met at the Society Headquarters on 15 November 1967. Ford Brown reported that the Society's assets are almost $50,000.

William Bethke reported on the establishment of three new Chapters: Southwest (Dallas), Delaware Valley (Philadelphia), and Minneapolis/St. Paul. He also reported that activity for forming a Chapter in the Chicago area has resumed. A group of interested people in Ann Arbor had an organizational meeting to explore the possiblity of a Chapter establishment there. The next meeting is scheduled in December. The question of the establishment of a foreign Chapter, or Chapters, was discussed. Dr. Luxenberg was asked to look into this.

L. Seeberger reported on progress being made for the 9th Symposium to be held in Los Angeles. Approximately half the expected number of exhibitors have already signed up. More papers are needed.

W. Bethke reported that the Fall '68 Technical Symposium will be sponsored by either the Mid-Atlantic Chapter or the Delaware Valley Chapter, while the 10th National Symposium (Spring, 1969) will be sponsored by the Washington D.C. Chapter.

W. Bethke reported that *SID* had been accepted as an affiliate member of AFIPS (American Federation of Information Processing Society).

Dr. Luxenberg reported that the Department of Commerce asked *SID* to be the co-sponsor of a proposed Information Display exhibit to be held in London during January and February 1968. The Board authorized Dr. Luxenberg to work with the Department to find out what is involved.

General discussion was held regarding our relationship with our two publishers — Western Periodicals and Information Display Publications, Inc. A committee consisting of F. Brown, L. Seeberger, R. Kuehn and H. Luxenberg was appointed to negotiate new contracts with both publishers.

The next Board of Directors Meeting is scehduled to be held in conjunction with the next Annual Business Meeting tentatively scheduled during the 9th National Symposium, 22-24 May 1968.

Respectfully submitted,
C. *MACHOVER*, Secretary

PROPOSED BY-LAW CHANGES

OLD
Article 6—Board of Directors

SECTION 1:
a. The Board of Directors shall consist of the elected officers, the immediate past-President and *twelve Directors-at-Large*. The President of the society shall serve as the Chairman of the Board.

b. Three Directors-at-Large shall represent each of four regions, such regions to be delineated along state and national lines for each year by the prior Board of Directors to provide approximately equal representation.

SECTION 2:
Directors-at-Large shall serve for three years. Voting effective for the first annual general business meeting shall elect one Director-at-Large for three years, one for two years and one for one year from each region. Thereafter each region shall elect one Director-at-Large for three years. Any interim vacancies may be filled by appointment by the Board of Directors of a member from that region until the next election, at which time a Director shall be elected for the remainder of the term, if any.

SECTION 3:
Any member or Fellow in good standing and residing in the region at time of nomination is eligible for the office of *Director-at-Large from that region.*

NEW

SECTION 1:
a. The Board of Directors shall consist of the elected officers, the immediate past-President, *elected Representative from each Chapter and the Regional Representatives.* The President of the Society shall serve as Chairman of the Board.

b. The Regional Representatives shall be appointed each year by the prior Board of Directors to represent areas of significant display activity in which a chapter does not exist. The Regional Rrepresentatives shall be responsible for the promotion of SID interests and establishment of new chapter in those areas.

SECTION 2:
a. *The Director elected as the Chapter Representative* shall serve for three years. Each Chapter shall submit candidates for election from its membership. Said candidates to be elected along with national officers at the annual election.

b. The Regional Representative shall be appointed by the Board of Directors.

SECTION 3:
Any Member or Fellow in good standing is eligible for the offices of *Chapter Representative and Regional Representative.*

OLD

SECTION 4:
Subject to the duties of Directors as prescribed by the bylaws, all society powers shall be exercised by or under the authority of, and the business and affairs of the society shall be controlled by, the Board of Directors. The Directors shall have all the rights and powers conferred upon Directors by law except as otherwise expressly provided in the Articles of Incorporation or these bylaws.

SECTION 5:
a. The Board of Directors shall *meet immediately after the annual general business* meeting at the place of that meeting and at such other times and places as the Chairman may direct.

b. At least two-thirds of the Board, including at least two officers, shall constitute a quorum for conducting business. Descisions of the Board shall be made by a majority of the quorum.

NEW

SECTION 4:
Subject to the duties of Directors as prescribed by the bylaws, all society powers shall be exercised by or under the authority of, and the business and affairs of the society shall be controlled by, the Board of Directors. The Directors shall have all the rights and powers conferred upon Directors by law except as otherwise expressly provided in the Articles of Incorporation or these bylaws.

SECTION 5:
a. The Board of Directors shall *meet within seven days of the annual general business* meeting and at such other times and places as the Chairman may direct.

b. At least two-thirds of the Board, including at least two officers, shall constitute a quorum for conducting business. Decisions of the Board shall be made by a majority of the quorum.

RATIONALE: The underlying basis for the positions of Directors of the Sociey for Information Display may be described by their fundamental responsibilities:

1. To represent simultaneously the chapters and national office in SID affairs, to promulgate among the chapters the national policy and to see that society business is conducted at the chapter level.

2. To promote the establishment of new chapters in those areas as interest and activity dictate.

These changes allow for more direct responsibility of the Chapter in the Board of Directors activities.

