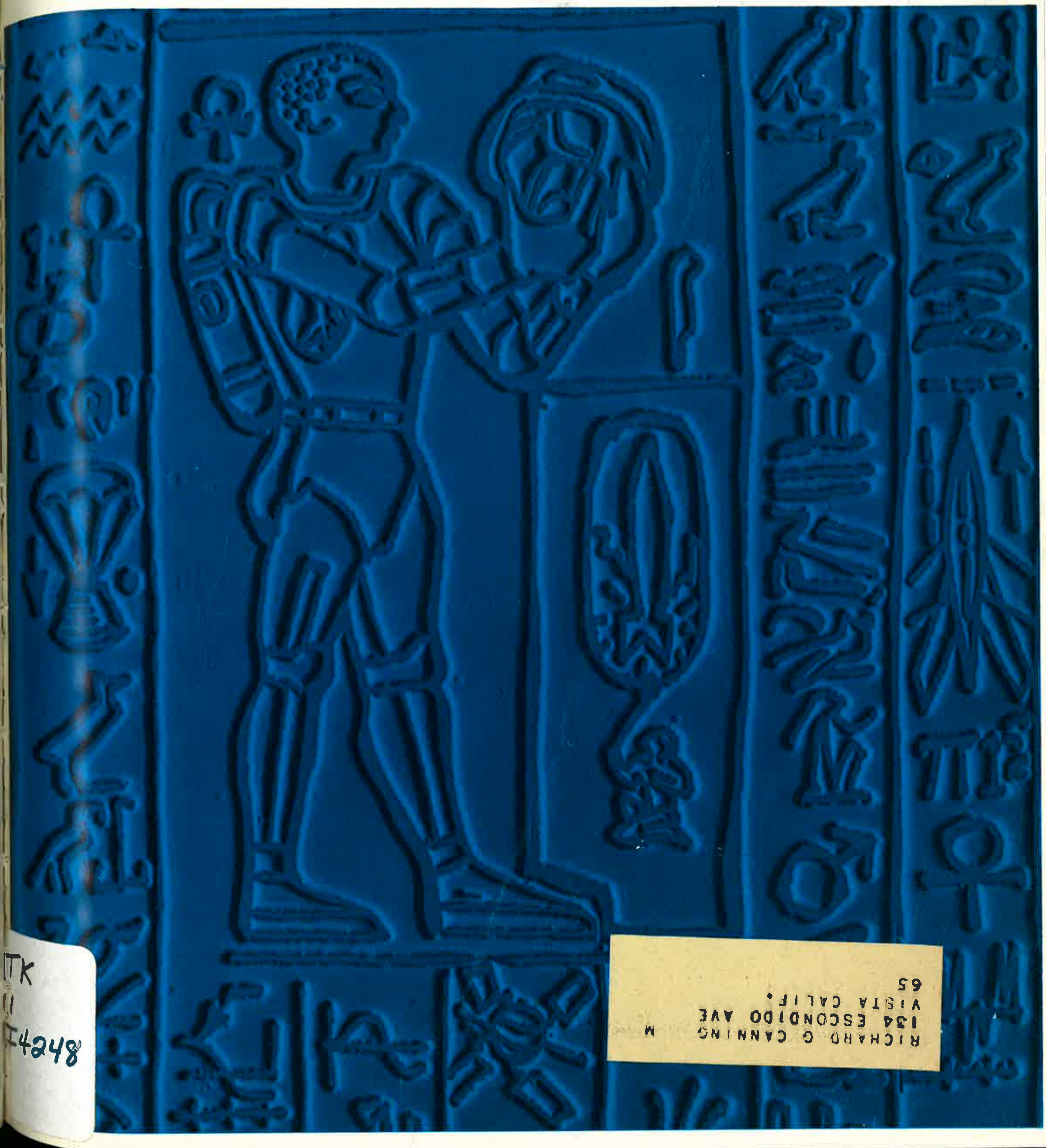
Volume 2 Number 4 July/August, 1965

Information Display

Journal of the Society for Information Display



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Volume 2 Number 4 July/August, 1965

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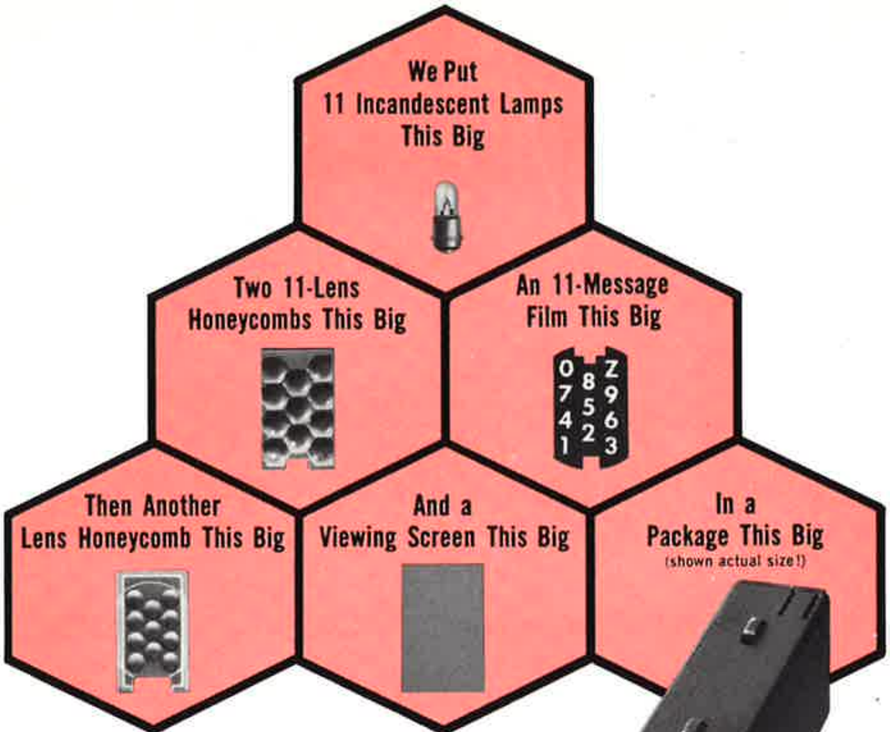

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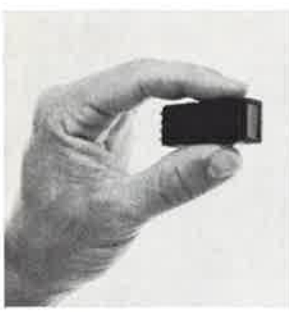

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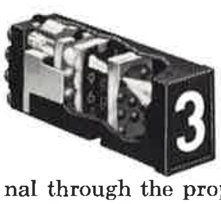

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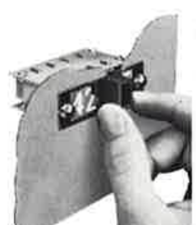

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EDITORIAL

BETTER MOUSETRAPS

"This specification covers the requirements for a mousetrap – the trap shall be spring type – mounted on a white pine base 1¾ inches by 4 inches – tripped by a pressure of not over 6½ grams – and closed in not over 0.005 seconds with a force sufficient to catch and retain a mouse not over 3 inches in body length and 1½ ounces in weight. Trap shall be given visual and mechanical inspection to verify that materials, design, construction, physical dimensions, and workmanship are in accordance with the applicable requirements. Traps shall be individually packaged in accordance with good commercial practice – packed 100 to a shipping container in accordance with the Uniform Freight Classification Rules or regulations of other carriers applicable to the mode of transportation. In addition to any special marking required by the contract or order, individual packages and shipping containers shall be marked in accordance with the requirements of MIL-STD-129."

It's all there: the standards, the specifications – all defined, all very proper. Apply them, and you have a mousetrap. Build a better mousetrap, and you can forget the specs. Why? Because the object is to kill mice, not build mousetraps. A palatable, poisonous pellet would be as effective, but wouldn't meet specs!

The analogy holds for any endeavor which prescribes standards, specifications and definitions. Let's talk about displays. We, as a group, are pioneers; we strive for, literally, the "big picture" with all its attendant ramifications – brightness, contrast, resolution, chromaticity, etc. We attempt to define these qualities and, as a group, strive to formulate and present standards and specifications for achieving them.

I wonder, though, if we presume too much; do we stress the approach and lose sight of the "big picture"? Can we (SID) really expect to put forth a dogmatic set of standards, specifications and definitions for all-time application? Such expectations, I think are born of naivete. We can propose, suggest and present; we cannot *enforce*. There is always evolvement, change.

Industry might accept our premises today, but "build a better mousetrap . . . ! !" So why bother?

The movies are a classic example of law without enforcement in a competitive situation Cinematography conforms to certain standards in film, size, cameras and projection. Deviate from them, and you are out of the running – unless your results are remarkably better than those achieved under present standards. Witness the onset of the "talkies." Here was a major evolution-revolution whereby the then current standards – and certain actors – became past tense. Although we are not in parallel competitive positions, the philosophy still applies.

I would suggest, then that this philosophy be one of scientific awareness – think, experiment, propose and present – but only to achieve the end: the "big picture." The approach will always, of necessity, be an evolutionary process.

There was the mousetrap and the pellet. But there was one lure before them, I recall: "the Pied Piper of Hamlin." He was very effective. I'll wager he breathed a sigh of relief when the mousetrap was invented. I'll even venture another guess: I'll bet he bought one.

WILLIAM P. BETHKE
Vice President of SID
Charter Member, ID Editorial Advisory Board

William P. Bethke is Vice President of the Society for Information Display and a charter member of the ID Editorial Advisory Board. He has held posts of Northeast Regional Director of SID, and Chairman, SID Definitions and Standards Committee. For the past four years, he has been Director of Engineering at the Rome Air Development Center, Griffiss AFB, Rome, N.Y., where he has been employed since 1952. He joined RADC as Staff Engineer, Plans and Operations Office, following an affiliation as Project Engineer, Watson Laboratories, Eatontown, N.J.

Mr. Bethke is a native of Milwaukee, Wis., born April 22, 1920. He was awarded his BSEE from Marquette University in 1942 and did postgraduate work at Illinois Institute of Technology, then served with the U.S. Army from 1942 to 1946. He has authored several reports on ground navigational aids and display techniques. In addition to his posts in SID, he is chairman of the RADC Scientific and Professional Committee; Chairman of the Vocational Advisory Board for the Rome, N.Y., Board of Education; and Chairman of the IEEE's Mohawk Valley Section.

Quantitative Measures of I

by H. R. Luxenberg and Q. L. Bonness

Editor's Note

This paper is one section of a report entitled "Display Techniques for Digital Weapons Control Systems" prepared by H. R. Luxenberg and Q. L. Bonness, of the Bunker-Ramo Corp., for the U.S. Naval Ordnance Test Station (NOTS), China Lake, Calif., under contract number N60530-10519. Another section of the same report appeared in the last issue of INFORMATION DISPLAY under the title "Photometric Units" by H. R. Luxenberg.

Introduction

Display device and system parameters are of two types:

(1) Those pertaining to system integration requirements with associated environmental and logistic considerations.

(2) Those pertaining to the interface with the observer.

The first category consists of such items as physical size, weight, power, signal levels, symbol encoding, interface requirements, temperature, humidity, shock, vibration, cost, reliability (MTBF), and maintainability (MTTR).

The second category includes such factors as brightness, contrast, color capability, resolution, viewing distance, and viewing angle.

All of these parameters are either available from the manufacturer (many must, of course, be properly discounted) or may be tested directly.

It is not the intent of this paper to duplicate detailed descriptive material which is already easily available and well presented in the current literature. For example, several good articles describe, in some detail, techniques for CRT character generation; others describe alphanumeric indicators, etc. Furthermore, it would be impractical to attempt to tabulate operating parameters for all currently available displays here. Several extremely good summaries are readily available, although even these suffer from some incompleteness. It is, however, the purpose of this paper to present a quantitative discussion of the physical units and psycho-physical significance of those parameters peculiar to display technology.

Since the function of a display unit is to transfer information to the operator by visual sensing, it is important to consider those parameters that determine the capability of the human eye to perceive information. Therefore, the following section discusses those factors that are important to the visual perception of information. A definition of each factor is given, and a discussion of the way in which it relates to the evaluation of display devices is included.

Brightness and Contrast

Contrast, not brightness, is the significant factor in display legibility. Brightness is generally specified because it is dependent only on the equipment, whereas contrast is generally a function of ambient lighting. Brightness is also specified because it would seem that the higher the brightness, the greater the visibility under higher ambient light. This is not necessarily true, since some displays of lower intrinsic brightness have better visibility than far brighter ones. (See Tables 1 and 2).

Furthermore, unnecessarily high brightness may be a luxury where ambient light is subject to control, since it has been determined experimentally that where observers have control over ambient lighting for reading they tend to choose lower values than are generally considered optimum. For example, under a controlled test[1], when the maximum available illuminations were 10, 30, and 45 foot-candles, the observers selected 5, 12, and 16 foot-candles as the optimum values.

The required brightness of a display should be obtained by the following procedure. First, select (preferably at the lowest acceptable level) the ambient light desired at the work station, and by means of a mockup measure the ambient light falling on the display surface. The source(s) of ambient illumination should be relocated, collimated or otherwise shielded to reduce this to a minimum. Acceptable contrast ratios are: for white symbols on a black background, 5 to 1; for line drawings or text on a white background, 25 to 1; for pictorial scenes, 100 to 1.

From a knowledge of the reflectivity of the display surface (unless it is glossy, unity is a conservative estimate), the brightness of the background is obtained, and multiplication by the desired contrast ratio will specify the brightness required of the symbols. For example, if the ambient illumination on an electroluminescent alphanumeric display whose luminance is 10 foot-lamberts can be held below two foot-candles, the resulting

FIGURE 1

res of Display Characteristics

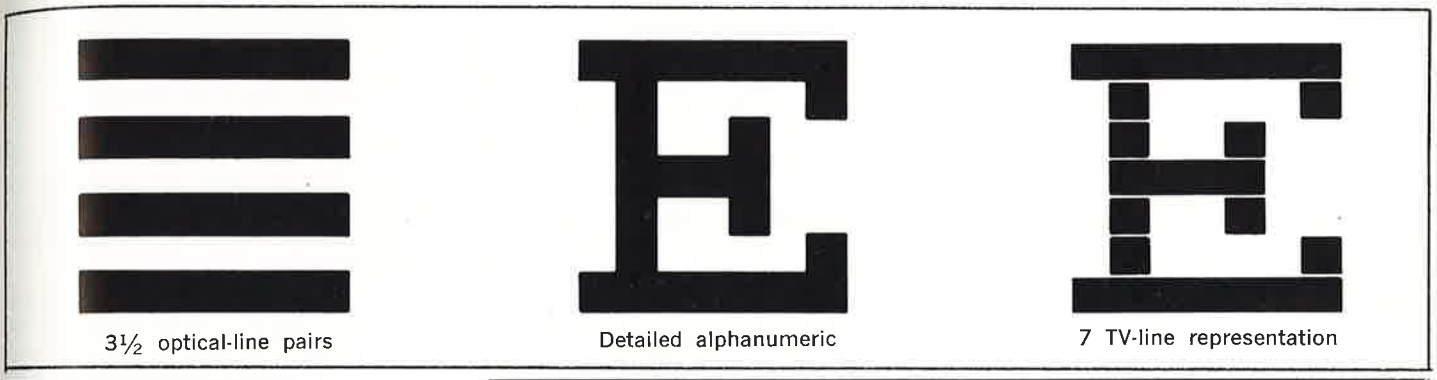


FIGURE 1: Character representation.

TABLE 1

Typical Brightness (foot-lamberts)*

Surface of the sun	4.8×10^8
Surface of a 60-watt frosted incandescent bulb ("hot spot")	36,000
Surface of a 60-watt "white" incandescent bulb	9,000
Surface of a 15-watt fluorescent tube	3,000
White paper in direct sunlight	9,000
Clear sky	2,000
Surface of moon, bright area	750
White paper on office desk	25
Pulsed electroluminescent mosaic panel	20
Television raster	20
Light valve, 10- by 10-foot diffusing screen, 2-kilowatt lamp	20
Theatre screen open gate	16

Note that pulsed electroluminescent mosaic panels have brightness comparable with television raster or opengate theatre screens.

*Brightness values compiled from:

(1) D. G. Fink, TELEVISION ENGINEERING HANDBOOK, McGraw-Hill, 1959.
(2) IES LIGHTING HANDBOOK, THIRD EDITION, Illuminating Engineering Society, 1959.
(3) REFERENCE DATA FOR RADIO ENGINEERS, I. T. and T. Corp., 1949.
(4) Measurements and Calculations by the Authors.

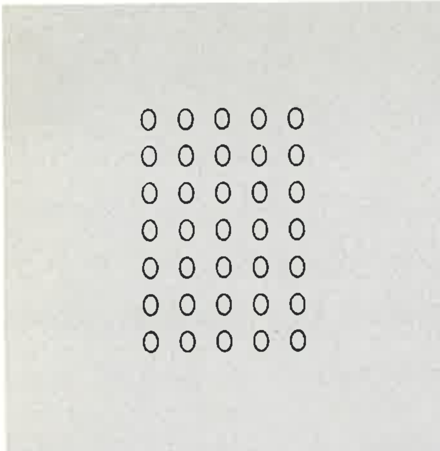


FIGURE 2: Full 5 x 7 dot mosaic (35 elements, full alphanumeric).

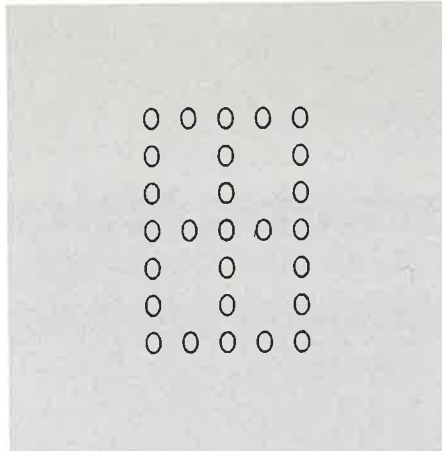


FIGURE 3: Reduced 5 x 7 dot mosaic (27 elements, numeric only).