Article 7—Nominations and Elections

OLD

SECTION 1:

Candidates for each elected office shall be selected by the Nominating Committee after after due deliberation as to qualifications and willingness to serve, if elected, of each nominee. The Nominating Committee will provide a slate of at least two candidates for each elected office. Said slate will be submitted to all qualified members in good standing at least 60 days before the annual general meeting. Suitable steps will be taken to assure the anonymity of the completed ballot which must be returned at least 30 days before the annual meeting. Legibile write-in votes will be considered valid.

SECTION 2:

Counting of the votes will be made by an independent auditor in time to permit installation of newly elected officers *and Directors-at-Large* at the next general business meeting. A plurality of the legal votes cast for each office will be sufficient to elect for that office. In case of ties, the current Board of Directors will choose between tied candidates.

NEW

SECTION 1:

Candidates for each elected office shall be selected by the Nominating Committee after due deliberation as to qualifications and willingness to serve, if elected, of each nominee. The Nominating Committee will provide a slate of *at least one candidate* for each elected office. Said slate will be submitted to all qualified members in good standing at least 60 days before the annual general meeting. Suitable steps will be taken to assure the anonymity of the complete ballot which must be returned at least 30 days before the annual meeting. Legible write-in votes will be considered valid.

SECTION 2:

Counting of the votes will be made by an independent auditor in time to permit installation of newly elected officers *and directors* at the next general business meeting. A plurality of the legal votes cast for each office will be sufficient to elect for that office. In case of ties, the current Board of Directors will choose between tied candidates.

RATIONALE: It has been the experience of the Nominating Committee of the past that the current requirement for selecting a slate of at least two candidates sometimes works a hardship on the committee particularly when candidates are nominated for re-election it is difficult to find a second candidate who will accept a nomination. Consequently, in the past, due to the present requirement, it was necessary to "put a man in" just to have a second candidate to meet the requirements of the by-laws. Since previous by-laws allowed for the re-election or the succession of an officer in the same office for the second term, this particular requirement provides considerable difficulty to the committee.

Article 10—Meetings

OLD

SECTION 1:

There shall be one annual general business meeting conducted during the first *two* months of each fiscal year. Such meetings shall be held at a time and place selected by the Board of Directors.

NEW

SECTION 1:

There shall be one annual general business meeting conducted during the first *five* months of each fiscal year. Such meetings shall be held at a time and place selected by the Board of Directors.

RATIONALE: To allow for more flexiblity and to allow this to occur in the first five months. It was the consensus of the Board that this allowed a time to be selected which did not compete with other professional society activities (i.e. IEEE, etc.) particularly since we expect to hold only one symposium with exhibits per year. Present by-laws require that this meeting be held in February or March.

ID Readout

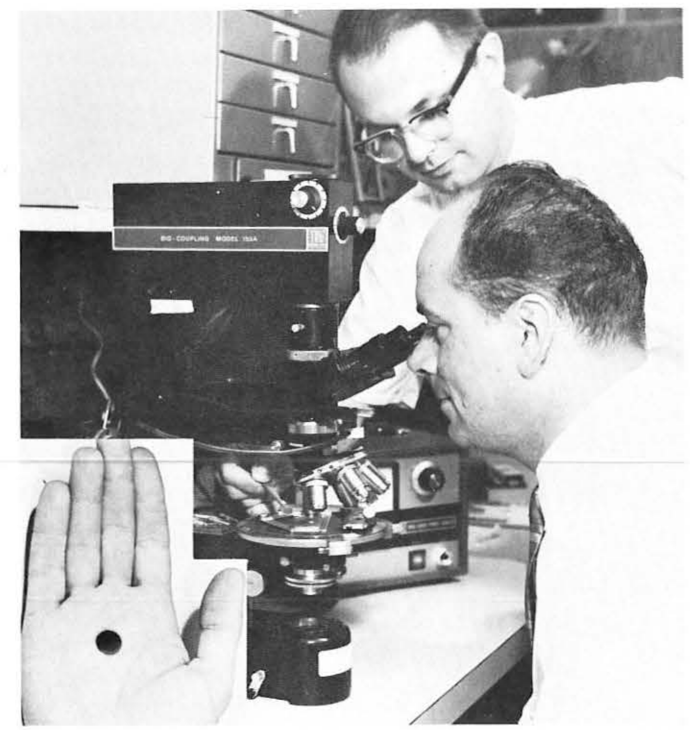
MINI-RECORDING RESEARCH

Someday spacecraft to the Moon may store data for 500 photographs on a one-in. sq. strip of magnetic film. And computers aboard these spacecraft may retain ten million bits of scientific information per square inch of film.

These possibilities loom bright with a development in microscopic or mini-recording achieved by two researchers at Caltech's Jet Propulsion Laboratory. Dr. Dimeter I. Tchernev and Dr. George W. Lewicki have succeeded in recording magnetic spots or "bits" with diameters smaller than one micron, or forty millionths of an inch, on film of manganese bismuthide.

The recording method, which employs the pulsed light beam of a laser, has proven the film can retain several hundred times more data than is generally stored on present magnetic film or tape.