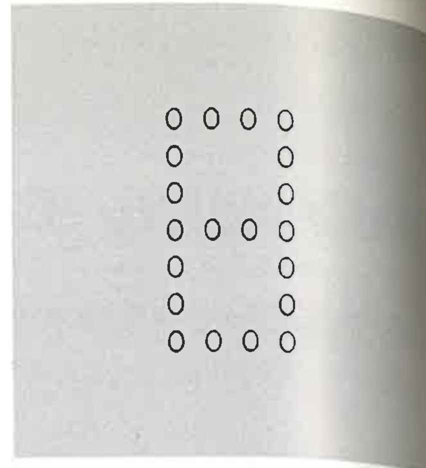


FIGURE 4: Reduced 4 x 7 dot mosaic (20 elements, numeric only).

contrast of 5 to 1 will be adequate for good legibility.

If, however, the observer is working at a desk where the illumination is 50 foot-candles, a sheet of white paper will have a luminance of 40 foot-lamberts and the 4-to-1 brightness difference between paper and display may prove annoying. Since the display brightness cannot be raised, the working lighting can be reduced. If the observer is given control over the ambient lighting, he will find an optimum (for him) working level.

Size-Resolution-Legibility

Resolution is generally described in terms of line pairs per millimeter (lines/millimeter). The average observer can resolve two lines that subtend an angle at the observer's eye of one minute. Since 1 minute of arc $\approx$ 0.0003 radian, the eye resolves at a viewing distance of 10 inches (250 millimeters) about 13 lines/millimeter.

There is some confusion in the literature between optical lines and television lines. Optical lines are synonomous with line pairs (i.e., an optical line consists of a black and white pair). To show one line pair on a television raster requires at least two television lines. Because the optical line pair may not coincide with the raster lines, more than two television lines are required. The correction factor of 1.4 is called the Kell factor[2]. Thus, one optical line pair requires 2.8 television lines, for full resolution.

TABLE 2
Contrast Levels

Textual copy (white on dark)	5-10 to 1*
Line drawings and black on white text	25 to 1
Photographs	100 to 1

*Legibility of fine detail degrades with increasing contrast if the eye is adapted to darker background level, because of dazzle effect.

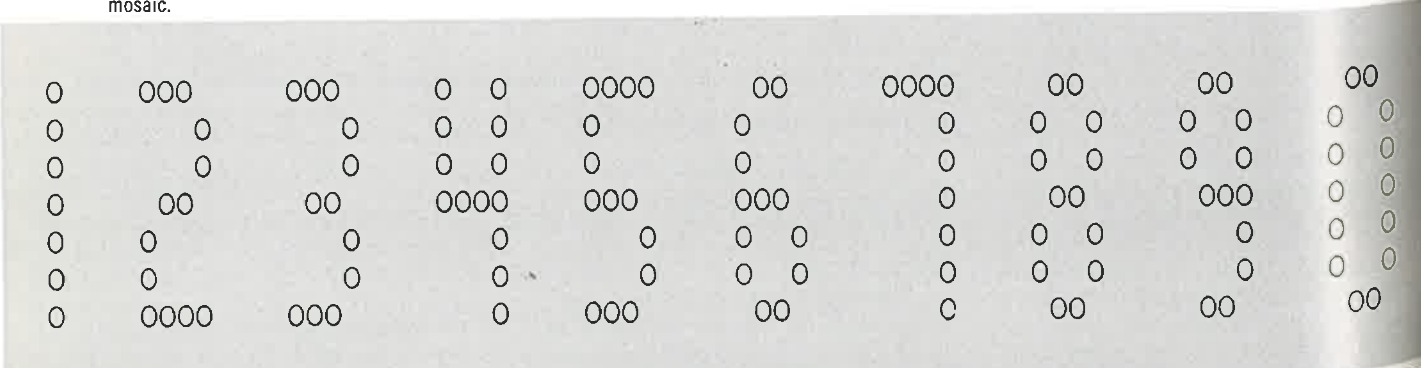
Resolution in terms of line pairs is significant for display purposes only when photographs are shown, where the observer is required to distinguish between two close objects. Actually, if the existence or nonexistence of a black line on a white background is to be determined, the line need subtend an angle of only 0.5 second at the eye.

If alphanumerics are to be legible, the vertical angle subtended at the eye should be at least 10 minutes of arc. Since 10 minutes of arc are approximately 1/360 radian, for each foot of viewing distance the character must be at least 1/30 inch in height. While the eye can resolve 10 optical line pairs in 10 minutes of arc, this does not mean that the detail present in an alphanumeric character requires 10 line pairs for legible presentation.

An examination of the "E" shown in Figure 1 reveals that no more than 3.5 optical line pairs are required. The seven-television-line representation of the "E" on the right side of the figure may appear somewhat crude when viewed close-up, but when viewed from a distance at which the lines are not resolved, it is quite legible.

Although the number of television lines used is just twice the number of optical line pairs for the illustration, near perfect registration of the raster scan to the figure being displayed was assumed. To take care of the misregistration problem, the Kell factor (2.8) is introduced. The product of 3.5 (the number of optical lines required) by 2.8 (the Kell factor) is very nearly 10, the number of television lines required to present a character of good legibility.

FIGURE 5: Numerics using reduced 4 x 7 dot mosaic.



[1]A. C. Stocker, "Displays, Papers and Lighting," *Information Display*, Vol. 1, No. 1, pp 16-26, September/October 1964.

[2]D. G. Fink, *Television Engineering Handbook*, McGraw-Hill, 1959.

While the legibility of the characters depends on their structure, there is no universal agreement on the optimum character shape. Among the recommended shapes are the following:

(1) Modified gothic (sans serif) character of height/width ratio of 3 to 2 for most letters, with the exception of I, M, and W, and a stroke width of ⅛ of the character width.

(2) The same as above, but with a height/width ratio of 5 to 3 and a stroke width of 1/6 to 1/8 of the character height (MIL-SPEC-33558).

The authors prefer the 3 to 2 height/width ratio with a bolder stroke, say 1/6 of the character width. The character is then nine strokes tall by six strokes wide. A minimum of two stroke widths should be provided between adjacent symbols.

Special Character Shapes

While well shaped gothic characters are most attractive and are generally agreed upon as providing the ultimate in legibility, certain types of display implementation preclude their use. Instead, they present characters of a stylized shape made up of discrete elements. Once these are "learned" they become nearly as legible as the pure gothic to which they are an approximation. Devices in this class use either dot or stroke mosaics, as discussed below.

The primary reasons for the adoption of these types of characters are economy and simplicity of implementation, as is readily apparent from the following considerations. Alphanumeric data are stored and processed in data processors in data binary coded form, requiring a minimum of six bits per character, exclusive of parity and clock bits. These six bits permit display of a maximum of 63 characters (or 64 if the "blank" is counted). This number can include 26 alphas, 10 numerics, and up to 27 special symbols, including punctuation marks, etc.

While the 6-bit code can be decoded into 64 "lines," one per possible character, in many display applications it is found more desirable to reduce the number of decoded lines by assembling the characters from a smaller number of elementary elements, as, for example, by a dot or stroke mosaic.

Dot mosaics

The coarsest mosaic that is capable of providing easily legible alphanumeric symbols is a 5- by 7-dot mosaic, as shown in Figure 2. Here, only 35 decoded lines are required. If only numerics and a limited number of symbols are required (e.g., +, −, ., etc.), some of the elements are not required, and the number of lines may be reduced to 27, as shown in Figure 3.

For numerics only, the reduced 4- by 7-mosaic shown in Figure 4 is satisfactory. This mosaic requires only 20 lines. In general, dot mosaics present better appearing characters than stroke mosaics, but stroke matrices are more economical in the sense that fewer lines are required. However, stroke matrices with as many as 35 specially shaped elements have been devised; these give extremely good characters, far better appearing than the dot matrix, with no more operating complexity. The elements may also be arranged in a parallelogram rather than in a rectangle to provide sloped or "italic" characters.

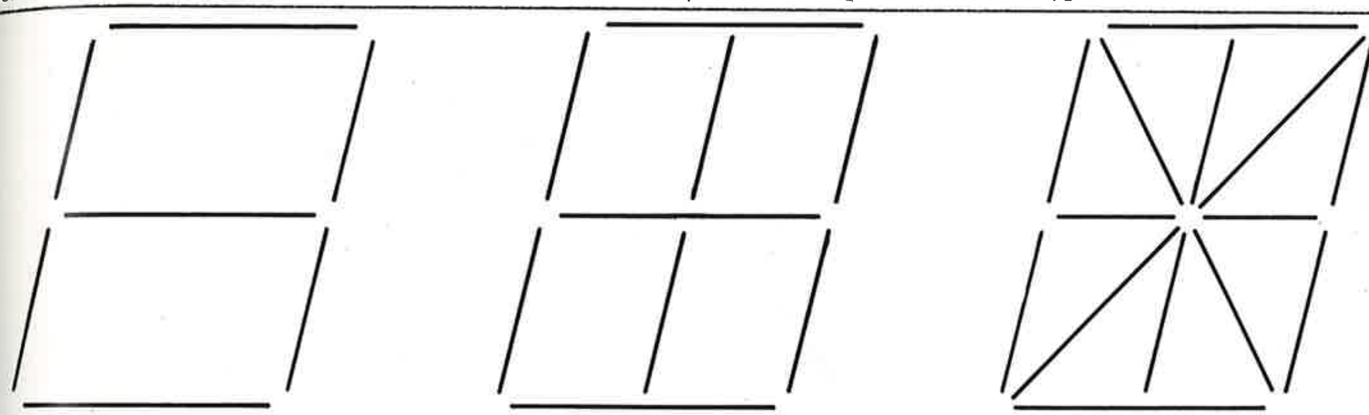
Stroke mosaics

This type of character presentation is known variously as the bar matrix, the segmented character, or the stroke matrix, depending on the manufacturer. The bars, strokes, or segments are arranged in a pattern similar to one of those shown in Figure 6.

The exact shape varies from one manufacturer to another, with some rounding of corners and minor variations in the way adjacent segments join.

The segments may be electroluminescent strips, electrochemical cells or cathodes in a glow discharge tube, or they may be trans-illuminated by neon or incandescent lamps. The power requirements, luminosity, and color differ in each method of implementation.

The characters are nearly as legible as those made from a 5- by 7-dot mosaic, but logic (switching) requirements are reduced from 35 inputs for the full 5-by-7 matrix to 16, 14, 9, or 7, depending on the type of bar matrix chosen. A decimal point or underline bar may be added in some instances. The same height/width/stroke ratios apply as for shaped characters.



(a) The double-hung window (seven elements, numeric only).

(b) The double-hung window (nine elements).

(c) The starburst (14 elements, full alphanumerics; also available is a 16-element starburst with the upper and lower horizontal elements split).

NOTE: Segments may be electroluminescent, gas tube cathodes, electrofluors, or illuminated by incandescent or neon lamps.

FIGURE 6: Segmented character formats.

Screen Characteristics

The length-lambert units of the previous section are defined by defining the luminance of a perfect diffuser, approximated by a fresh chalk surface, to be numerically equal to the incident illumination in length-candles (e.g., a perfect diffuser in bright sunlight is illuminated by 9000 foot-candles and has a luminance of 9000 foot-lamberts as seen from any direction).

For other-than-perfect diffusers, a reflectivity factor is used to obtain the luminance. Note that the reflectivity need not be less than unity and it may vary with direction.

For specular reflection the luminance of the reflected image is that of the source itself. If the perfect diffuser in the example above is replaced by a perfect mirror, the luminance of the mirror is 4.8×10^8 foot-lamberts (same as the solar surface) on the axis of the reflected rays and zero off-axis. Thus, the reflectivity or "gain" of the mirror in this case is a sharply peaked function with a maximum value of $(4.8 \times 10^8)/9000$ or greater than 5×10^4.

Directional screen with flaked aluminum surfaces (to give high gains) are frequently used to obtain greater image brightness, but at the price of a restricted viewing angle. An increase of granularity in the aluminum paint provides a greater viewing angle; or the surface may be embossed with tiny convex mirrors, which will not be visible at normal viewing distances.

The mirrors spread the incident parallel rays into a cone generally of rectangular cross-section, to cover the audience space desired. The angles of the cone are simply related to the width or height and focal length of the tiny mirrors.

An analogous situation holds for rear-projection screens. The analog of a perfect mirror is a clear layer. Either more diffusion or a lenticular structure may be used to provide the desired spread of light. Except for very small screens (i.e., those subtending a small angle at both eye and source), gains greater than 2 to 3 produce visible and annoying "hot-spots."

Uniformity of Luminance

A projection screen (either front or rear) will not be uniformly luminous over its entire surface, although for all practical purposes it may appear so. In this section, the reasons for non-uniformity and practical limits are discussed.

The two major causes for screen fall-off are: (1) lack of uniformity in illumination, and (2) the variation of gain with the angle between line of sight and the reflected or transmitted projection ray. This angle is called bend-angle.

Illumination fall-off is primarily due to a $\cos^4 Ø$ factor which enters when a finite-area lamp source and conventional optics are used in the projector. The angle Ø is the half-angle subtended by the screen at the projector. With small sources and aspherical optics, the factor may be increased, perhaps to $\cos^3 Ø$ or better, but at a cost[3]. The easiest cure is to reduce Ø by increasing the projection distance. If space is limited, a folded optical path may be required.

Even with a uniformly illuminated screen, the illuminance will fall off with bend-angle, unless the screen is a perfect diffuser (constant gain). The angle at which the gain is one-half its peak value is called the half-power, or 50% bend-angle. Higher gains mean smaller half-power bend-angles, unless the gain is deliberately lowered by the addition of light absorbing material for contrast control (see below).

While the eye is extremely sensitive to luminance differences in adjacent areas, it is relatively insensitive to a gradual 2-to-1 variation over a large area. For this reason, a 2-to-1 variation in screen luminance is generally acceptable, and even a 3-to-1 variation will go unnoticed by the casual observer. Therefore, the restriction to a 30% fall-off (often seen in display specifications) is a luxury that the eye does not appreciate; a 50% fall-off is a much more reasonable specification value.

Contrast Control

From a knowledge of the incident illumination and the screen gain in the direction of view, the luminance is calculated by a simple multiplication. Unfortunately, ambient light is also reflected back to the observer, adding to both highlighting and shadow luminances, thus reducing their ratio (the "contrast").

With a front-projection screen the only effective means of control is to use a high-gain (directive) screen, placing the observer on the reflected projector ray and avoiding all ambient light sources in the neighborhood of the projector. Only scattered ambient light will then degrade the contrast. This directivity explains the effectiveness of the currently popular lenticular screen for home projection use. The lenticules direct the reflected light primarily into a sharply defined rectangular cone, with sharp fall-off outside, rather than into a broader region with gradual fall-off.

With rear-projection screen, more freedom is permitted in contrast control. A high-gain screen is inherently a poor reflector; hence, contrast is immediately enhanced, even with light sources on the line of sight. As the gain is reduced by increasing diffusion to provide the desired viewing angle, the front reflectivity is, unfortunately, increased.

The reflectivity may, in turn, be lowered by adding opaque material or a neutral density filter. This reduces the gain but does not change the bend-angle as in the case of increasing diffusion. The effect of the filter is discussed further under the section on projection systems which follows.

Projection System Parameters

In projection systems the amount of light reaching the projection screen is a function of a number of parameters, but for well designed optical systems certain rules of thumb are applicable. Several useful ones are:

(1) A light valve television system using a xenon arc lamp has an output of between 0.7 and 1.5 lumens/watt.

(2) A 35-mm slide projector using an incandescent lamp has an output of between 1 and 2 lumens/watt.

These are typical figures only, and the upper or lower limits may be exceeded by exceptionally well designed or by poorly adjusted equipments.

For a uniformly diffusing matte screen, the screen brightness in foot-lamberts is equal to the luminous output of the projector divided by the screen area in square feet. For example, the screen brightness produced by a 2000-watt xenon light valve operating at an output of one lumen/watt on a 10-foot square screen is 20 foot-lamberts.

Both front- and rear-projection screens may appear either brighter or dimmer than a uniform diffuser, depending on the nature of the screen and the line of view. The ratio of brightness to illuminance is a maximum when the line of view extends directly back to the projector for a rear-projection screen, or along the reflected ray from the projector for a front-projection screen.

This maximum value is referred to as the gain of the screen. Typical useful screen gains line in the range of 0.5 to 2.0, although higher-gain screens are used when the restricted viewing angles associated with them are not objectionable or are desirable.

The higher the screen gain the higher the contrast, in general, for both front- and rear-projection screens. This is true for rear-projection screens, since the reflection of ambient light from the front surface is low with high-gain screens. For front-projection screens, the directivity of higher-gain screens is such that off-axis ambient light is not directed into the viewing area.

An additional degree of contrast control is available with rear-projection screens, in that a neutral density faceplate may be incorporated. If the (one-way) transmission is x%, the two-way attenuation of reflected light is x^2%. A 50% neutral density faceplate thus attenuates the projected beam by a factor of two and the undesirable ambient reflection by a factor of four.

Because of all the variables introduced by the screen parameters and the ambient lighting conditions, it is not practicable to specify brightness and contrast values for a projection system without defining the viewing conditions. It is for this reason that projection systems are best defined in terms of lumens output.

Brightness in foot-lamberts for a unity-gain screen is obtained by dividing the lumen output by the screen area in square feet. Contrast is obtained by multiplying the ambient light in foot-candles by the screen reflectivity coefficient and computing the ratio of "light" to "dark" values.

[3]Helmut Weiss, "Wide Screen Slide Projection," *Information Display*, Vol. 1, No. 1, pp 8-15, September/October 1964.

The Determination of Display Screen Size And Resolution Based on Perceptual and Information Limitations

by Glenn E. Whitham

Abstract

The material presented in this paper offers useful, handbook type information to enable the display system designer to determine rapidly the limiting values of basic display parameters so that he can devote his attention to those unique details inherent to the design of a specific system.

By considering displays in terms of their minimum resolvable elements, a series of design charts have been developed from which limiting design range values can be obtained for display element size, overall size, symbol size and maximum symbol quantity for ordered or random symbols. Within these limits more exact parametric values can be specified in terms of the effect on them of other system parameters. In this manner the feasibility of a display configuration can be verified in terms of fundamental limitations, and inconsistent requirements can be modified in the conceptual phase.