The JPL project has yielded, in the words of the researchers, "what we believe to be the smallest magnetic bits of information ever recorded."



MINI-RECORDING: Dr. Dimeter I. Tchernov looks through microscope of laser instrument as Dr. George W. Lewicki inserts magnetic film for test of the miniature recording technique which they have developed at Caltech's Jet Propulsion Laboratory. Drs. Tchernev and Lewicki use a ruby laser light beam and special magnetic film to record several hundred times more data than can presently be stored on comparable size tape or film. Insert at lower left shows film disc, less than an inch in diameter, on which several million bits of scientific information can be imprinted by the laser beam.

Writing is done with a pulsed ruby laser similar to the type used by eye surgeons to "spot-weld" detached retinas. The laser beam is focused on the film through a microscope and reduced to micron size. Laser intensity was regulated to heat spots to 360° and no more. By reducing the beam strength slightly, the researchers recorded spots only a half-micron wide.

"QWICK-QUERY"

A system which enables executives to obtain information from computers more quickly and simply has been developed by Consolidated Analysis Centers Inc., computer services company with offices in Los Angeles, New York and

Washington, D.C. The process was devised by Dr. Harry Markowitz, known in the computer field as the originator of SIMSCRIPT, a widely used computer programming language. He also developed the mathematical theory of portfolio selection, a technique now being used by financial investment researchers and others. Dr. Markowitz, co-founder of C.A.C.I., is chairman of the board and research director of the company. The system has been copyrighted under the name of "Qwick Qwery." Without the help of a programmer, the process makes it possible for an executive to obtain tailor-made reports in a matter of minutes as compared with the delay of days or even weeks normally required for computer programming and checking. The system is being offered by C.A.C.I. to companies or agencies on a lease, purchase, or service bureau basis.

PICTUREPHONE

Bell System's PICTUREPHONE see-while-you-talk set has been completely redesigned to incorporate additional features that trials have shown the public wants in a videotelephone. The improved "Model II' sets will succeed the first generation sets — now providing limited commercial services between New York, Chicago, and Washington, D.C. Trials of the new set will be conducted next year at Westinghouse Electric Corp. Service will link selected offices in Pittsburgh and New York.

With Model II PICTUREPHONE set, the user can change the size of the field of view to close-up or wide angle by "zooming" electronically, display drawings and printed matter (in a "graphics mode" of operation), move more freely from side to side while remaining "on camera," and change the camera focus to transmit larger scenes up to 20 ft. away.

The display unit of the new set — a tapered, cube-shaped unit with rounded corners — swivels through nearly a full circle on a pedestal slanting up from a frosted chrome, ring-shaped base.

A new silicon-target television camera tube, developed at Bell Labs, makes the "electronic zoom" practical and provides a better picture under both poor and normal lighting conditions. An important feature of the new camera tube is that it is not damaged by direct exposure to bright lights. In addition, an iris in the camera automatically compensates for a wide range of ambient light intensities.

NEW INTERFACE SYSTEM

Realtime Systems Inc., N.Y., has developed a general purpose interface system for the IBM 1130 which enables the computer to perform a wide variety of data acquisition and data transmission functions through its storage access channel. These added capabilities now make it possible to use the 1130 as a fully integrated scientific computer, data acquisition system or as a remote terminal to a larger central computer.

Data acquisition functions that can be handled using the 1130 interface include analog and digital input, analog and digital output. Data transmission devices supported include teletype, asynchronous data phone and automatic calling units. These new capabilities make it possible to use the 1130 as both a general purpose computer and as a special purpose computer for laboratory and pilot plant data acquisition and control systems. Laboratory instruments such as gas chromatographs, mass spectrometers, automatic chemical analyzers and tensile testing machines can be tied directly into the system.

COMPUTER COMMUNICATIONS INC., Inglewood has been awarded a $215,000 contract by JET PROPULSION LABORATORIES to provide programming support for a computer-based communications system, the JPL Communications Processor System, which is part of the world-wide NASA Communications System Network . . . Advanced Products Div., Link Group, GPL INC., has received two contracts totaling more than $700,000 to develop a Radar Image Mapper and an Orthographic Radar Restitutor. Systems are for the Army Engineer Topographic Labs, Fort Belvoir, Va. . . . Assets and business of NORTHRIDGE RESEARCH INC., Van Nuys, have been acquired by TRAID CORP. The firm becomes part of Traid's Photo Instrumentation Division.

An add-on award from NASA, John F. Kennedy Space Center, has been awarded to HAZELTINE CORP., Little Neck, N.Y., for a third Digital Display Generator, bringing contract amount to approx. $625,000 . . . CALIFORNIA COMPUTER PRODUCTS INC., Anaheim, has received a sub-contract to provide the "militarized" digital plotter for use in Tactical Information Processing & Interpretation Systems being built by TEXAS INSTRUMENTS INC., Dallas, for the Aeronautical Systems Div., Wright-Patterson AF Base, Ohio . . . SYSTEM DEVELOPMENT CORP., Falls Church, Va., will assist the National Military Command System Support Center in development of a Movements Requirements Generator-Package 1, under terms of a one-year, $353,548 contract awarded by the Defense Communications Agency.

A new firm, SYSTRONICS INC., Ann Arbor, Michigan, has been formed for design, manufacture and marketing of on-line computer peripheral equipment. Samuel N. Irwin is president and founder of the firm . . . BUNKER-RAMO has sold to UNION DIME SAVINGS BANK, N.Y., for $1,400,000, an automated on-line system that processes instantly every type of transaction for tellers in all four offices of the bank. System includes 36 new electronic teller machines, a new communications computer and a data storage capacity of 2.1 billion bits of information.

Otto Bernath, president, has announced formation of UNIVERSAL SYSTEMS INC., with principal offices in Washington, D.C. The company will specialize in Systems Engineering and Systems Design in communications oriented computer systems, but will offer complete services to all manufacturers and users of computers . . . CLARE-PENDAR CO., Post Falls, Idaho, has received a contract award for 8,000 switches from the EDO CORP., College Point, N.Y. This is the third large award received by the firm in as many months . . . CAL-R INC., Santa Monica, has acquired the Ceramic Capacitor Div. of THE SCIONICS CORP., manufacturers of microfilm information systems, data acquisition systems and thermal test systems . . . VARO INC., Garland, Tex., has constructed a 20,000 sq. ft. building on the firm's 58-acre main Garland site to provide additional space for production of image converter and image intensifier tubes. The structure will be used for manufacture of microcircuits.

Magnetic disc + TV monitors = low cost graphic display terminals

Low-cost graphic-display systems are now possible, using TV monitors and high-density parallel-readout disc memories. Standard television monitors are available than can display up to a million "dots" or picture elements. By generating "dots" in the proper time sequence, graphic displays can be presented on the television monitors.[1] Because the TV monitors have no storage capabilities, the dot patterns must be regenerated or refreshed at a 30 to 60Hz rate to avoid flicker.

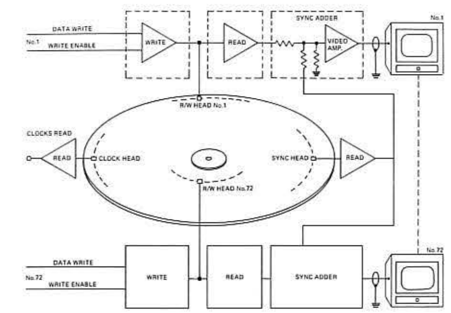


FIGURE 1: Simple system uses one FPD track per display.

High-density magnetic discs are very suitable for refreshing or repeating the dot patterns. The Data Disc FPD (Fixed-head Parallel Digital) disc recorder has complete read, write, and clock electronics for each of 72 tracks on a single disc. The disc stores the digital dot pattern used to create a picture on the TV monitor and supplies (refreshes) the pattern to the CRT at a 30Hz rate. Each track stores 100K bits at 3 megabits/second.

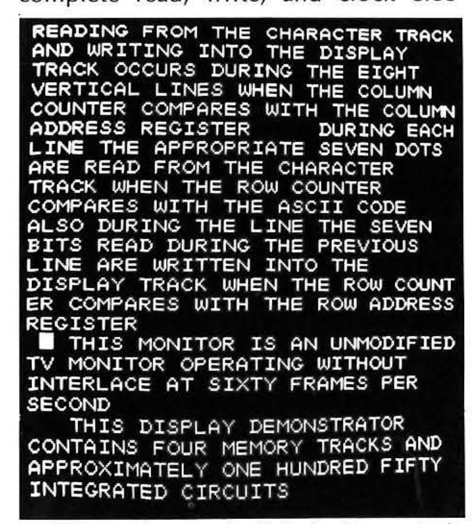


FIGURE 2: Photograph of display from a single track.

A simple system (Figure 1) uses one FPD track per display. Figure 2 is a photograph of a display from a single track. An unusual property of this type of display is the ability to display up to 100K points from one track *without* flicker. A small computer can be used to generate a picture point-by-point, with the point information accumulated on the disc as it is generated.

For higher resolution displays, more than one track may be combined to provide much larger refresh-storage capacities and higher data rates. Figure 3 (top) shows a basic system using only 8 tracks. The bit rate of this system is 24 megabits/second with a channel-storage capacity of 800,000 bits, providing a display of greater than 800 X 800 picture elements.

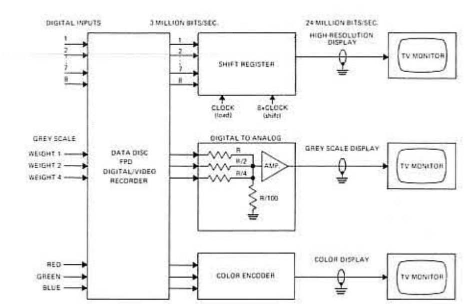


FIGURE 3: Basic system using only 8 tracks.

For grey-scale displays, several tracks may be combined in a digital-to-analog converter to give a multi-level grey-scale output. Figure 3 (center) illustrates a system where track 1 stores a grey-level weight of one, track 2 stores a grey-level weight of two, and track three stores a grey-level weight of four. The converter adds these signals algebraically to produce an eight-level signal.