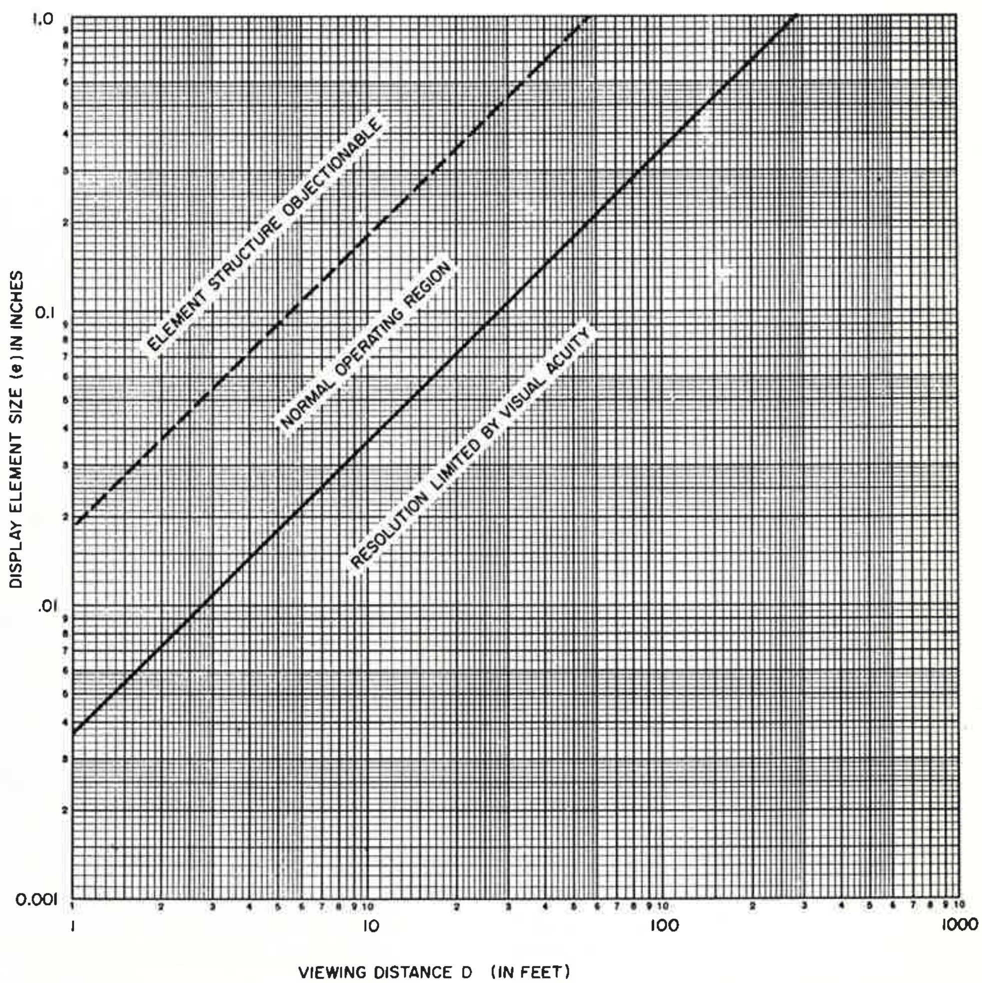


FIGURE 1: Relation of element resolution to viewing distance.

Introduction

The designer of a display system has available many devices and techniques from which he can select the most suitable for his particular purpose. A primary factor that must be considered in making his selection is the determination of optimum values for such fundamental display parameters as size, resolution, and information content. The basic limitations to these parameters are visual perception, and format and amount of required information. Within these limitations an idealized first-order determination of display size and resolution has been obtained.

This paper contains a brief description of how these parameters are determined with resulting design values presented in chart form for use by the designer. Modification of these results can be made in accordance with unique conditions related to a specific system and with due regard to psyhcoperceptual limitations. The model considered is applicable to many systems with little or no modification.

Based on preliminary work of limited scope on random position data displays, it is evident that additional probability analysis of typical model situations would be useful in establishing further design limitations. However, considerable analysis time and computer programming time would be required to yield significant results.

This discussion is limited to two-dimensional displays with a highlight brightness range which permits employment of normal photopic vision. The discussion does not consider low contrast, gray scales, color, and viewing angles other than normal to the display surface.

Element Size

The determination of display element size or display resolution is predicated on a nominal visual acuity limit of one minute of arc for a subject having normal vision. To be sure, various factors such as element form affect this value somewhat, but for the first order solution they have been neglected. If each display element has a maximum dimension e, then the relation between e and the maximum viewing distance D at which two such adjacent elements can be discriminated is given by

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

This relation is shown as the solid line on Figure 1. From this chart the choice of element size can be made based on viewing distance.

Examples. A console display for a single operator is normally viewed at a distance of about 18 inches, at which distance the limiting resolvable element size would be 4 mils. Appreciably smaller elements cannot be resolved, but ele-

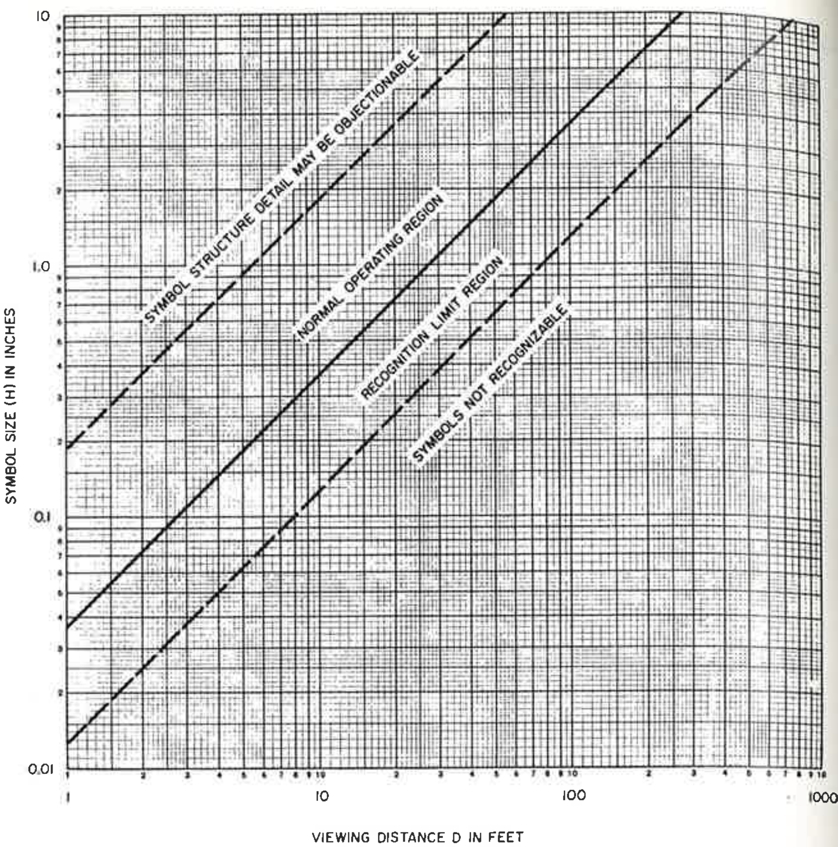
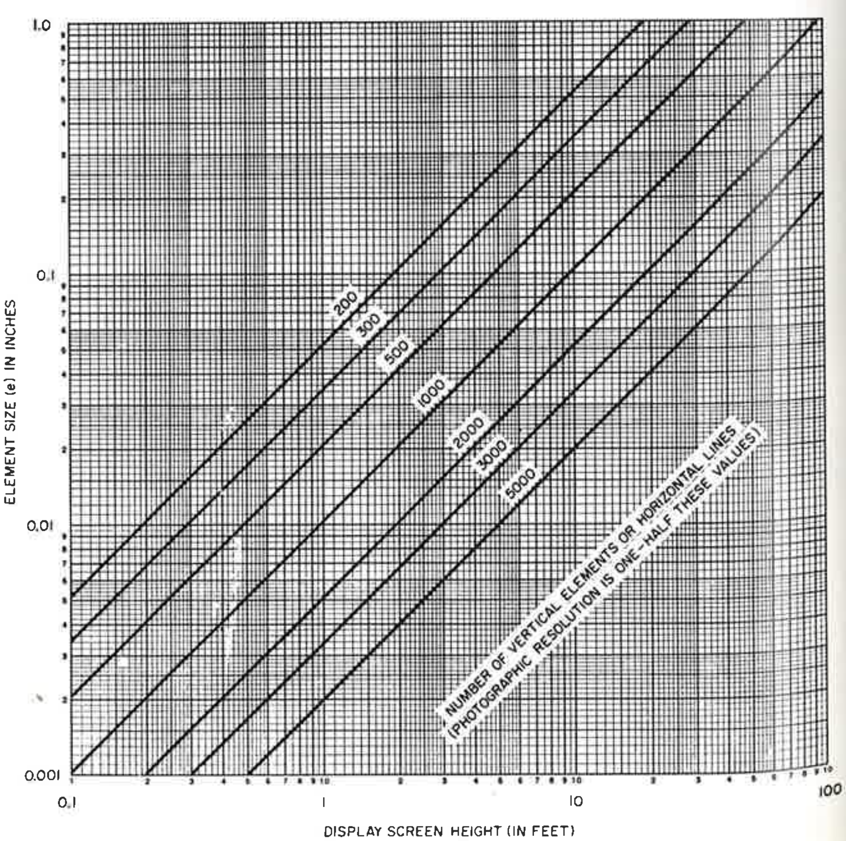


FIGURE 2: Relation of symbol resolution to viewing distance.

FIGURE 3: Relation of screen height to element size and number of vertical elements or horizontal lines.



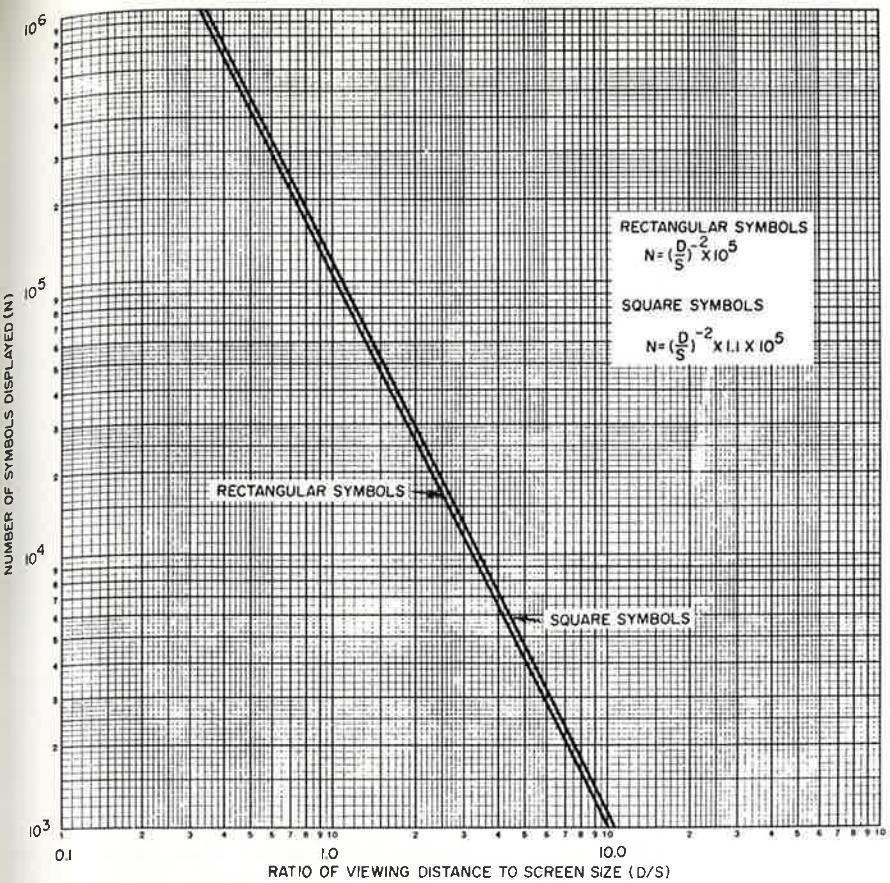
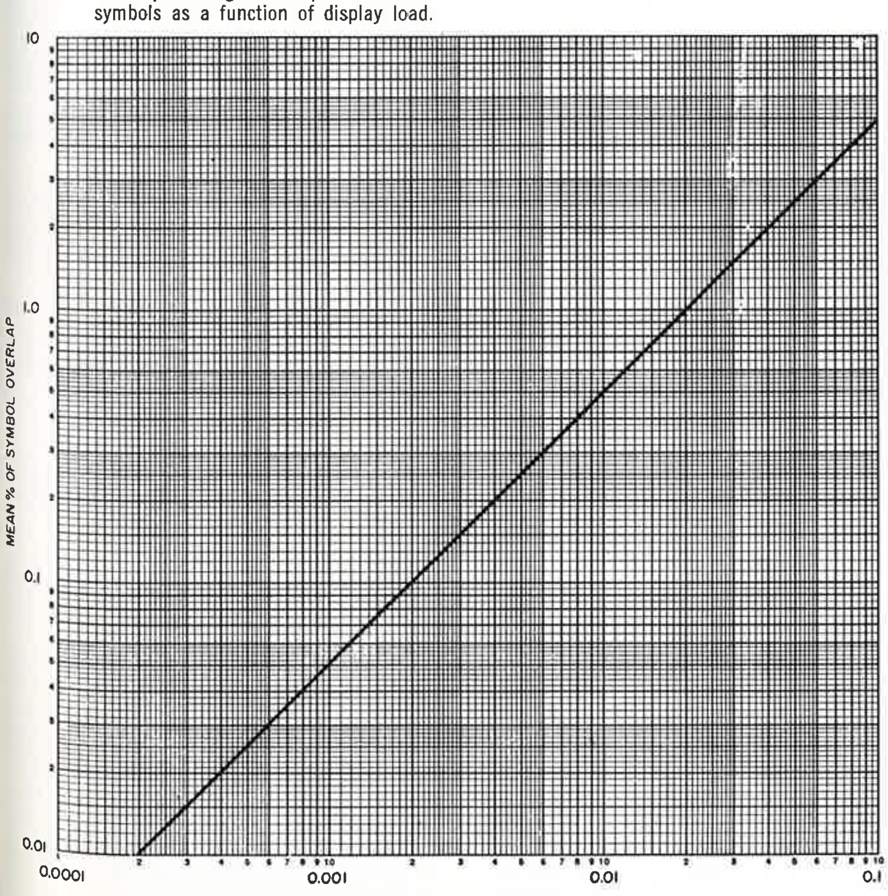


FIGURE 4: Maximum number of symbols of limiting resolution that can be displayed on a square screen having side dimension "S".

FIGURE 5: Mean percentage overlap of random symbols as a function of display load.



ments of two or three times the limiting value will result in acceptable displays, and greater than about five times will produce an objectionably "grainy" display. Thus it can be seen that for CRT displays the usual spot size range of 5 to 20 mils is quite compatible with the visual perception requirements of a console display.

The same procedure can be used to determine element size for group displays. Figure 1 shows that a typical acceptable element size range is 0.1 to 0.5 inch for a viewing distance of 30 feet.

Symbol Size

For the special, but rather important case where the display format is comprised largely of symbology, a determination can be made of the required symbol size for a given viewing distance. Assuming that the desired symbols can be formed from a matrix having no more than 10 x 10 elements, a symbol will visually subtend 10 minutes of arc in the limiting resolution case. Actually, while recognition of symbol form can often be made below this limit, smaller symbols would not normally be used. Symbols of three to five times the minimum size are usually acceptable, but will degrade the maximum display data capability.

The relationship of symbol size to viewing distance is indicated in Figure 2. For console displays, a symbol size range of 0.05 to 0.25 inch is appropriate, while for a group display viewed at 30 feet, the range is 1.0 to 5.0 inches.

Line Resolution

It is sometimes convenient to specify display resolution in terms of lines: the number of horizontal lines in a TV raster, or the number of resolvable line pairs in a specified distance, as used for measuring photographic resolution. Figure 3 shows the relationship of the total number of vertical elements or horizontal raster lines in a display to the display height and element size. The equivalent number of line pairs is, of course, one-half the number of elements or raster lines.

Determination is made of the number of vertical elements or raster lines in conformance with the positional accuracy or resolution requirements of the displayed data. Having determined this, the maximum element size can be found for any specific screen height.

Examples: For a typical 500-line TV screen with a height of 15 inches, the maximum element size is 25 mils (see Figure 3) which is consistent with the spot size of normal TV CRT's. Situation type data displays usually require a resolution and differential position discriminability. However, equipment limitations have often resulted in the use of fewer than the optimum number of lines.

Load

The amount of information which can be displayed by a symbology format is proportional to the total number of discrete symbols which can be simultaneously presented. To determine this number, an analysis is first made based on an ordered array of adjacently placed, non-overlapping symbols occupying the entire area of a square display surface. Following this, an approach to the problem of randomly distributed symbols is investigated based on acceptable levels of data loss by symbol overlap for various display load factors.

Ordered Symbol Arrays

For an ordered array we will consider two cases: an array of rectangular symbols spaced vertically and horizontally, as typified by an alphanumeric message format; and an array of adjacent square symbols, representing the maximum number of non-overlapping symbols possible for a situation display.

Rectangular Symbols

For this case, rectangular symbols with a height H and width of 0.65H are used, and are spaced vertically by 0.5H and horizontally by 0.1H.

Thus, each symbol occupies an area of 0.75H by 1.5H. If the symbol height visually subtends 10 minutes of arc for limiting conditions, then the total symbol area will subtend 7.5 by 15 minutes of arc. For a square screen having a side dimension S, it can be shown [1,2] that the number N of symbols of limiting resolution which can be accommodated is given by the relation

$$N = \left(\frac{D}{S}\right)^{-2} \times 10^5 \qquad (2)$$

where D/S is the ratio of viewing distance to screen size.

Square Symbols

If square adjacent symbols, which visually subtend 10 minutes of arc for each side are used, the maximum number is given by [1]

$$N = \left(\frac{D}{S}\right)^{-2} \times 1.1 \times 10^5 \qquad (3)$$

Practical limits for the value of D/S normally lie in the range between 1 and 5. Plots of equations (2) and (3), given in Figure 4, demonstrate that maximum symbol populations are between 4×10^3 and 10^5 for normal values of D/S. While these values are attainable for ordered formats, a more complex problem is posed where symbols are randomly positioned, as in a typical situation display.