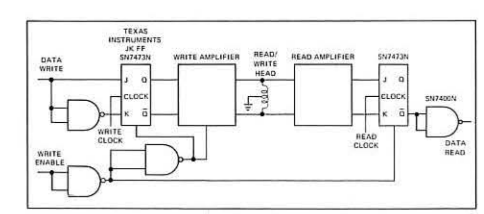


FIGURE 4: FPD track electronics composed of 10 integrated circuits and two power transistors.

Color displays may be generated by using three tracks, one for each primary color, as shown in Figure 3 (bottom). Various combinations of these arrangements shown in Figure 3 may be used to give high-resolution displays with grey scale and color.

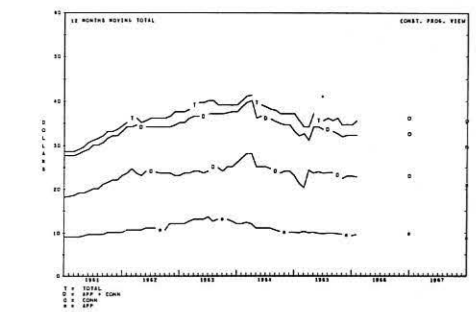
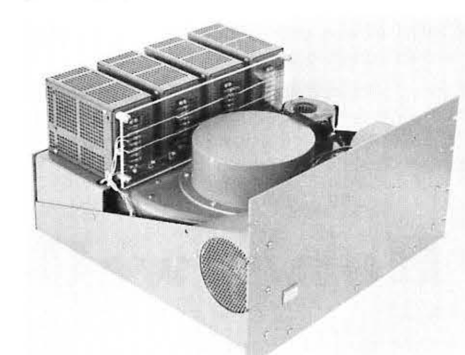


FIGURE 5: Photograph of display.

The FPD track electronics is composed of 10 integrated circuits and two power transistors as shown in the block diagram, Figure 4.

In addition to providing refresh storage for TV raster-scan monitors, the disc can store the X and Y commands for an X-Y type display.[2] Figure 5 is a photograph of such a display.



Data Disc FPD Digital/Video Disc Recorder offers up to 72 parallel-digital recording tracks, each with its own read, write, and clock electronics. Any track can be written without disturbing data being read from adjacent tracks.

[1] Hendrickson, Herbert C., "A High-Precision Display System for Command and Control," *Information Display*, pp. 32-36, July/August 1967.

[2] McDonald, H. S., Ninke, W. H., and Weller, D. R., A Direct-View Console for Remote Computing," *Proc. International Solid-State Circuits Conference*, THPM7.3, pp. 68-69, 1967.

ID Products

Light Modulator

Crystalab Products Corp., Rochelle Park, N.J., has introduced the EOM-700 Electro-Optic Light Modulator, first of a series of new Pockels cells designed to modulate the outputs of gas lasers from low audio through ultrasonic frequencies. Low beam distortion is claimed because of high quality of KDP crystals used in the modulators. The crystals are grown by Crystalab and are free of inclusions, strain and striae, according to the firm. Barrel threads on the modulator can accomodate standard Size 6 camera lens and filter adapters, permitting use of a variety of filters and polarizers.

Circle Reader Service Card No. 25

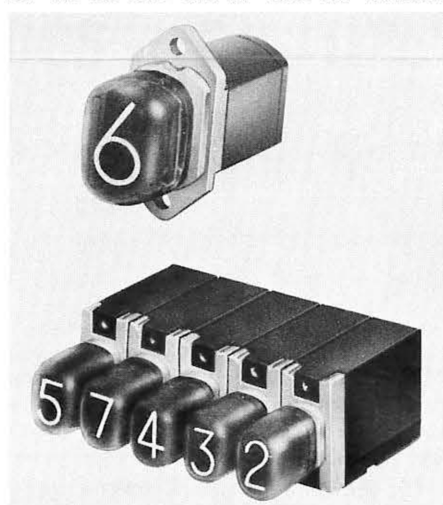
Pre-asembled Mounting Rack

Master Specialties, Costa Mesa, Calif., has introduced pre-assembled unitized mounting racks, complete with integral terminal blocks, to hold from one to 144 plug-in modules, in matrix configurations of up to 5 x 20 or 12 x 12 individual switches. Installation of mounting rack assembly is simplified by installing the entire assembly into a single cutout in the front panel, rather than many individual cutouts required by conventional switches. Overall weight is reduced by up to 50%. Assemblies are available from stock.

Circle Reader Service Card No. 26

Nixie Tube Drivers With IC's

New driver modules for Nixie tubes which use integrated circuits have been introduced by Burroughs Corp., Plainfield, N.J. Two series, the BIP-8800 and BIP 9800 are available.



All modules accept 4 line 8-4-2-1 BCD inputs which are compatible with TTL and DTL. All units of both series have been designed to exceed applicable sections of MIL-E-5400J and MIL-T-5422E environmental specs.

Circle Reader Service Card No. 27

Portable Graphic Input Device

Model 20 Grafatran Graphic Input Translator — a low-cost, portable graphic input device for translating graphic information contained on large formats such as drawings, diagrams and maps into analog voltages — is now available from Bolt Beranek and Newman's Data Equipment Div., Santa Ana. Grafatran's analog voltage outputs can be used for subsequent analog or digital processing in a wide range of applications — including graphic data analysis, computer-aided design, automated teaching systems, mapping, character recognition studies, and many other commercial and industrial applications. Model 20 consists of a writing stylus and two precision film potentiometers (radial and azimuth) mounted on a gimbal assembly. The radial potentiometer has a travel of 10 in., the rotary azimuth potentiometer can measure up to 100°. The writing stylus is attached to the shaft of the radial potentiometer with a special anti-parallax coupling that allows the stylus to be held at any comfortable angle without affecting reading accuracy at a given point. Friction and inertia are minimized, permitting essentially free-hand operation for sketching, tracing or writing. Open-circuit electrical accuracy is ±0.1% of full scale; mechanical accuracy is ±1 millimeter.

Circle Reader Service Card No. 28

Digital Optical Tachometer

Digital Optical Tachometer (DOT) Model 505460, a compact, solid state laboratory instrument used to measure the variable speed of rotating objects, is offered by Clary Corp., San Gabriel, Calif. DOT features a direct digital readout in revolutions per minute. Pulse and analog outputs are also supplied which can be fed to other electronic intruments. Measurement is made by pointing the photo-reflective probe at the rotating object marked to provide fluctuation in reflected light.

Circle Reader Service Card No. 29

Sub-Subminiature Indicator Light

Vermaline Products Co., Franklin Lakes, N.J., offers B-7019 sub-subminiature indicator light with 1 in. leads, for computer and digital devices. It is manufactured of stainless steel and accomodates a T1 Bulb epoxied in place, 6V, 12V, 30,000. Lens size is 3/16 in. diameter x ¼ in from panel; unit mounts in 3/16 in. hole. The unit is available in many lens colors and various variations.

Circle Reader Service Card No. 30

Shielded Dynamic/Static Focus Coils

Available from Syntronic Instruments Inc., Addison, Ill., two focus coils are designed specifically for sharp focus sophisticated high resolution displays, including the new 1" neck diameter scanconverter storage tubes and small flat faced high resolution CRTs. Approx. 12 oz. weight makes coil ideal for airborne applications. On Type C 5215, peripheral lead exits make possible closer component assembly; or, to obtain more compact CRT shield assembly, Type C 5315 can be furnished with leads exiting the front surface. Spot distortion is avoided and best possible image-to-object ratio obtained by positioning the single gap forward, away from the electron gun. Fringe fields and field distortions are eliminated by carefully machining the top quality soft magnetic iron case to shape the focusing field with great accuracy. A mu-metal shield prevents magnetic coupling between focus coil case and yoke. Any combination of impedances and a variety of impedances are available for the static and dynamic coils.

Circle Reader Service Card No. 31

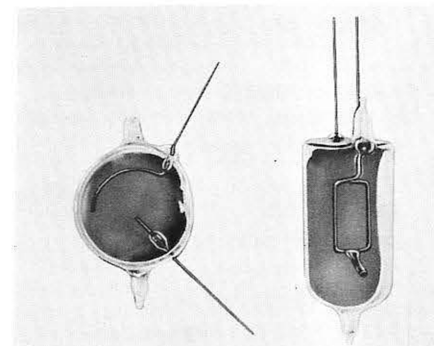
Single-Channel Oscilloscope System

As an extension of its 7000 series of 7-channel monitor oscilloscope systems, California Instruments Corp., San Diego, has introduced a new single-channel power supply, model 7200, which may be used with any of five individual oscilloscope modules. Extremely compact, the latter employs 1 x 3 in. CRT's and require only 1⅜ in x 4¼ in. of viewing and function-control area. They may be plugged directly into the power supply or connected via extension cable for remote operation.

Circle Reader Service Card No. 41

Miniature Photo Cells

Six new types of miniature photo cells are now available from Calvert Electronics, N.Y. Size is less than ½ cu. in. Gas filled and vacuum cells are included in the range, with minimum sensitivity ranging from 30 to 150μA/lumen. Caesium photo-cathodes are employed in order to give best response to tungsten illumination; peak of spectral sensitivity occurs at 9,600 Angstroms.



Circle Reader Service Card No. 42

Electro-Magnetic Digital Clock

Numex Corp., Waltham Mass., offers an electro-magnetic digital clock featuring time correction input control and legibility in direct sunlight. The device uses no mechanical linkages and boasts a million hour lamp life. Clock uses a magnetic stepping motor and projects a 300 ft. lambert, 1½ in. numeric display. It provides binary coded decimal outputs for use with time recording systems.

Circle Reader Service Card No. 43

200-Watt Power Supply

An advanced design solid state 200-watt power supply for operation of mercury short arc lamps has been introduced by PEK, Inc., Sunnyvale. The unit is designed to provide optimum lamp performance in such applications as photo-resist exposure, semiconductor manufacture and precision photography. Designated 701A Series, the new power supply employs a circuit for control of maximum current and voltage, volt-ampere curve slope and power window in order to deliver rated power at the lamp over a wide range of input voltages. The 701A offers more reliable lamp starting through a single pulse start circuit, minimum electro-magnetic interference and elimination of spark gaps. Output power regulation offers ±3% accuracy; current ripple is less than 5% rms. The unit is rack mountable. Available optional accessories include a lamp running-time meter and lamp voltage and current meters.