Random Symbol Arrays

An approach to this problem was made by considering a square matrix of M total symbol positions and having N symbols of square shape randomly placed on the matrix. For this configuration, an expression was derived[3] for the mean value of the probability that two or more symbols would occupy the same position as a function of the display load ratio N/M. In Figure 5 the mean value of the percentage of overlapping symbols is plotted as a function of the load ratio. The series expression for the distribution of this probability function is not easily evaluated, but is expected to be rather broad. Inspection of Figure 5 indicates that for these conditions, the mean overlap percentage is equal to half the load percentage. Extrapolation of this data is difficult, since neither the overlap distribution function nor the analysis of partial overlap situations is readily subject to analytical expression. However, it might reasonably be postulated that load values of one to five percent would result in acceptably small overlap percentages for typical applications.

For a specific set of conditions, a more exact analysis can be effected by use of Monte Carlo techniques in conjunction with suitable computer programs which take into consideration various data formats, format distributions, and the degree to which data is not randomly positioned. Having this type of data, realistic maximum display load values can be specified for various degrees of data degradation caused by symbol overlaps.

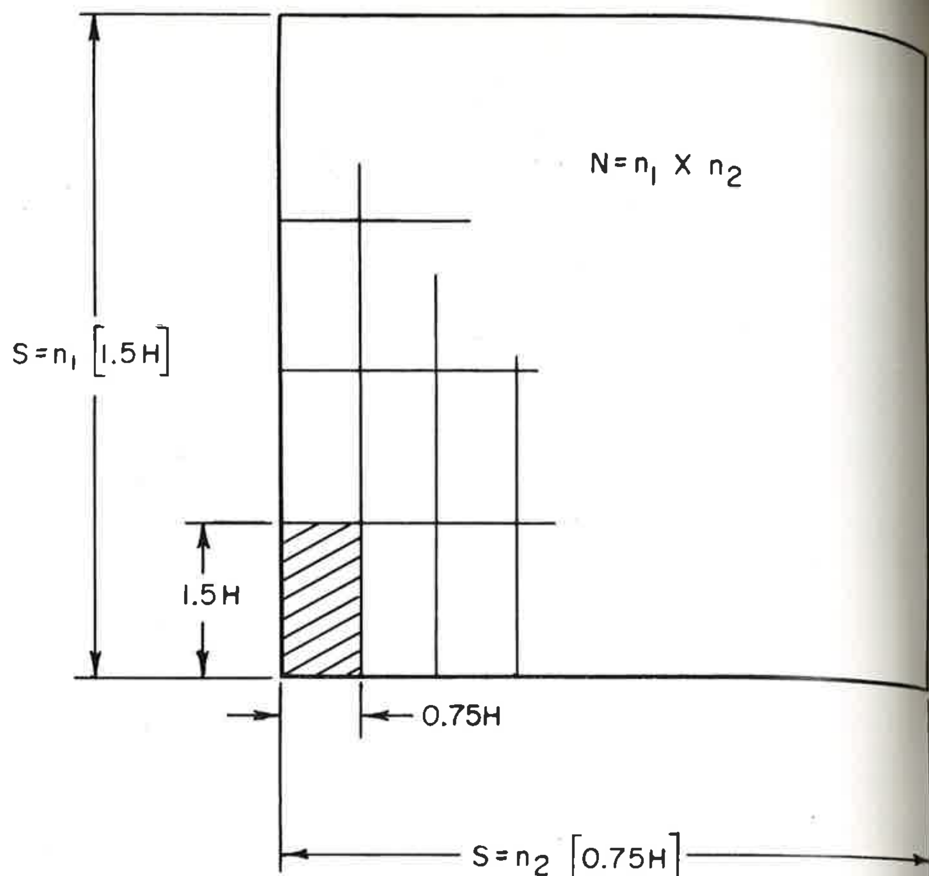


FIGURE A-1

Conclusion

It should be realized that while the preceding analysis will enable approximate determination of values for such major display parameters as overall size, resolution, symbol size and maximum information content, there always remains the necessity to consider system information requirements at the man-display interface, and other psycho-physical limitations of perception which may preclude use of the maximum physical capabilities of the display system.

Appendix A: Determination of Maximum number of Symbols of Limiting Resolution that can Occupy a Square Screen

Equation 1 of the text showed that the relation between minimum resolvable element size and viewing distance D is

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

For a symbol of height H which is 10 times e, the relation between symbol size H and viewing distance D is therefore

$$e = 0.003\ D \qquad (A1)$$

It is this relation which is plotted in Figure 2.

Assuming a rectangular symbol having a height H and a width of 0.65H, which is a typical proportion for alphanumeric characters, we can establish nominal horizontal and vertical separations of 0.1H and 0.5H, respectively. Thus, each sym-

1. See Appendix A.
2. These relations strictly hold only for viewing the screen at a normal angle.
3. See Appendix B.

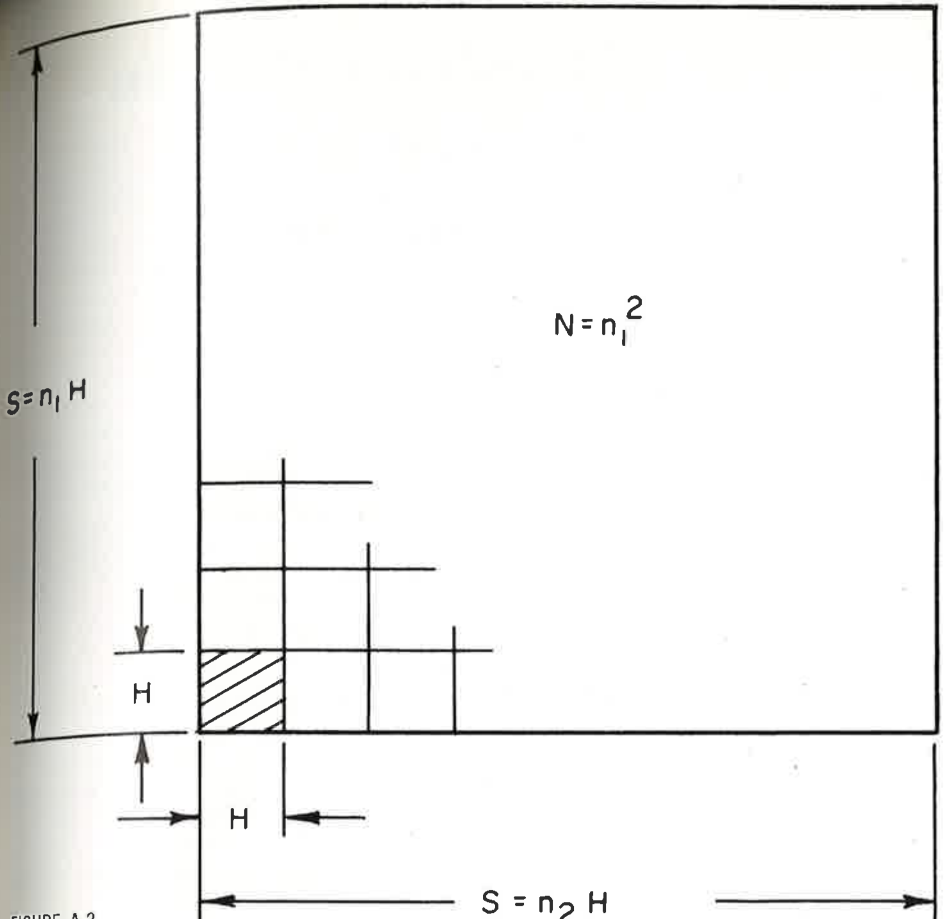


FIGURE A-2

bol occupies an area of 0.75H by 1.5H. If these symbols comprise the total area of a square screen having a side dimension S, as in Figure A-1, the total number of symbols will be the product of the numbers along the vertical and horizontal sides, n_1 and n_2. However, n_1 and n_2 are related by the proportion of the symbol area so that

$$n_2 = n_1 \frac{1.5}{0.75} = 2n_1 \qquad \text{(A2)}$$

Thus,

$$N = n_1 \times n_2 = 2n_1^2. \qquad \text{(A3)}$$

But,

$$n_1 = \frac{S}{1.5H} \qquad \text{(A4)}$$

so that (A3) becomes

$$N = 2\left[\frac{S}{1.5H}\right]^2 = 0.89\left[\frac{S}{H}\right]^2 \qquad \text{(A5)}$$

Substituting (Al) for H gives

$$N = 0.89\left[\frac{S}{3 \times 10^{-3}\,D}\right]^2$$

$$= 0.99 \times 10^5 \left(\frac{S}{D}\right)^2 \approx \left(\frac{D}{S}\right)^{-2} \times 10^5 \qquad \text{(A6)}$$

which relates the maximum number of normally discriminable symbols to the ratio of viewing distance to screen size.

For the case of square symbols of height H adjacently located on a square screen having a side dimension S, as in Figure A-2, the total number of discriminable symbols is

$$N = n_1 \times n_2 = n_1^2 = \left[\frac{S}{H}\right]^2$$

$$= \left[\frac{S}{3 \times 10^{-3}\,D}\right]^2$$

$$= \left(\frac{D}{S}\right)^{-2} \times 1.1 \times 10^5 \qquad \text{(A7)}$$

It should be emphasized that these represent maximum limit values which appreciably exceed those which normally would be used when other factors such as the effects of symbol size and quantities on human information assimilation rates are considered.

Appendix B: Determination of Overlap Probability of Randomly Placed Symbols

A partial analytic solution to the problem of randomly placed symbols can be obtained by considering a matrix having M total symbol locations and which contains N symbols located at random. The mean value of the number of symbols which overlap, i.e., are not uniquely located, enables determination of the mean overlap percentage. Evaluation of the distribution of this function is also required for a complete solution to the problem.

To find the mean value of the number of overlaps, let D be the total number of occupied matrix locations. The mean number of overlaps P is then

$$\overline{P} = N - \overline{D} \qquad \text{(B1)}$$

The probability that a given location will not be chosen is

$$\left(\frac{M-1}{M}\right)^N$$

and the probability that it will be chosen once or more is

$$1 - \left(\frac{M-1}{M}\right)^N$$

Therefore, the mean value of D, which is the mean value of unique locations chosen is

$$\overline{D} = M\left[1 - \left(\frac{M-1}{M}\right)^N\right] \qquad \text{(B2)}$$

From (B^1) and (B^2) it follows that the mean number of overlaps is

$$\overline{P} = N - M\left[1 - \left(\frac{M-1}{M}\right)^N\right] \qquad \text{(B3)}$$

Numerical evaluation of (B^3) directly using realistic values is difficult. However, the fact that

$$\left(1 - \frac{x}{y}\right)^y \cong e^{-x} \qquad \text{(B4)}$$

if $y >> x$ permits use of tables of natural logarithms or Poisson distributions for evaluation if (B^3) is put in the form

$$\overline{P} = N - M\left[1 - \left(1 - \frac{1}{M}\right)^N\right]$$

$$= N - M\left[1 - \left(1 - \frac{N/M}{N}\right)^N\right]$$

$$\cong N - M\left[1 - e^{-N/M}\right] \qquad \text{(B5)}$$

The mean percentage of symbol overlap $\overline{\sigma}$ is thus

$$\overline{\sigma} \cong 100\left[\frac{N - M\left[1 - e^{-N/M}\right]}{N}\right]$$

$$\cong 100\left[1 - \frac{M}{N}\left(1 - e^{-N/M}\right)\right] \qquad \text{(B6)}$$

which has been evaluated and plotted in Figure 5 of the text.

Evaluation of the overlap distribution function leads to iterative expressions which are impractical to evaluate except by use of a computer. While this was beyond the scope of the present investigation, it is evident that further effort in this area would yield useful data.

The author would like to acknowledge the assistance of Mr. David M. Jones in the area of probability analysis.

Some Pragmatic Considerations Influencing the Selection of Air Force Display Techniques

by Edmund J. Kennedy

Abstract

The selection by the Air Force from among many promising display techniques is influenced in part by pragmatic considerations that are sometimes overlooked. These considerations include logistics, availability and cost.

Data is presented on the impact of these on industry and the Air Force and the ill effects of failing to provide for the practical things. In some cases these ill effects, that could have been avoided, have unjustifiably been interpreted as limitations of the technique.

A useful approach to dealing with pragmatic considerations is to relate them to total cost over the lifetime of the system and a simple conceptual approach to the problem is presented.

Introduction

The Air Force and Industry, for different reasons, have a common interest in providing the best possible displays to the operational commands. Sometimes there is disagreement between these two parties that is based on a temporary failure to recognize this common interest. But more often there is a failure on the part of one or both to understand just what constitutes the best possible display. This is readily understandable since the best possible anything cannot be defined except in terms of one or more characteristics. The best possible display is in fact defined in terms of multitude of interdependent variables that interact in seemingly mystical ways to confound and confuse the display engineer. By now most of us have a good grasp of engineering design considerations and how they interact with operational requirements and cost factors. However, there are a few things that appear to have been neglected. The purpose of this paper is to show that in addition to the usual, well-known factors, there are practical considerations often overlooked by industry that are becoming of prime interest to the Air Force in deciding the direction of display development. These considerations can, and reasonably should, become part of the defining characteristics of the best possible display.

Although there have been some rewarding efforts in this direction, there is no way, at the present time, to quantify all the characteristics, and it is even more impossible to set up equations that one can solve to find the best display. However, many of these characteristics can be examined in relative isolation, quantified, and empirical equations devised to examine them.

The Process of Selection

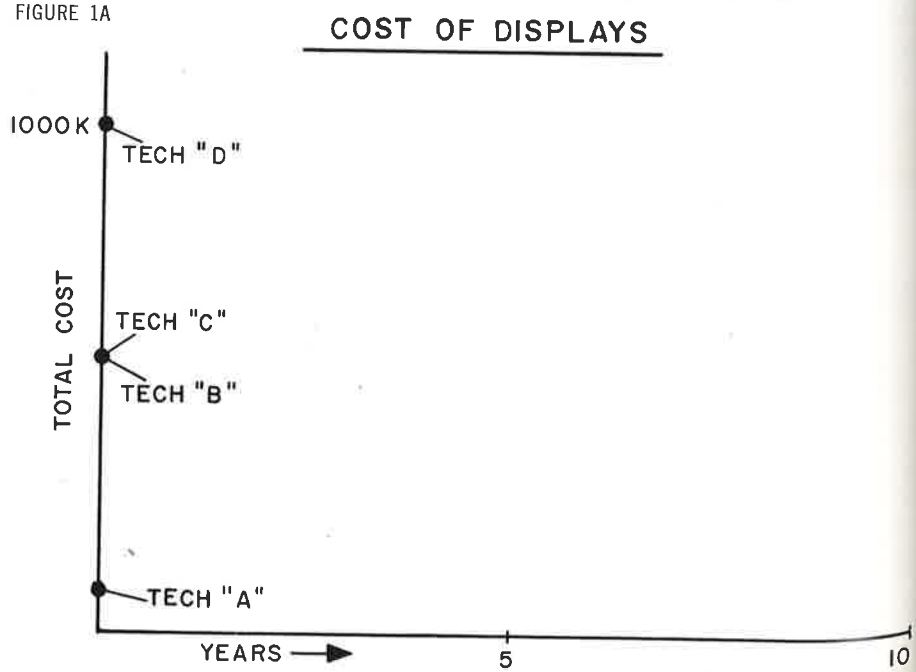
The specific factors and the factor weighings that are used to select hardware for systems application are not releasible. In any event they will vary to conform to the requirements of particular applications. Historically, the factors cover the areas of engineering, management and cost of acquisition. Seemingly, these very broad areas should be quite enough to permit selection of the equipment to provide the best display. And, depending on the criteria that one uses to judge, the Air Force usually does get the best of those proposed. In many cases the display could have been bettered had additional factors been fully considered. Experience has demonstrated that pragmatic considerations such as logistics, availability, and total cost are at least as important in hardware selection as the more usual considerations of brightness, contrast and response time.

The selection of industry proposals for development is based on somewhat more ephemeral characteristics than those used for systems hardware. However, the specific development items proposed by Air Force agencies or by industry for funding are those that are aimed eventually at Air Force systems use. These same practical considerations must be included among the critical factors that lead to selection or rejection. In fact now that we have some experience and some display capability to serve as a basis for judgement, the pragmatic are becoming some of the more critical criteria.

Pragmatic Considerations

In display engineering or any other form of engineering as well as in the management of our lives and careers, we are faced with a continuing series of compromises and tradeoffs. These tradeoffs are normally made on the basis of very practical considerations. There are multitudes of practical considerations and the importance of given ones covers a wide range and varies greatly from one

FIGURE 1A



situation to another. In one way or another most of them are accounted for and working solutions for problems are provided. Nevertheless, it is impossible to account for every single factor affecting the practicality of a hardware development. It would be a useless effort even to try. However, experience has shown that there are a few, very important, generalizable considerations that are overlooked through neglect, lack of understanding, or the attitude that they are someone else's problem.