Circle Reader Service Card No. 44

Circle Reader Service Card No. 46

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BUNKER-RAMO CORPORATION
Canoga Park, California

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

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

HUGHES AIRCRAFT COMPANY
Culver City, California 90230

HUGHES AIRCRAFT COMPANY
Vacuum Tube Products Div.
Oceanside, California

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

RADIATION INC.
Melbourne, Florida

STROMBERG CARLSON CORP.
Data Products, San Diego, California

SYNTRONIC INSTRUMENTS INC.
100 Industrial Road, Addison, Illinois

Circle Reader Service Card No. 47

New Literature

Longer Video Tape Life

Tips on extending the life of video tape through proper handling and storage are contained in a bulletin offered by Ampex Corp., Redwood City, Calif. The tips fall under three main headings entitled, "Handle Video Tape With Care!," "Treat Tape Gently on Your Recorder" and "Store Tape Under 'People Conditions'."

Circle Reader Service Card No. 53

RFI/EMI Designer Kit

A special Designer's Kit is now available to assist engineers in the proper selection of RFI/EMI and Magnetic Shielding materials. The Kit contains samples of a wide variety of RFI/EMI-Magnetic Shielding materials, and is available from Primec Corp., Los Angeles, who manufactures a complete line of RFI/EMI and Magnetic Shielding materials, gaskets and enclosures.

Circle Reader Service Card No. 54

New Generator Brochure

A new eight page brochure which describes the Kato line of A.C. generators with controls form 1 to 1500 kilowatts is available from Kato Engineering Co., Mankato, Minn.

Circle Reader Service Card No. 55

Square Indicating Lights

GEA-7366A, illustrated four-page bulletin provides descriptions, features, ratings, components, ording directions and outline drawings with dimensions for the General Electric line of CR101 Type C square indicating lights.

These lights are suitable for use on motor control centers, operator panels, consoles, control desks and for the panel building, electronic and instrumentation fields.

Circle Reader Service Card No. 56

Automatic Deposit Stations

A four-page brochure from Milgo Electronic Corp., Miami, describes Lectro-Teller automatic deposit stations. The electronic banking device serves as a round-the-clock bank teller in locations such as shopping centers, office buildings, and industrial plants as well as a supplementary teller at the bank. In addition to its use by banks, the Lectro-Teller can be used to collect cash payments for savings and loan companies, department stores and utilities. The two-color brochure illustrates the various features of Lectro-Teller, including individual packaging of each deposit in plastic envelopes and a validated customer receipt for each deposit. The Lectro-Teller provides an illuminated 238 square inch display space for advertising.

Circle Reader Service Card No. 57

Functional Analog Modules

RO Associates', San Carlos, Calif., complete new line of Functional Analog Modules for industrial control, instrumentation, and system applications are described in a brochure which includes information on applications, function, specifications, mechanical dimensions, and prices.

Circle Reader Service Card No. 58

Circle Reader Service Card No. 59

on the move

C. J. BARTLESON, noted authority on color and its perception, has joined Macbeth Corp., Newburgh, N.Y., as vp/director of research. He was previously in charge of research on visual psychophysics in the Research Labs of the Eastman Kodak Co. in Rochester. Elected president of the firm is WARREN B. REESE, who was previously exec. vp. He has been with the firm for seventeen years. Reese is also a director of Kollmorgen Corp.

Raytheon's North Dighton, Mass. facility has named JOHN L. HARLOW administrator for all display programs. Among current display programs is an airline reservation system for Air France which utilizes Raytheon's digital information display systems for rapid access to information stored in computers.

Standard Computer Corp's president, ROGER T. HUGHES, has announced appointment of R. PAUL NIQUETTE as vp/plant operations. He is responsible for design, engineering and manufacturing of all versions of the firm's IC-6000 computer and for other data processing equipment and systems now under development.

WILLIAM R. MACKLIN is now director of marketing for the USECO div. of Litton Industries, according to BRUCE Y. CATHCART, div. vp/general manager. Macklin joined Litton in 1963 and has served in various sales management capacities.

DONALD DeWOLF KING has been named vp/director of research for Philips Laboratories, the central research facility for North American Philips Co., Inc. (Norelco) and its associated companies. Dr. King is well-known in the field of microwaves and electro-optics.

Joining Ferroxcube Corp. as a design engineer is NOEL M. RICHARDSON. He is in the Memory Systems Div. in Englewood, Colo., and previously was with Collins Radio Co. and Martin Marietta.

Astrodata Inc. has announced appointment of LEWIS BYRD as manager of Range Systems Engineering, operating out of White Sands Missile Range, N.M. Byrd was previously with the Army Electronics Command as a div. manager for the Atmospheric Science Laboratory.

LEWIS BYRD

EUGENE KONECCI

EUGENE B. KONECCI, Kleberg Professor at the University of Texas, has been elected a director of Applied Devices Corp., N.Y. electronics firm. Dr. Konecci, former Space Council and NASA official, is a leading authority on aerospace technology and served as sr. prof. staff member of the President's National Aeronautical and Space Council in the Executive Office in Washington

Named to serve as national coordinator of keyboard sales for Micro Switch, div. of Honeywell Inc., is JOHN J. TROPSA, who joined the firm in 1951 as a salesman in N.Y. FRANK E. WILSEY, vp/marketing, made the announcement.