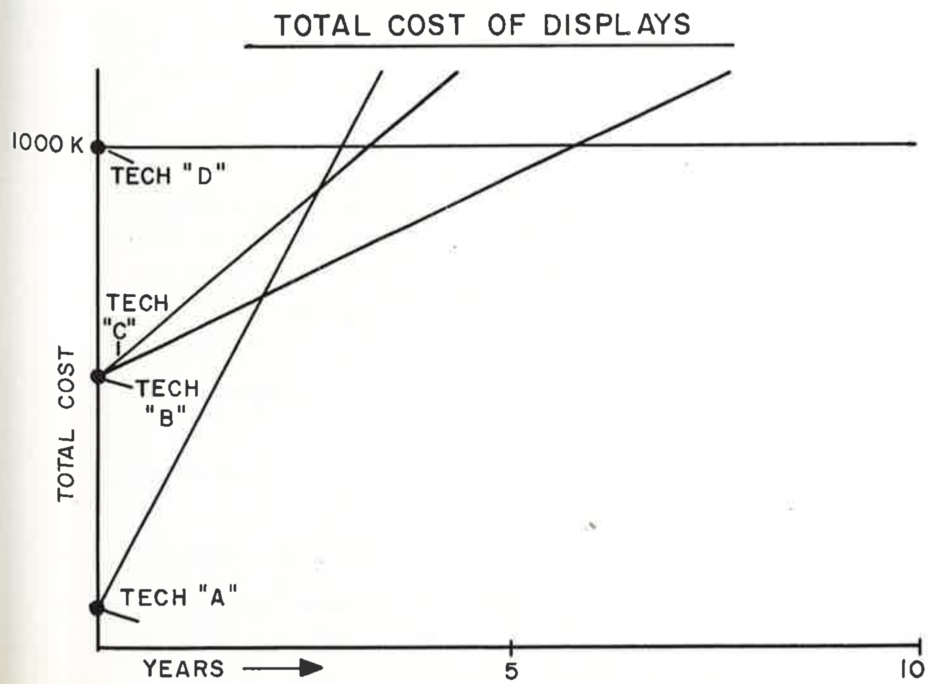
Failure to provide for these considerations for these reasons leads to poor experience with the hardware that has bad effects for both Air Force and industry. Failures of this type in their effects are very difficult to distinguish from poor performance due to inherent limitations of the technique.

The problem for industry is to find means to insure that their technique and equipment developments do not overlook critical practical considerations. The problem for Air Force is to recognize the difference between technique limited and inadequately engineered hardware. Neither problem has an immediate solution, but careful attention on the part of industry to factors affecting the long range practicality of their products is a first step.

Figure 1A indicates the possible costs of some hypothetical display systems as they are usually considered. Since technique D is most expensive, B and C are less and equal and A is least expensive, technique A is the obvious choice . . .

Figure 1B, however, brings us to an example of our first and probably in many cases most important pragmatic consideration — Total cost over the life of the system.

FIGURE 1B



A number of assumptions, perhaps unwarranted, must be made for the sake of discussion and illustration. First, is that the annual cost of a display is determinable; second, is that the annual cost is constant over the life of the equipment; third, is that the initial cost is determinable. Assuming the assumptions to be true, the total cost of a display system can be expressed by the slope-intercept equation $Y = MX + B$, where Y = Total Cost, M = Annual Cost, B = Initial Cost, and X = Time in Years. The set of equations shown in Figure 1B are extremely useful as aids to the discussion of display costs. It is immediately obvious that initial cost of procurement can be relatively overrated as the deciding factor in the choice of a technique ($Y \neq B$). Similarly annual cost alone cannot act as a basis for decision ($Y \neq M$), nor can initial cost and annual cost provide an adequate basis for judgement without consideration of time ($Y \neq M + B$). Only when the time that the equipment will be in the inventory is considered can a choice be made among A, B, C and D. Other examples of pragmatic considerations might be:

Logistics

In some instances one of the primary problems in logistics is the sheer bulk of the expendable material that must be supplied simply to keep equipment working. From the standpoint of logistics this is not a severe problem for installations within the ZI where transport is no problem and storage is relatively simple. The problems are much more severe in remote localities, particularly those sites that can be supplied only at infrequent intervals due to weather or other factors. Logistics becomes highly critical for the airborne command post. Therefore, we must be extremely careful to choose techniques that have logistic requirements compatible with the environment in which they are to be used. Within a given technique equal attention must be devoted to design decisions that affect the mass of logistics required for a specific application.

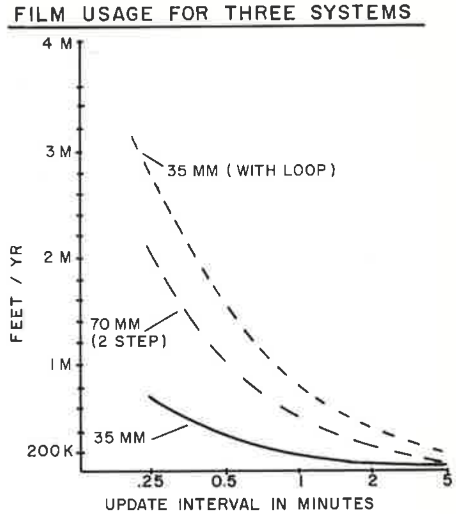


FIGURE 2A

Among film systems two of the decisions with far reaching implications have been the choice of film size, and the processing technique. Recognize clearly that there are very many variables influencing these decisions. Not the least of these are the quality of the display itself and the state of the art at the time of decision. However, for the sake of illustration, these can be ignored.

Figure 2 shows the amout of film and the quantity of processing fluids required annually for three alternative design approaches.

The center curve is representative of an approach that is based on a two step negative-positive approach using 70 mm film. Despite any other advantages the approach may have, it does use considerably more film than an alternative approach, bottom, based on a 35 mm reversal technique. The curves for both of these are indicative of the best designs within their respective approaches to a film system. Often there are alternative designs such as that shown in at the top for a 35 mm reversal system that uses large film loops and thus dissipates the saving in bulk inherent in the approach. These differences have little practical impact until there is a need for continual very rapid updating. Similar effects on the volume of chemicals required are complicated by the different effects of recirculation and disposal of used fluids.

Aside from sheer bulk, a major complication for logistics is the inclusion of rare, costly items of a critical nature as a part of the design. This is particularly important since such an item could make a display unsuitable for field use.

COMPARISON OF TWO APPROACHES TO FILM PROCESSING

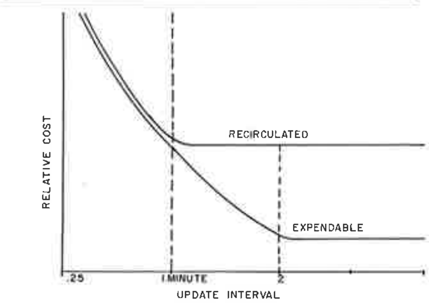


FIGURE 2B

Availability

Availability can be one of the most critical of all practical considerations in the selection of techniques and hardware. The recent moon launch is a perfect anecdotal example of an expensive highly complicated beautifully executed mission that was wasted because the power to the TV cameras was not available when needed. Availability is determined by both reliability and maintainability. Many of our present day displays rely on xenon lamps as light sources. MTBFs for xenon lamps are usually stated at about 1000 hours but actually this figure is low. Nevertheless, they do fail. Since these lamps are under many atmospheres pressure prudence requires that they first be permitted to cool and then be enclosed in a plastic safety shield before removal. A good estimate is that 50 to 60 minutes is required for replacement. This is not a very long time but that specific hour could be critical. Therefore, good design insures that this is not a limiting factor in the technique by providing for automatic insertion of a new standby lamp into the operating portion of the display.

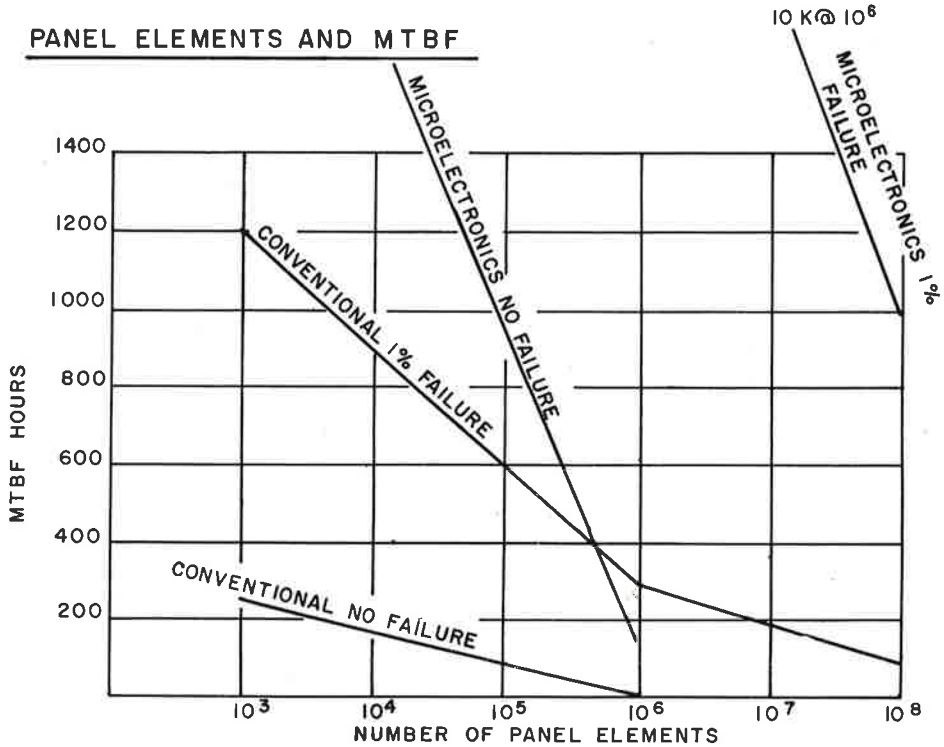
The cathodes used in the light valves have MTBFs variously estimated at from 25 to 100 hours. For these devices specific attention must be devoted to increasing life and reducing replacement time if they are to achieve their full promise for military applications.

A very severe problem of a somewhat different nature is faced by the discrete element displays. In order to achieve good resolution, a large number of elements in both X and Y are needed. Assuming an equal number in each direction, the total number increases as the square of the linear increases. Doubling from 500 to 1000 elements in X and Y increases the total from 250,000 to 1,000,000 elements. Based on seven components for each element and one million elements MTBF as shown in figure 3 is about 0.1 hours. This figure, of course, is for a single element failure and more than one can be tolerated.

Microelectronic techniques have the potential for eliminating any reservations about reliability due to this factor at least. Assuming ten image elements per chip and one million elements MTBF will approximate 100 hours for a single element failure, and ten hours for a 10 million element array. MTBFs for failures up to 1.0% of the total array are shown as a sample of what can be expected.

Of course another way to handle availability is by duplexing and multiplexing circuits components and displays themselves. Similarly, there are no problems of logistics that cannot be solved by getting something bigger and better; this might be ships, storage facilities, holes in the ground or boosters for rockets. These and most other practical considerations can be accommodated *if* we can tolerate the cost. Cost is a very appealing measure that has universal meaning and is very easy to describe and understand in terms of the slope-intercept equation illustration in Figure 1B.

FIGURE 3



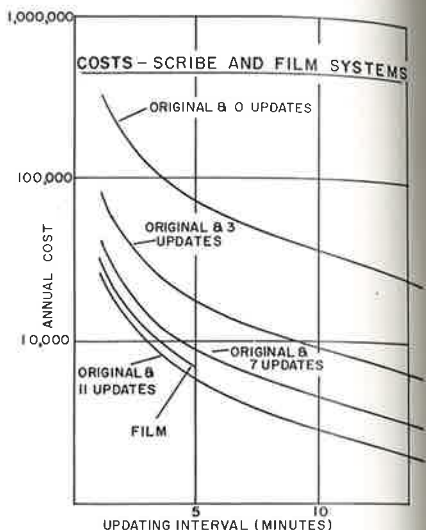


FIGURE 4

Costs

Any known technique has limitations that are real and absolute. However, many techniques have apparent limitations that can be overcome by inventiveness and ingenuity or, in some cases, by scrupulous attention to pragmatic considerations in engineering. Total cost over the life of a display system must necessarily be considered in deciding on courses of action. The following examples show how cost can be considered, show what can be real or apparent limitations, and, in some cases, indicate possible solutions.

Scribe Systems

These systems, for specific applications, have a number of appealing features. One of the outstanding features is low initial cost. However, the cost of the glass or metal slide upon which the data are scribed is relatively high. Thus, reverting to our equation Y = MX + B, these systems have low B and a high M. Comparison with other systems, on this basis, is complicated by the fact that these systems unlike film systems have an inherent capability to add on to an existing display instead of regenerating a complete new display as in the film systems. In an operational situation that requires tracking aircraft, a single slide can handle the original track and as many undates as can be tolerated.

A comparison of the costs of a scribe system and a film system is shown in figure 4 and must account for the rate of updating, the maximum time permitted between updates, and the maximum number of updates permitted on the display.

The data show clearly that there is no decision that one or the other is less expensive. All one can say is that "it depends."

Film Systems

Representative high quality film systems that can be built today have moderate initial costs and annual running costs that can vary from moderate to extremely high.

In part the annual cost, is due to the inherent nature of the film system – you throw away the film.

The amount of film that is thrown away and the annual cost varies over a considerable range. The range is determined by the choice of technique and the application of engineering skill based on a realization that the annual cost is as critical as the initial cost.

Aside from skillful, purposeful engineering based on conventional techniques there are some interesting approaches to extending any limits of the technique by reducing film costs. The first of these is aimed at reducing film costs by reusing the film or by providing a reusable counterpart. Approaches that are showing some promise in this direction are thermoplastic and photoplastic recording, and electrostatic printing techniques. If any of these approaches result in a reusable medium capable of a large number of reuses at a *unit* cost considerably less than conventional film many gains can be anticipated. The initial cost of systems will probably rise slightly but the decreased annual cost will result in lower total cost if the anticipated life of the system is long enough.

An extremely interesting approach is one that is aimed at reducing film cost by providing a color display by means of a single film frame rather than the three frames presently used. Such a technique, if feasible, could have a great impact on film systems. It could reduce annual film cost by two-thirds. Much more important, could be the impact on display design. At the very least it would eliminate two of the three projection barrels. The effects of this change could affect the design of the entire system by relaxing the severe requirements for registration and result in considerable savings in the initial cost and the annual cost as shown in figure 6.

The Light Valves

With the advent of the light valves it might appear that most of the cost problems will reduce to trivia. After all, these devices are already available commerciallly and they are in use in the entertainment field and have appeared in

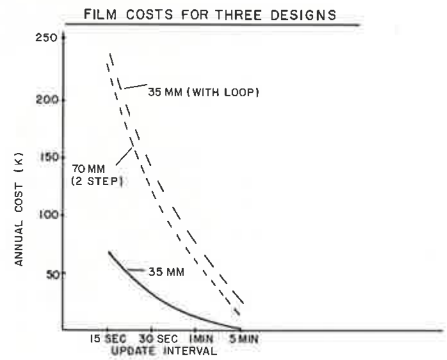


FIGURE 5

some military applications.

The application of the light valve to the computer driven command and control environment imposes requirements that are much more severe than those for presenting a championship fight in a theatre once or twice a year. Greatly increased performance must be provided in hardware that is extremely reliable and maintainable. These requirements interact to their mutual disadvantage. Increased performance is provided by more and better equipment that, in the absence of extreme care, becomes less reliable and maintainable. Even when these requirements are met, the initial cost of the equipment is likely to be an order of magnitude greater than commercially available equipment.

Annual cost can become a highly criti-

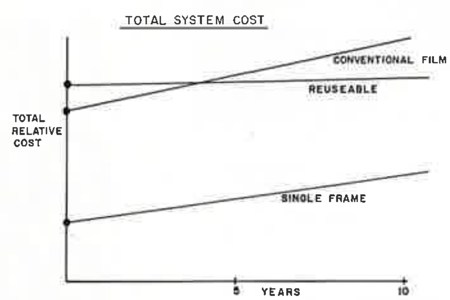


FIGURE 6

cal item if reliability is low. Aside from maintenance normal to any electronic/mechanical system two expendable items are relatively short lived and expensive. The xenon lamps have a rated life of at least 1000 hours or six weeks. The cost is roughly $400 each or perhaps $3,500 per year for each display. Not a very large amount, and very likely unavoidable, so little energy need be devoted to it. However, the cathode, which is essential to the operation of the equipment has an average life ranging from 35 to 100 hours. In the present designs, the short cathode life is due to the fact that the cathode is in the same chamber as the oil; the vaporized oil forms deposits on the cathode that lead to failure. The annual cost of cathodes can be extremely high. The light valve that meets military requirements can be considered as a device with a high initial cost and a moderate to low annual cost.

The attractiveness of the light valve will be considerably increased if the annual cost of operation can be reduced to a minimum by building in high reliability.

General Considerations

The importance of pragmatic considerations in guiding the development of display systems and techniques is only beginning to be realized. One of the most useful of these is the total cost. Major contributions to the total cost, like many taxes, are often disguised or hidden. Among the more important of these are the costs for technical data and for aerospace ground equipment (AGE). A critical look at Air Force requirements for technical data and contractors' costs and performance in providing AGE is needed if we are to control total cost.

There is an apparent feeling in some circles that AGE is the proper vehicle for recovering losses due to low bids on the prime equipment. This attitude is reflected in unreasonable costs.

A much more difficult problem is when a contractor fails to provide, in his design of prime equipment, for the checkout and testing that the AGE equipment is designed to perform. This results in an adapter/converter between prime equipment and AGE at a cost of many thousands of dollars.

Conclusions

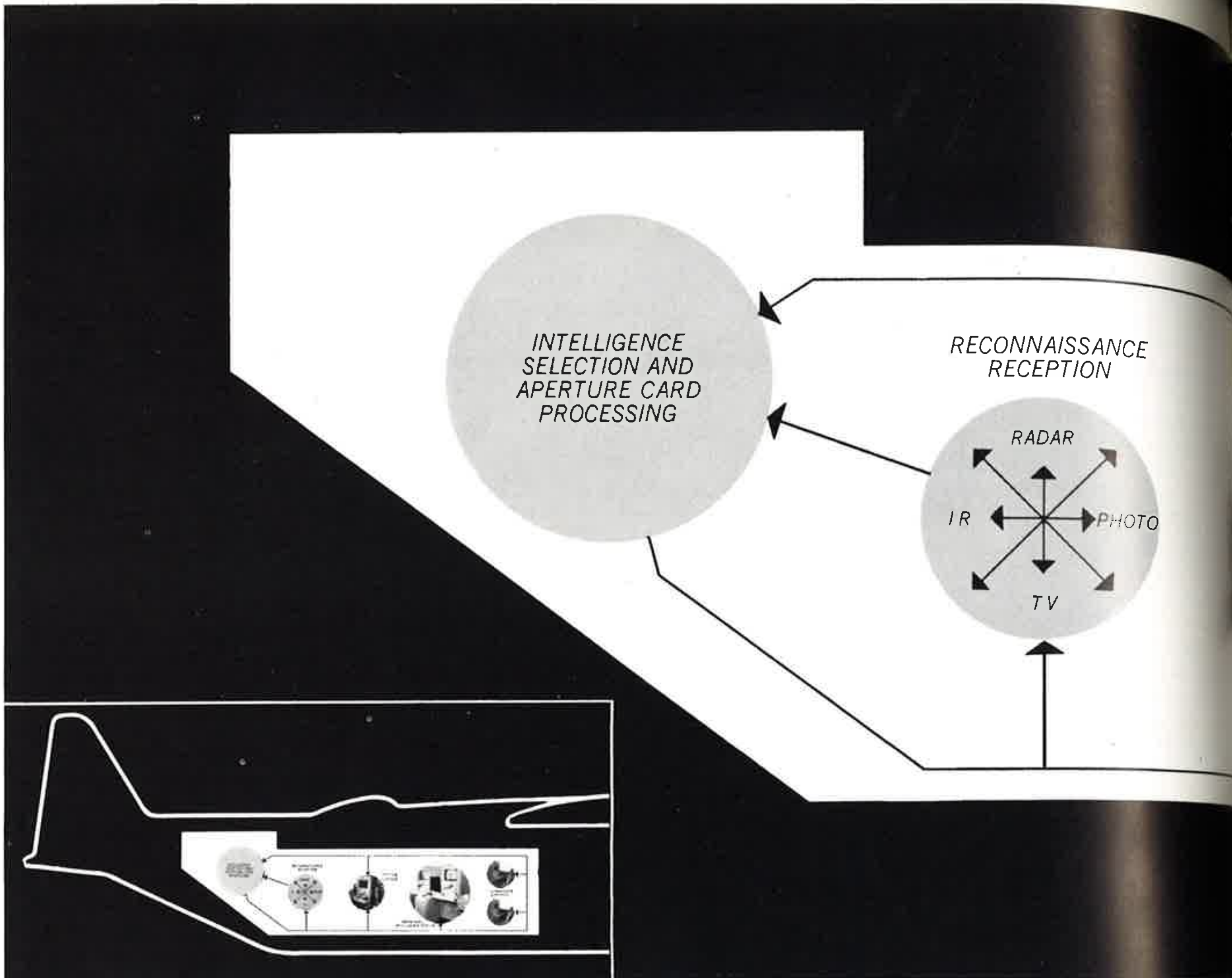
Failure to consider practical factors can lead to hardware designs that are poor approaches to a best possible display consistent with the state of the art.

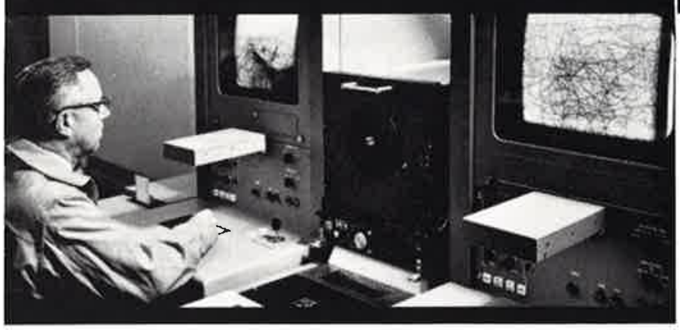
Such designs do not provide Air Force with desired capability and are easily confused with technique limitations. This can lead to premature abandonment of useful techniques.

One useful approach to dealing with pragmatic considerations is to relate them to Total Cost. Total Cost can be related to Initial Cost, Annual Cost, and Useful Life of the equipment.

Total Cost is influenced by many factors, not all of which are obvious. However, certain key items are expendable materials, maintenance/reliability, and AGE.

Air Force is undertaking a program to obtain data, define and quantify many of the variables affecting the cost and effectiveness of display equipment.





THE SKY'S NO LIMIT ON GPL COMMAND & CONTROL SYSTEMS

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MAN . . .
And the Navigation-Display Interface

by David B. Nichinson
President
Kollsman Instrument Corporation

> **Editor's Note**
> Continuing its policy of participation in ID-oriented technical symposia with other professional and scientific societies, the SOCIETY FOR INFORMATION DISPLAY co-sponsored the Institute of Navigation's twentyfirst annual meeting June 21-23 in Long Beach, Calif. The June 22 luncheon address by David B. Nichinson, President of Kollsman Instrument Corp., is reprinted here in its entirety because of its interest to readers of INFORMATION DISPLAY.

I am truly pleased to have been invited to express a few comments at today's luncheon. This joint session with the *Society for Information Display* is, to me, particularly significant and perhaps even symbolic.

As you know, I have been identified with the navigation profession for quite a few years. Most members of our profession, perhaps like those fortunate ones in other technical fraternities, truly enjoy their chosen work. We enjoy talking about our work — its problems — its challenges — and the potential solutions. We communicate freely — with one another. This work becomes a way of life. At times, to the lament of our wives and our families, our treasured work becomes almost life itself.

Periodically, however, I feel uncomfortable about what appears to be excessive inbreeding in the exchange of our ideas. The Dopplers fight the Inertials — even the Celestials fight the Inertials — and suddenly we effect a temporary peace with a Stellar-Inertial Doppler — or a Doppler Inertial — and conjure up an appropriate acronym. Our exchanges, however, are much too confined for they are with one another.

Navigation is prerequisite to effectively arriving at the selected destination. It is not, however, the end in itself. With the utmost of perfection in our navigational techniques and measurement, we must still resort to other subsystems if we are to successfully complete our mission. The complexities of today's assignments require the interface and reiterative exchange with many other disciplines.

At a session like today's, we are not only communicating what we know, what we think, what we propose, but we are sharing these possessions with others who, in their own faiths have also been called upon — who are to participate along with us to jointly attain our common goal — the timely and effective arrival at our destination.

There is something else symbolic in today's navigation display program. The Institute of Navigation is primarily concerned with the development of quantitative information, its acquisition, its processing, and its application to the successful execution of the navigational equation. Throughout its domain, the information is factual, physical and objective.

The Society for Information Display enters with the acknowledged acceptance of man within the system and concentrates on the manner of communicating with this vital, most critical, but, unfortunately, the most subjective and most unknown facet of the total system. The acknowledged and accepted return of man as an indigenous part of our system (or at least as part of many of our newer systems) is, to me, most gratifying. Man's positive responsibility for information management and decision is, indeed, encouraging.

My comment on man's return may be greeted with some skepticism — for when did he abandon this role? During the last war, starting around 1940, truly revolutionary strides were made in the field of electronics. This progress and the attendant development of servos, analog computers, and the previously unmastered portions of the electromagnetic spectrum, all fostered an intensified era of push-button thinking. Man was called upon to create new machines — but subconsciously, or perhaps even consciously, was being evicted from his own machine's decision process — except for that push-button. While the basic technologies were advancing and even galloping, and high degrees of automation were surprisingly being achieved — almost like those ever-appearing strains of new viruses — the simple push-button proved almost diabolically evasive.

The dynamics and the complexities of evolving systems seemed to multiply faster than the automated solutions appeared. The need for increased precision, greater speed, and more expanded scope, collectively necessitated whole new orders of quantitative measurement and processing. The exponential explosion of our endeavors added so many more variables, that man's unique decision abilities became more engulfed in information management and the decision process than ever before.

We are now desperately in need of man — inside and outside his vehicle. Man is not to hold back the advancing tide of automation, nor is he to preserve those functions which can be done better and easier by his creations, but he is still, and vitally, required to judge that being done — to control it — to use it wisely. Man must not be transformed to the servant of his own creation but must remain the master. For example, our large command and control installations are not, in themselves, managing a situation. They are but accumulating and reporting basic and prerequisite information and are but part of man's decision making process and responsibility.

We are also now focusing attention on not only the introduction of man, but we are almost in search of a new man. We must get to know him – to train him – to enhance his abilities – to fulfill the essential role of greater and more responsible decision making. We are not simply expecting him to create – he is to, and he must, participate.

Returning to our navigation domain – in a rigorous sense, navigation involves the vehicle's present position and the course and distance to its destination. While the somewhat static, though reiterative, characteristics of this basic information can be transformed to more meaningful dynamic terms and thereby provide prior trends and even anticipate future evolutions, the actual decision process must, by necessity, give due consideration to a wealth of other related environmental factors.

In the case of a simple aircraft, the course to be pursued could be materially influenced not only by the static factual data of present position and destination, but, at times, influenced even more so by weather, fuel consumption, traffic, equipment limitations, or even difficulties. All such pertinent information must be processed for more proper decision. In a true practical sense, man alone currently possesses the basic abilities to perform this function. All of this information, therefore, must be effectively communicated to man for his management, for his digestion, and for his decision.

Information management, under different names, has been with man from his very beginning. Man, using his natural sensing elements, has received inputs regarding environmental conditions, physical well-being, proximity to danger, etc., and has reacted, or processed, these inputs to motivate his actions. Man's social evolution has enhanced some of these abilities, while others have been attenuated since they may no longer be truly essential to self-preservation nor prerequisite to man's pursuits.

Although we live in the "push button" era, analytical system engineering analysis, as well as empirical experience, has taught us that man, for the moment at least, is still the most important decision element in our complex dynamic control systems. All information management systems possess the same basic requirements, including the processing of masses of information and their reduction to a minimum number of easily understandable presentations which lend themselves to rapid interpretation. With man, however, part of the system, the manner of presentation, involves as many physiological and psychological considerations as technical ones.

Certainly, as of today, the vast majority of the interface with man is in the visual band. The visual channels possess, by far, the greatest accessibility to man's data processing centers. In time, however, this medium may be complemented by, or even displaced by other channels, for instead of displacing man, greater attention is now being directed to the positive introduction of man to our more complex systems. Intensive study is now being directed to better understand this human subsystem and explore those techniques which may enhance man's ability to fulfill even more complex information management assignments. For the present, however, the visual presentation format is the most effective when large quantities of data must be conveyed.

The data handling capacity of the human visual system is substantially higher than any other sensory mode and, in addition, provides some unusual discrimination properties not present or yet detected with man's other senses. Communication by visual display, therefore, rates well when measured in terms of data handling capacity, memory, resolution, accuracy, longevity, channel band width, and other unique parameters such as color differentiation, and moving target perceptivity.

Many discussions of display do, however, place disproportionate emphasis on that transmitted rather than the receipt and interpretation of that provided. Unfortunately, in this same visual area, as a result of man's complexity, "seeing" is not to be immediately assumed as "believing." While the ideal technician may generate the desired navigation information with appropriate definition and precision and conclude that, once presented, there could be no question of judgment, such, unfortunately, may not be the case when interfacing with man.

In the organization with which I am affiliated, while we are engaged in many other domains, we are very strongly identified with what might be deemed a simple parameter of flight altimetry. While our instruments perform the many complex sensing and computing functions which are part of altitude measurement, after two decades of intensive work, the most difficult problem which confronts us is still presentation. We are called upon to provide a simple reading and, in spite of the relative simplicity of this display task, and with due respect for all of the human engineering which has been performed, we, as a company, and others in our segment of the industry, still provide a vast assortment of individually tailored altitude presentations.

Some airlines and military groups prefer three-pointer presentations. Others prefer the drum and pointer. Some aircraft prefer the vertical scale approach. The Navy prefers the counterpointer – and now we are seriously considering the drum-counter-pointer configuration. Each of these display the simple indication of altitude. It would appear that all factors influencing the type of display selected would be comparable – pilot intelligence – pilot physical condition – types of aircraft – operational requirements, etc.

The resulting assortment, however, is not the product of capricious nor arbitrary men, but rather the mature conscientious and deliberated belief and conviction that one presentation is, indeed, better than another, and their lives could well depend on their decision. It is evident, therefore, that even with a relatively simple item – a single altitude reading – the subjectivity of the operator – the influence of his training – the influence of his environment – can and do have significant bearing on how and what he sees and what he believes worthy of inclusion in his unique decision making process. He may not believe that which he sees – he may believe that which he thought he saw.

This interface between man and his creations requires continuous and reiterative interchange. Neither domain, man nor his creation, can be developed separately and simply welded together. Each must understand and work with the other. We might quickly conclude that man possesses a good appreciation of that which he has created. Surprisingly, however, he, at times, is embarrassed to learn that there is more to learn about his own developments. His creations take on characteristics and personalities of their own. At times, they logically do things which they are not supposed to do, things which circumvent all of the protective planning included in their evolution. In addition, much must be learned of man's response and acceptance of that being communicated.

Perhaps, in working with other senses, more straightforward exchange will be possible. In the visual area, however, we take too much for granted and our conclusions are much too subjective. Much has to be learned about this communication medium, for we know so little.

As I speak, I have noticed that one member of the audience has beautifully articulated one of my comments much more effectively than all my words. I noticed that on several occasions he looked at his watch. He looked again and again. The last time he also put his watch to his ear to see if it was still running. It spite of what he repeatedly saw, he did not believe time was passing so slowly. In this case, however, I too am using my visual communication and data processing and I believe what I see. I get the message.

Thank you – I have truly enjoyed being with you!


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Sixth National Symposium
Society for Information Display
New York City
29-30 September 1965

This important event will be held at the Commodore Hotel in New York City and will have a number of features that promise to make the forthcoming SID National Symposium more rewarding than ever.

Fordyce Brown, President of Photomechanisms, Inc., is the overall Convention Chairman. He has chosen a well qualified, hard working group of chairmen responsible for specific activities. Solomon Sherr of Sperry Gyroscope is Vice Chairman.

Edmund Kennedy of Rome Air Development Center, Papers Chairman, is presently reviewing papers to choose those that should be exciting, challenging, speculative, provocative or even controversial.

For Program Co-Chairmen, William Bethke of RADC and Carl Machover of Information Displays, Inc., will arrange for the various speakers and other activities.

The Exhibits and Equipment Show is being coordinated by Sherman Blumenthal of Touche, Ross, Bailey and Smart. Frank Masters of Trade Associates, Inc., is the Exposition Manager.

The Facilities Chairman is Charles Emmert of CBS Laboratories. Burton Price of Philco Corporation is Chairman of Registration, and Henry Oppenheimer of CBS Laboratories is the Financial Chairman.

Publicity Chairman is Gordon Burroughs, Burroughs Engineering.

Technical Sessions

On Wednesday, technical sessions will begin with the keynote address by Brig. Gen. A. T. Culbertson, Commander, Rome Air Development Center. The technical sessions will all be related to displays but will cover broad areas, including Systems, Science and Art, Display/Computer/User Interface, as well as Physics, Electronics, Optics, Photochemistry, Physiology and Psychology as they are applied to Information Display.

At lunch, Fordyce Brown will be the Master of Ceremonies; he will present Dean John Sullivan, Florida Atlantic University, who will speak on Information Display in Education. Following this will be more technical sessions and then a banquet address by E. J. Stockwell of NASA's Office of Tracking and Data Acquisition. Robert Klein, Kollsman Instrument Corp., will be the Master of Ceremonies.

On Thursday, there will be more technical sessions morning and afternoon with Harold G. Davis from North American Aviation Space and Information Systems Division as the luncheon speaker and Carl Machover as Master of Ceremonies.

Five Minute Papers

Included in the technical sessions will be a series of five minute papers, an innovation at technical symposia that promises to provide more information in less time.

Ladies Program

For the first time, a special Ladies Program has been arranged. Each morning, a continental breakfast will be served in our Ladies Hospitality Suite. Hostesses will be available with authoritative information on where to go and what to do in New York City. Tours of the United Nations and a "Dutch Treat" lunch in the Delegates Dining Room, as well as the SID Banquet in the evening, are arranged for Wednesday. On Thursday, brunch at La Fonda del Sol, a tour of Rockefeller Center, and a show at the Radio City Music Hall are scheduled.

Registration

Advance registration forms and a preliminary program have been mailed out, but additional advance registration forms can be obtained from Burton Price, Philco Corporation, 390 Welsh Road, Willow Grove, Pennsylvania 19090 (Telephone 215, OL 9-7700).

Any other Symposium information can be obtained from Fordyce Brown, Photomechanisms, Inc., 15 Stepar Place, Huntington Station, L.I., N.Y. (Telephone 516, HA 3-4411).

Preliminary List of Exhibitors

Burroughs Corp.
Electronic Components Division
P. O. Box 1226
Plainfield, New Jersey
Mr. John L. Turnbull
Manager, Advertising
Booths 35 and 36

CBS Laboratories
A Division of Columbia Broadcasting System, Inc.
227 High Ridge Road
Stamford, Connecticut
Mr. Alexander J. Autote
Manager, Marketing Services
Booth 42

CELCO (Constantine Engineering Laboratories Co.)
70 Constantine Drive
Mahwah, New Jersey 07430
Mr. Robert O. Meres
Purchasing Agent
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General Precision, Inc.
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Mr. Arthur Brundage
Booth 48

Kollsman Instrument Corp.
80-08 - 45th Avenue
Elmhurst, New York 11373
Mr. Jack G. Anderson
Vice President
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LTV Military Electronics
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Booths 53 and 54

Mosler Safe Co.
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Mr. Alan C. Root
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Advertising & Sales Promotion
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Thomas Electronics, Inc.
122 Eighth Street
Passaic, New Jersey 07056
Mr. Eugene V. DiSciullo, Sales Mgr.
Booth 6

ID Authors

Dr. H. R. Luxenberg

Dr. Luxenberg's biography appeared in the last issue of *Information Display* with another related article.

Glenn E. Whitham

Glenn E. Whitham is Staff Consultant, Control Systems Dept., Surface Radar and Navigation Operation, Raytheon Co. He holds an SB EE from MIT, and has engaged in graduate studies at Northeastern University. He has been a staff member of MIT Radiation Lab and Los Alamos Scientific Lab. At Raytheon, he has been associated with display or information systems in Tartar, Hawk, Mauler, on-board logistic spacecraft displays, FAA bright displays, and numerous control center display systems.

Quentin L. Bonness

Mr. Bonness joined The Bunker-Ramo Corp., where he is Senior Staff Engineer, via the original Ramo-Wooldridge Corp. in 1956 and has been principally engaged in systems analysis for applications of data processing and display systems. He received his BS/EE from the University of Nebraska, and his MS/EE from the University of Illinois. Prior to his current affiliation, he was employed at GE and Gilfillan, and taught EE at Nebraska. His professional memberships include IEEE, ACM and SID.