LESTER M. CRABB is now vp, image intensifiers, for the Machlett Laboratories Inc., subsidiary of Raytheon. Crabb has been product line manager for light amplification tubes for the last three years.

Named to head Kollsman Instrument's new Electro-Optics Div. is JACK H. VENNER. The new div. was formed from the Space Div. organized five years ago; emphasis remains on space programs.

JACK H. VENNER

TED KRAMER

TED KRAMER now serves as Div. Mgr. for Photo/Etch Co., div. of Industrial Electronic Engineers Inc., Van Nuys. Kramer has administration over all processes, production, personnel and sales for the firm, which was formed as a separate div. of IEE earlier this year.

Computer Communications Inc., Inglewood, Calif., has announced appointment of TIMOTHY F. FOLEY as product sales manager, and DALE (SKIP) NEWBERG as marketing administrator. Foley served formerly as director of systems marketing for Western Union's Information Systems and Services. Newberg joins CCI from the national sales staff of TV Guide Magazine and was previously associated with Control Data in Minneapolis.

ASHLEY A. FARRAR has joined the corporate staff of Sanders Associates Inc. and will direct the company's marketing activities in the Washington, D.C. area, according to ROYDEN C. SANDERS JR., president of the company. Farrar will have offices both in Washington and at corporate headquarters in Nashua, N.H.

Gap Instrument Corp., Westbury, N.Y., has announced appointment of THOMAS J. COSGROVE as vp/manufacturing. Actively involved in the electronics industry for more than a quarter century, Cosgrove has a broad background of related experience in the administration and management of the manufacturing function.

Monsanto Co.'s Organic Chemicals Div. has consolidated its research and development efforts on synthetic and formulated fluids for automotive, aviation and industrial applications within one major technical group. DR. WILLIAM R. RICHARD JR. of St. Louis, formerly in charge of the division's technical effort in functional fluids, has been appointed to a newly created, senior position of manager, research and development, automotive, aviation and industrial fluids. Reporting to Dr. Richard will be T. P. SANDS, manager, research and development, petroleum additives.

Elected vp in charge of R&D for Trans-Lux Corp. is CHARLES J. HOLLOMAN, formerly chief engineer. He joined the firm in 1965 to head development of electronic communications systems. The firm has been involved in extensive research in the use of microcircuitry for such displays in all industries.

ID Correspondence

Sir:

We are trying to locate an index for every magazine carried in our Information Systems Library. However, we were unable to find one for *Information Display*. We would appreciate it if you could tell us if your journal is indexed. *Information Display* is very important to us and we feel it necessary to keep an account of the articles found in it.

PATRICIA OLSEN
Information Systems Librarian
The Pillsbury Company
Minneapolis, Minnesota

[How many other readers desire a cumulative index in ID? Please write, informing us of your interest in such a service, so that demand for an index can be ascertained.—Ed.]

Sir:

While the results of the experiment described by Kinney and Showman *(Information Display, September/October 1967)* seem to be unequivocal, their interpretation is not. The authors kept the type point size constant in comparing lower-case with upper-case letters. In many applications, the designer is interested in optimizing performances regardless of size. Particularly on erasable surfaces like cathode tubes, the critical experiment would require a further study of the effects of varying type sizes on the performance as measured by Kinney and Showman. While it may be true that in some tabular displays, type size must be minimized to crowd in as much data as possible on a display, surely there are many applications where a few brief comments appear on a rather large surface. Before categorically recommending upper-case lettering for these applications, the authors must perform the experiment varying type size.

The authors, quoting Cornog, Rose, and Walkawitz, maintain that legibility is confused with readibility, perceptibility and visibility. If so, the authors have compounded the confusion by recommending the choice of upper-case letters solely on the basis of legibility. In most applications, the criterion is probably *intelligibility*, not legibility. The authors in saying" . . . if more legible means superior performance in all reading situations, then the argument will go on forever," imply that intelligibility is not a measurable variable. A possible way of measuring intelligibility (to a much closer approximation) would require the subjects to use the word that is displayed to solve a mini-problem. True, the experimental design would be a lot messier, but it would be worth the effort required to give the problem a decent burial.

Despite my criticisms. I enjoyed the article and feel that the work of the Kinney group is certainly among the most careful experimentations in legibility of English characters.

SAMUEL A. ROSENFELD
Auerbach Corp.
Arlington, Va.

Sir:

It was my good fortune to be a student in the course on displays given at U.C.L.A. August 28th through September 1st. *Display Systems Engineering*, taught by Messrs. H. R. Luxenburg and R. L. Kuehn was very well organized and presented.

A great deal of pertinent information was packed into the five day course. Assuming the course to be a sample of what will be in the new book released by McGraw-Hill in November, *(Display Systems Engineering* by H. R. Luxenburg and R. L. Kuehn) it will be a very useful tool for display design engineers.

CHARLES P. HALSTED,
Manager
Display Technology
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