Dr. Edmund J. Kennedy

Dr. Kennedy served in the Infantry during World War II, then obtained his BS, MA, and PhD degrees from Columbia University. He entered government service in 1954 as project engineer in what later became the Human Factors Laboratory. Until 1963, he served as Chief, Control & Guidance Branch, where major responsibilities were displays aspects of large "L" systems. He has served on several national committees, and is now Chief, Advanced Analysis Section, Display Techniques, RADC.

ID Papers

All manuscripts submitted for publication in **Information Display** should be addressed to: R. L. Kuehn, Publications Chairman, 1831 Seadrift Drive, Corona Del Mar, California. Authors are requested to enclose a recent photograph and up-to-date biography. If illustrative material accompanies text, suitable stiffening should be used to protect artwork and photographs.

ID Readout

Cambridge University Display System

The Mathematical Laboratory of Cambridge University is using a Display Control System, supplied by Digital Equipment Corp. (UK) Ltd., for research into man-machine communications and computer-aided design. The system, ordered in January, went on-line less than three days after delivery. It consists of a PDP-7 computer with 8192-word core memory and an incremental CRT display and light pen. The display functions as a sub-computer, obtaining data and instructions directly from the PDP-7 core memory. It has random point, vector, increment, and other plotting modes. Use of the light pen allows the operator to "draw" symbols and shapes directly on the face of the display, as in Digital's experimental GRAPHpad program. GRAPHpad simplifies and speeds up the drafting steps normally required in designing electronic logic circuits.

Integrated Manned Space Systems Simulator

The Manned Orbital Laboratory Simulator shown above is part of an advanced system, called an Integrated Manned Space Systems Simulator, recently completed at the General Dynamics Corp. Astronautics Div., San Diego. The entire system will be capable of simulating in detail every conceivable manned mission in Earth orbit, to the moon, or to any planet in the Solar System. Its purpose is to study man's role in space to gain a better understanding of the requirements for crew systems and spacecraft design. The photograph above shows TV screen on which computer-driven views are presented exactly as they would be seen through windows of a spacecraft by an astronaut.

Nonconfusing Control Panels

The high degree of efficiency required of the operator of modern electronic and mechanical equipment necessitates control panel design that is conducive to fast and accurate control responses. Unfortunately, spatial constraints sometimes make the ideal functional grouping impracticable. As a consequence, certain compromises must be made in the design of the panel, according to Michael V. Fiore, Systems Div., General Precision Inc., who presented a paper entitled "Control/Display Association Stereotypes in Grouped Panel Arrangements" at the recent Aero Space Technical Conference in Houston, Tex. In the paper, he disclosed some results of a research program he has carried out on this problem. He noted that regardless of labeling, color coding, shape coding and other cues to correct association, if the operator has habits of association contrary to those which the panel arrangement calls for, the probability of error increases greatly. The average person has what he calls association preferences when switches and associated lights are involved, according to the author. It was found that when groups of controls and displays are arranged in a rectangular configuration so that the controls are on two adjacent sides and their corresponding displays are on the remaining adjacent sides, a tendency exists to associate displays with controls directly opposite rather than adjacent to them.

Air Surveillance from the Ground

Aerospace Group, General Precision Inc., has produced equipment whereby aerial surveillance can be relayed to and displayed for ground commanders in real time. Radar and infrared sensors on reconnaissance aircraft can see what no visual observer can see. By adapting a unique digital data transmission system to an existing video data link, pictures of the infrared and radar readouts are transmitted to and displayed by a ground console. At the same time, precise aircraft position and flight condition information is transmitted and displayed on the same console. A digital clock is included in the system to provide the necessary timing signals and, sequentially, control and scanning of the three information channels. Total synchronism of pictorial observation data and flight condition data is the system's prime feature.

Advanced Navigation Systems

The U.S. Air Force has officially accepted an advanced navigation system incorporating the best features of three types of navigation systems in use in aircraft. Designated the AN/ASN-59, the Stellar-Inertial-Doppler (SIDS) navigation system produced by Litton's Guidance and Control Systems division will provide the Air Force with continuous, automatic 24-hour, all-weather navigation to an accuracy much greater than previously obtainable in a lightweight system. The basic method of navigation is inertial, the same technique employed in newest Air Force and NATO jet fighters and Navy patrol and attack aircraft. The inertial subsystem automatically tells the pilot his position and the heading and distance to any of 90 destinations, and operates continuously without reference to the ground, sky or radio or radar beams. Velocity information from a Doppler navigation system increases the long-range accuracy of the gyro-stabilized inertial system, which measures aircraft acceleration, heading, altitude, ground speed and track angle. The astro-tracker subsystem obtains star fixes to check the latitude and longitude position data indicated by the inertial subsystem. A computer processes the information from these three navigation subsystems, provides output signals for displaying navigation data on the pilot's or navigator's control panels, and performs computations necessary to control the SIDS system. Most advanced feature of Litton's SIDS system is the astro-tracker subsystem, which automatically tracks two or more stars in daylight, as well as at night, to determine the precise position of the aircraft, corrects the position indicated on the control panel, and sends appropriate corrective gyro bias signals to eliminate the cause of the error. Using position and heading information derived by the inertial subsystem, the computer determines the elevation and bearing of predetermined stars within the field of view of the astro-tracker subsystem at that time and position, and sends pointing angle commands to the tracker telescope. The computer stores elevation, bearing and other information on at least four preselected stars in view at any time and point on Earth. The telescope slews to the commanded pointing angles and, if a star is within the field of view, a star presence signal is generated. Also generated are star position signals indicating whether the star is left, right, above or below the center axis of the telescope. The digital computer, upon receipt of these indications, generates control signals to center the star in the telescope field. If, within 15 seconds after slewing to the commanded elevation and bearing, there is no star presence signal, the computer will generate signals for a search, which continues until a star presence signal is generated or the search time runs out. Then the telescope slews to another star.

Polaris Submarine Navigation Simulator

A new $500,000 training simulator will be added to the New London submarine base's "high and dry fleet" which lets Polaris submarine navigators steer through every navigational situation submarines meet at sea. Built by Sperry Rand's Sperry Gyroscope Co. Div., the trainer can simulate any undersea position in the world, at any operating depth, in any weather, at any time of the day or night — and with the navigation system working normally or with simulated problems. Most of the navigation equipment aboard the trainer is a full-scale operating copy of the units aboard every Polaris submarine afloat. It is arranged physically to reproduce the layout of the subs' actual navigation centers. In the trainer, a voyage can be stopped, repeated, or sped along faster than real time. An instructor at the computer console watches displays which tell him the "actual" position of the make-believe boat, while a printer types out a running log showing where the student navigators think they are, for after-class evaluations.

Document Retrieval Seminar

A four-day seminar on evaluating document retrieval systems will be given in the nation's capital beginning Sept. 7, and will be repeated in Philadelphia, Boston, and New York during the balance of the month. It will be sponsored by the Center for Information Resources, Inc. (CIR), Washington, D.C., a subsidiary of Herner and Co. The following subjects will be included among those covered by the course: Measuring the operating efficiency of document retrieval systems; factors affecting operating efficiency; test design and methodology for the evaluation of operating efficiency; analysis of test search results with emphasis on determining the reasons for recalling unwanted documents and for nonrecall of wanted documents; interpretation of analysis from the points of view of indexing policy, search strategy, system design, and other effective variables; relationship between operating efficiency and economic efficiency; and test design and analysis of search results. Lecturers for the course will include Cyril W. Cleverdon, F. Wilfrid Lancaster, and Saul Herner.

Chapter News

The Mid Atlantic Chapter's May meeting was held at the Naval Training Device Center, Sands Point, L.I., N.Y. NTDC is located on the site of the former Guggenheim estate overlooking Long Island Sound. The administration and contract departments are located in the main house, while the engineers are in what used to be the stables, a beautiful building about 50 feet high and 200 feet in length, entirely built of hand cut stone blocks about four feet thick. The work was done by Italian craftsmen brought to this country for this specific purpose. Commander E. C. Moss, the Assistant Director of Research, described the Center's function of developing training devices for all of our armed services. The Center is divided into the Physical Sciences Laboratory, the Electronics Laboratory, the Visual Simulation Laboratory, the Computer Laboratory, and the Human Factors Laboratory, in addition to the various laboratory service departments. Mr. Sol Domeshek, Head of the Physical Sciences Laboratory, and Mr. H. Voss, the Assistant Head of the Human Factors Laboratory, described a number of their projects. We were then taken outside where Major Cunningham demonstrated some of their equipment for simulating the sound and blast effects of various guns and cannon.

Fall Joint Computer Conference

Approximately 20 technical papers are being selcted from an unprecedented 300 drafts submitted for review, to be considered for the Fall Joint Computer Conference, Nov. 30-Dec. 2 at the Convention Center, Las Vegas. Cochairmen of the technical program committee are S. Nissim and T. B. Steel Jr. Drafts were submitted from every section of the United States, and from several foreign countries. Topics include aspects of information sciences, ranging from exotic programming theory to data system management and practical applications. Each paper is being refereed by three or more qualified subject matter specialists not associated with the FJCC technical program.

Information International Inc.

Information International Inc. has announced a new policy with regard to educational use of its automatic programmable film reader, installed at III's Cambridge, Mass., office. It will make available its PFR-1 system, which has the capability of reading, digitizing and analyzing pictorial or graphic data under program control, to any educational organization whose efforts in research could benefit from its use. It is offering the use of the complete system, generally during second or third shift hours, at the reduced rate of $50/hr.; in one hour, a researcher could read, digitize and record on magnetic tape over 5000 oscilloscope traces, at a cost of 1¢/trace. III has inaugurated the program because of the large number of inquiries from universities, both in the United States and abroad, and because they operate on limited budgets and grants. Users have the advantage of utilizing programs the firm has already developed. Any programs required which may not yet be available, must be programmed by the individual. Highly sophisticated programs may be developed using techniques originated at III, to implement judgments approaching those of the human in analysing filmed data. The firm will provide documentation of the system and existing programs. Colleges and universities developing programs for the PFR-1 are expected to fully document such programs and submit them to III, who will make them available to other users. Inquiries should be directed to: Educational Plan, Information International Inc., 200 Sixth St., Cambridge, Mass. 02142.

Automatic Coding Document Recorder

The coding step in microfilm storage and retrieval of documents has now been made fully automatic by the S-C 4400 Document Recorder, according to an announcement made today by Stromberg-Carlson Corp. The S-C 4400, developed by the firm's S-C Data Products Div., translates computer language into ordinary words and symbols and records the information directly on 16mm or 35mm microfilm. The system for, automatically printing the Recordak Corporation's MIRACODE system index coding on film records, can also automatically print other retrieval codes. The S-C 4400 receives data from a computer or computer-generated magnetic tapes and records it directly on film. At the same time, the document recorder codes the film for automatic and semi-automatic storage and retrieval systems. The MIRACODE concept uses a photo-optical code consisting of squares and rectangles to identify each frame of film. Once the film is processed, it is stored in magazines. An operator seated at a retrieval station can command a central file of magazines, containing a million or more records, within arm's reach.

Institute of Navigation Awards

Col. Duffy

Col. Robert A. Duffy, USAF, was presented the 1964 Thurlow Award and bronze plaque for outstanding contributions to the science of navigation, at the recent Long Beach, Calif., 21st meeting of The Institute of Navigation. The Thurlow Award regarded as the highest honor in the field of navigation, was founded by Sherman Mills Fairchild in 1945, in memory of Col. Thomas L. Thurlow, navigation pioneer and engineer-pilot-officer in the U.S. Army during the 1920s. Other awards presented at the national meeting were the 1964 Burka Award for the best paper in the Institute's *Journal* during the year, to Maj. William L. Polhemus USAF (Ret.); and a special Citation for Superior Achievement to Wladimir A. Reichel for invention of the fluxgate compass, and other contributions to aircraft instrumentation and navigation, presented posthumously and accepted by Andre Reichel, the recipient's son.

Business Notes and News

Burroughs and The Bunker-Ramo Corp. have both recently announced price reductions in their product lines. Burroughs Corp. reduced the price of its premium rectangular Nixie (Reg.) tube to that of round tubes, with increased warranty of two years. Burroughs announced that, through the reduction, it hoped to encourage users to specify rectangular types over round ones in both new applications and in instruments where round tubes are already being used. Bunker-Ramo reduced both rental and sale prices of its Series 200 product line of input/output equipment (rental adjustment about 15%, price adjustment about 5% for one sample item, the Model 203 unit, which features an alphanumeric keyboard and a 9-in. video display screen) . . . Systems Engineering Laboratories Inc. has moved into a new 50,000 square foot plant at 6901 Sunrise Blvd., Plantation, Fla. (near Ft. Lauderdale). It was built at a cost of more than $500,000 to provide the firm with the most modern facilities available to produce its digital data system, general-purpose computers, and related electronic products . . . General Precision Link Group has received a $700,000 award from Rome Air Development Center for a film data readout system to be used for extraction of information from a large volume of multi-formatted film data inputs . . . Fairchild DuMont Electron Tube Div. has received a $200,000 contract for storage tubes to be utilized by Belock Instrument Corp. in a newly-designed module of the APN/59 radar . . . Informatics Inc., Sherman Oaks, Calif., has received over $400,000 in contracts from Rome Air Development Center to develop a system for online computer use. The systems to be known as DOCUS (Display Oriented Compiler Usage System) will employ sophisticated display equipment, operating online with modern, large-scale computers . . . Data Products Corporation, Culver City, Calif., has received a Navy Bureau of Ships contract of approximately $1 million for additional RO-280 high-speed military LINE/PRINTERS (TM), including spare parts, field services and a training program . . . RO-280 can print more than 72,000 characters/min. The firm recently completed negotiations in over $3 million of new orders in a 45-day period, unprecedented for DPC.

on the move

C-E-I-R, Inc., has named **Robert D. Frank** mktg. mgr. for the Southwest region, with headquarters in Los Angeles.

Capt. Roger J. Crowley Jr. (USN-Ret.), director of the New Hampshire Aeronautics Commission, has been elected a director of Computer Control Co., Inc., and **Thomas H. Farquhar** has been appointed mgr. of mktg. development for the firm.

Telemetrics, Inc., subsidiary of Technical Measurement Corp., North Haven, Conn., has appointed **Fred L. Barla** as mgr. of display systems sales.

The Bunker-Ramo Corp. has named **W. J. Gruen** to direct its newly-formed Information Technology Laboratory, and **H. L. Shoemaker** to head its new Information Systems Laboratory. Other Bunker-Ramo appointments include **Col. F. K. Nichols (USAF-Ret.)** as dir., Washington region, Defense Systems Div.; and **Walter Clark,** dir., public relations and advertising, Business and Industry Div.

Ralph G. Schwab has been named asst. controller and **Lawrence S. Losinno** accounting mgr. of Ultronic Systems Corp.

Les Brown has been named to the newly-created position of chief engr., cine products, at Beckley & Whitley, Inc.

Hans E. J. Neugebauer has been appointed director of scientific liaison at the new office of Zerox Corp. in Brussels, Belgium.

Richard S. Anderson has been named VP, Genisco Technology Corp., and gen. mgr., Genisco Systems Div. **Victor Selvig** continues as asst. gen. mgr. of the division.

E. W. "Cy" Denny has been named western regional sls. mgr. for General Atronics Corp. Instrument Div. He will operate from a sales office in Inglewood, Calif.

Joseph Burns has been named to head the newly-formed Display Services Dept. of Fairchild Dumont Electron Tube Div. The department encompasses storage tube engineering, CRT engineering, and research and development. **Guy F. Barnett** has been appointed manager of CRT engineering.

Marshall D. Smith has been appointed product manager of EON Corp.

Cairns Engineering Sales Corp., Los Angeles, has been appointed technical sls. rep. in Southern California for Indiana General Corp., Electronics Division-Memory Products.

Harry K. Sedgwick, Weston, Mass., has formed Design Management Consultants, devoted to analysis of the engineering function in industry and establishment of suitable management controls to insure overall efficiency.

H. R. Getty has been named mgr., advanced communications, Martin/Orlando.

Ralph A. Johnson has been appointed to the new position of gen. mgr., Control Systems Div., Radiation Inc.

Charles F. Hartel has been appointed mgr. of program admin. for Stromberg-Carlson Corporation's Data Products Div., San Diego.

Election of **Robert J. Schlesinger** as VP/mktg. and product development, ITT Data & Information Systems Div., has been announced.

Shepard M. Arkin has been appointed asst. director of government mktg., and mgr. of government mktg. programs for Raytheon Co.

Harry J. Gray has been named Sr. VP/finance and admin., and **John J. Connolly** has been promoted to VP of Litton Industries. Litton's Data Systems Div. has named **C. Gordon Murphy** as Pres., succeeding Connolly, who will be in charge of Components Group; DSD also named **William T. Stratton** program mgr., AF command and control systems. Other Litton appointments include **Daniel B. Campbell,** dir., international mktg., Westrex Communications Div.; **Richard R. Douglas,** asst. gen. mgr., Advanced Circuitry Div.; and **Charles S. Bridge,** VP/dir. engrg., Guidance and Control Systems Div.

Robert E. Wallace has been appointed dir. of mktg. for Auerbach Corp., a new position with the firm.

Itek Corp. has named **John C. Herther** asst. mgr. of its Optical Systems Div.

Sperry Gyroscope Co. has appointed **John D. Freitag** mktg. mgr., avionic systems, in the firm's Information and Communications Div.

Archibald T. McPherson has retired from the National Bureau of Standards after 46 years of government service; his last post was special asst. for international standards in the NBS Institute for Applied Technology.

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BAIRD-ATOMIC D1G1TUBE™ DISPLAY TUBES GIVE YOU CLEAR, RUGGED, RELIABLE READOUT FOR HUNDREDS OF THOUSANDS OF TROUBLE-FREE HOURS!

The inherent simplicity and ruggedness of a Baird-Atomic cold cathode neon glow D1G1TUBE assure you of perfect performance throughout its extremely long life. The bright, distinct, digital character display will not fade with age! ☐ In fact, a D1G1TUBE will often outlast the equipment in which it is installed. So if you buy D1G1TUBES now, you won't have to pay later in replacements, in downtime at the wrong time, or in the immeasurable cost of mistakes in readout interpretation. A wide range of character sizes is available in round or rectangular shape tubes. ☐ Write to Baird-Atomic Electronic Products Division for the new brochure on D1G1TUBES detailing the electrical ratings, operating characteristics, circuits, and applications of these dependable display tubes.

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ID Products

DC-DC Power Supply

Arnold Magnetics Corp., Los Angeles, has announced a new miniaturized DC-DC power supply for CRT applications. Termed SHU-1000F, it provides an accelerator voltage of 1000 v DC at 34.6 ma and a filament voltage 6.3 v RMS (approx. 6 kc) square wave at 1 amp. Since they have a similar thickness, they are ideal for operation with miniature cathode ray tubes with ample power to supply bleeder currents. Output voltage is adjustable +5% to −10%. Line regulation is 0.3% max. Ripple is 0.3% max.

The physical design is such that the mounting surface area is only 3½ in. by 1⅝ in. Height is 3⅝ in. An oscilloscope less than 2 in. wide can therefore result. Exceptional stability is assured by all-silicon circuitry, and the unit is hermetically sealed in a black anodized aluminum case.

Circle Reader Service Card No. 13

Instant Proofreading

Proofreading once requiring 20 man hours can now be completed in less than 10 mins. by a digital plotter, according to California Products Inc., Anaheim, Calif. Other CalComp plotters display digital computer output as maps, charts, graphs or drawings, complete with numerical, symbolic and written annotations. The machine-tool "proofreading" operation produces a graph.

Circle Reader Service Card No. 14

Remote Clock Indicator

Industrial Electronic Engineers Inc., Van Nuys, Calif., has published a 1-page data sheet on its new remote Digital Clock Indicator Assembly which will accommodate any of the following IEE rear-projection readout devices: Series 10, 120 and 220 (last having a front plug-in capability for front panel accessibility) and Series 360. Utilizing the various readouts, RDCIA units are available with display characters ranging in size from ⅝ in. to a full 2 in.

The units are available in packages with up to eleven rear-projection readouts for indicating seconds, minutes, hours, days, etc. A typical application would be to indicate time-of-day or countdown at missile launch centers, tracking stations, or comparable installations.

Circle Reader Service Card No. 15

1-In. Vidicon Deflector

Cleveland Electronics, Cleveland, O., has announced availability of a new 1-in. vidicon deflection assembly designed in a cylinder shape. It will operate standard vidicon, permachon or uvicon tubes with a basic 40-gauss field. The yoke will furnish 600 to 700 TV lines resolution with distortion of less than 1%. The focus coil section is shielded by Mu metal in such a manner that ambient electronic interference is reduced.

Circle Reader Service Card No. 16

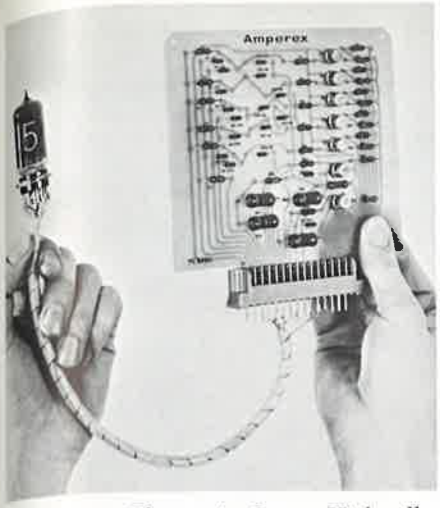
3-In. Image Pickup

Westinghourse Electronic Tube Div., Elmira, N.Y., has announced availability of a new 3-in. image dissector pickup camera tube having an extremely high resolution of 3000 TV lines/in., excellent black and white contrast, and a short rise and decay time. Termed WL-23111, it is ideal for microfilm readout, TV film scanning, and high-speed flying-spot scanning.

The new tube is inherently more rugged and longer lived because it has no target or hot cathode to deteriorate. Circuitry is simpler since there is no beam-forming gun. Standard image orthicon components can be used when scan rates permit. A zoom effect can be achieved electronically, simply by magnification through scan reduction. A several-hundred-power magnification is possible by decreasing the deflection amplitude and underscanning the image. Resolution is the same as that for the original area imaged on the photocathode. No change in light level is necessary during the underscan operation.

Circle Reader Service Card No. 17

New Conversion Matrix



Amperex Electronic Corp., Hicksville, Long Island, N.Y., has announced a new conversion matrix and biquinary readout tube which uses 30% fewer transistors and approximately 50% fewer components. Termed DP101, it contains a solid-state conversion matrix for decoding BCD tubes, and a driver for biquinary numerical indicator tubes.

Because it utilizes the unusual Amperex Bi-Qui numerical indicator tube, approximately 50% fewer components are needed in the conversion matrix and 30% fewer transistors are required to drive the Bi-Qui tube, according to the manufacturer, who states the Bi-Qui tube provides an additional advantage with its built-in error-detection capability.

Circle Reader Service Card No. 18

Bar Graph Generator

Colorado Video Inc., Boulder, Colo., has announced a Model 101 Bar Graph Generator for use with standard closed-circuit TV systems to provide a graphic display of eight separate input signals in the form of a series of vertical bars, the height of each being proportional to the associated input voltage.

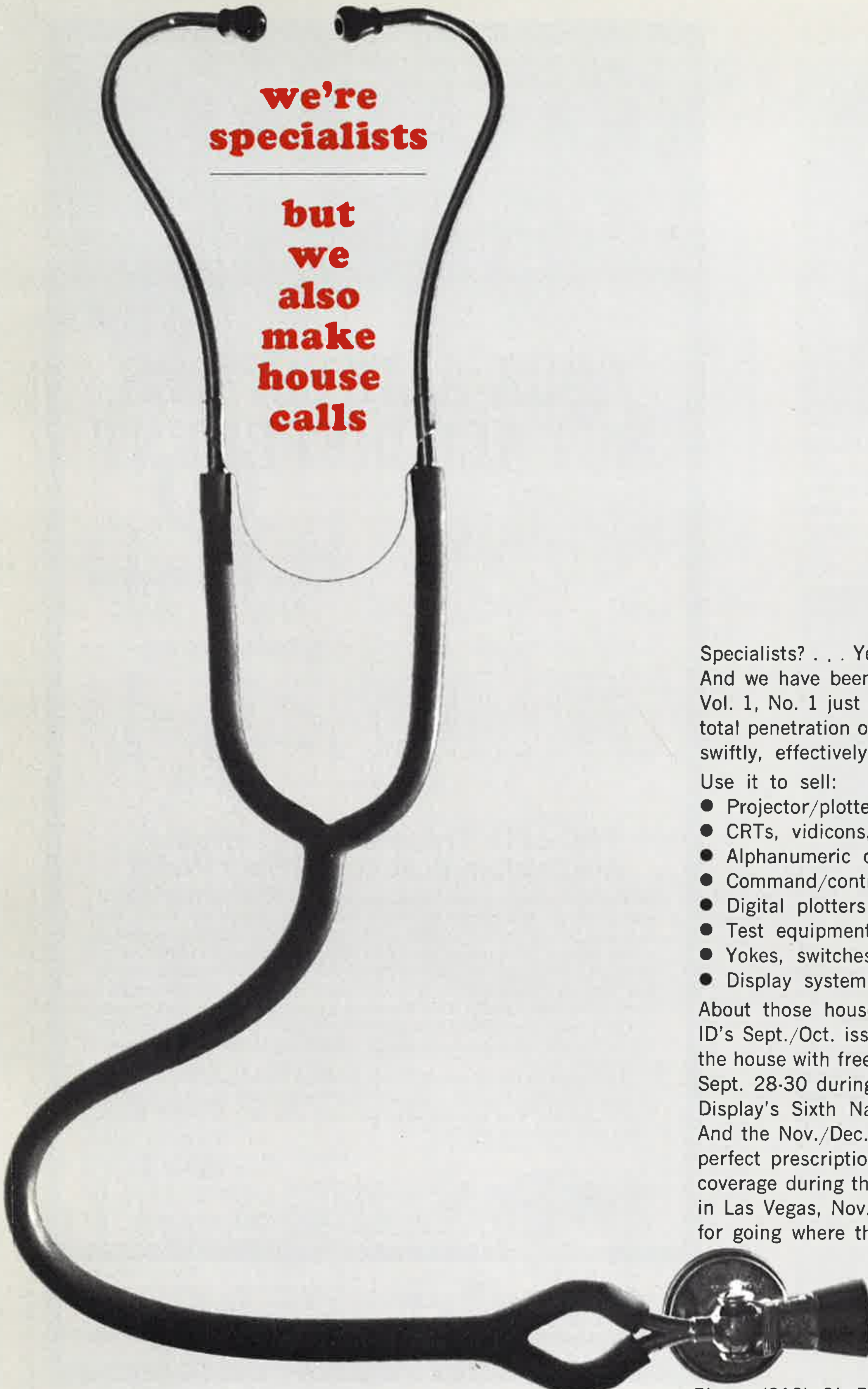
Controls allow the positioning and spacing of bars for the best display efficiency. Data may be mixed with normal TV images, and two or more units used in parallel when additional bar groups are desired. Individual channels may be readily distinguished, and groups identified by size, location, or video polarity.

Circle Reader Service Card No. 19

Philco READ System

Philco Corp.'s Communications and Electronics Div., Willow Grove, Pa., has published a brochure describing its Real-time Electronic Access and Display (READ) system. READ is described by the manufacturer as a versatile alpha-numeric and graphic CRT display which provides instant access to computer-stored information. It is composed of a central controller, which contains a character generator, a vector generator and a format controller. Consoles may be

Circle Reader Service Card No. 20


we're
specialists
but
we
also
make
house
calls

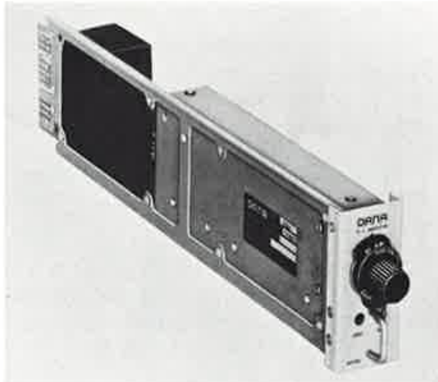
Circle Reader Service Card No. 21

Circle Reader Service Card No. 22

provided with a typewriter keyboard, a cursor, and a light pen. Consoles, projection devices and microfilm printers are available.

Circle Reader Service Card No. 23

10MA Wideband Amplifier



Dana Laboratories Inc., Irvine, Calif., has announced availability of its Model 3400 Amplifier series, a wideband amplifier to drive medium-power recorders, passive filters, and display devices.

The direct-coupled differential amplifier has a full-scale load current of 10 ma. Full-scale output voltage is ±10 v, and the small-signal bandwidth is a minimum of 50 kc. The instrument offers a totally isolated power supply, as well as modular dimensions that allow 10 Model 3400s to fit into one Model 3010 rack enclosure.

Circle Reader Service Card No. 24

Failure-Safe Readout

A special circuit to sense and report failures is incorporated in a new segmented readout offered by M. B. Associates, Phila., to eliminate false digit displays. In most segmented readouts now offered, a segment failure can cause the display of a digit different from the one planned. The MBA readout, termed Model NSDFS, contains seven segments, illuminated by neon lamps. When a lamp fails, its actuation voltage rises and exceeds circuit voltage, causing it to appear to the drive as an open circuit. The special failure circuit detects such open circuits, and is designed to automatically turn off segments that could cause an erroneous digit to appear in the event of any failure, making undetected error impossible.

Circle Reader Service Card No. 25

Multi-Slide Switch

Switchcraft Inc., Chicago, has announced a new slide-action switch which features multiple switching action, plus interaction between two switch stations. Termed the Series 39000 Multi-Slide Switch, it was developed primarily to give design engineers an entirely new switching method with which to solve the human engineering problems created by their almost total dependence upon the use of masses of pushbutton switches in the design of complex control consoles.

Circle Reader Service Card No. 26

Except for providing illuminated status indication, the Multi-Slide Switch can be assembled to provide any switching function common to conventional pushbutton switches.

Circle Reader Service Card No. 27

Digital Display System

The Raytheon Co. Equipment Div., Wayland, Mass., has recently announced its DIDS-400, a table model digital information display system for rapid retrieval, editing, and composing of computer-stored information. The system eliminates card punching, batch totaling and other intermediate steps in data processing by providing a direct interface between computer and operator.

Through use of an alphanumeric keyboard, information in a random access memory can be recalled almost instantaneously for flicker-free presentation on a 6-in. by 9-in. display area. It may then be corrected or replaced with new information and returned to the computer memory for future use. As many as 1040 characters of an easily-read type face can be displayed on the TV-like screen upon operator command. The system consists of three basic units, the display console, the control unit, and an optional hard-copy printer.

Circle Reader Service Card No. 28

Hard Copy Generator

Photomechanisms Inc., Huntington Station, N.Y., has announced availability of a small, rack-mounted hard-copy generator that converts transient information displayed on the face of a CRT into dry, permanent, hard copy suitable for storage and subsequent reference. Called DATASTAT II, the system generates photographic images containing as many as seven shades of gray, in addition to providing high contrast copies of alphanumeric data. A self-contained monitor/camera/processor/printer, the system combines the high speed and sensitivity of silver halide recording with the economy and simplicity of operation of electrostatic printing.

DATASTAT II will accept input data at any rate up to 4 frames/sec. The first hard copy print is produced with a total time lag of 30 secs. and succeeding 8½ X 11 hard copy prints are produced at the rate of one every 5 secs.

Circle Reader Service Card No. 29

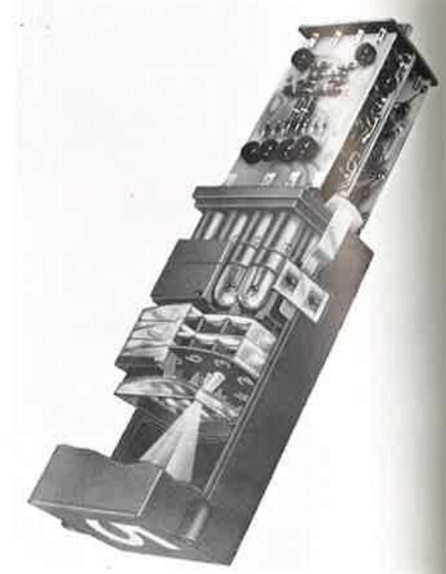
Display Oscilloscope

Applied Development Corp., Monterey Park, Calif., has announced availability of its Kauke MS-Series display oscilloscope for multichannel analog display. It was originally designed for PAM bar chart display with all IRIG formats. The system combines a 30-channel analog multiplexer with a MS-3 scope, 17-in. screen, or a MS-4 scope with a 14-in. screen for bar chart type display up to 30 measurements in parallel.

The system can be expanded to 100-channel display capacity per scope. Individual channel intensification (number locator), alternate x-y or y-time display, zero and full-scale reference are available as options. A numeric or alphanumeric character generator is also available as a system accessory, with display resolution up to 200 characters/sq. in.

Circle Reader Service Card No. 30

Solid State Driver/Decoder



Industrial Electronic Engineers, Inc., Van Nuys, Calif. has developed a new solid-state driver/decoder module which provides binary to decimal conversion for their Series 10 and Series 360 rear-projection readouts. The unit uses all silicon transistors and has four-wire BCD input logic with 8421 binary code which provides 10 decimal outputs. Twelve decimal outputs are available as an option.

This new driver/decoder is a new version of their old Series 600/610 driver decoder and is designed to accept a binary coded input, translate it into decimal and light the proper lamp in the readout to display the desired character. It operates on a low current signal of 2 ma. maximum at −6.0 v dc or +6.0 v dc depending on option selected. It requires a power supply current of 350 ma. max at −8.0 v dc or +8.0 v dc depending on option selected. Output supply voltage is 6.3 v dc, which is rated voltage for operating the No. 44 lamps used in the readouts. The unit will withstand temperature extremes from 0°C to +70°C ambient and features a forbidden code rejection.

Circle Reader Service Card No. 31

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LOGICATOR®

2/3 ACTUAL SIZE

EITHER TYPE

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500ms max.	SPEED	30ms max.
Inherent	MEMORY	Solid state available
During character change only	POWER	Continuous for illumination
24vdc at 2 watts max.	VOLTAGE	4vdc at 285 mw/seg. nom.
Ambient light	VISIBILITY	Internal, to 800 ft. lamberts
36° either direction	VIEWING ANGLE	45° either direction
Ambient light	PHOTO RECORDING	Self-illuminated
0.250 x 0.190 inches	CHARACTER SIZE	0.340 x 0.200 inches
0.500 x 1.000 x 1.500 inches	CASE SIZE	0.350 x 0.500 x 1.200 max. inches

 • **MAY WE CUSTOM DESIGN A DISPLAY FOR YOU?**

Circle Reader Service Card No. 37

PROJECTION OSCILLOSCOPE

DALTO 290

NEW

OSCILLOSCOPE 290

PRESENTS THE BIG PICTURE IN MANY WAYS, ANY COLOR

A Real Time Display for a wide range of applications— from alphanumeric readout to master plotting-board display — the OSCILLOSCOPE 290 is the ultimate in big-screen oscilloscope projection for both large and small groups. In either direct or rear-view projection, the OSCILLOSCOPE 290's needle-sharp picture presents the facts with the clarity and brilliance required by the most critical of audiences.

The OSCILLOSCOPE 290 may be used over a wide variety of subjects including: alphanumeric displays for computer read-out . . . combat information-center displays . . . master plotting board displays . . . basic training in electronic wave forms . . . projection of airline schedules . . . radar target acquisition . . . aircraft position plotting for control-tower operators, etc.

The DALTO PROJECTION OSCILLOSCOPE 290 combines high brightness and resolution with wideband linear deflection amplifiers to provide top quality images capable of filling a 12 foot screen.

Schmidt optics and CRT are the same as used in the famous Dalto TV Projectors. The electronics may be remoted or joined as shown. P4 phosphor is standard for white display, other colors or multi-color also available. Automatic beam regulation protects CRT regardless of rate or amplitude.

DALTO | ELECTRONICS CORP.
NORWOOD, N.J.

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ID Advertisers

Index — July/August, 1965

B-L 120 Microfilm Printer/Plotter

FIRST

SECOND GENERATION CRT MICROFILM PRINTER/PLOTTER ON THE MARKET TODAY

The B-L 120 is a truly expandable, modular system, completely **solid-state** and features the latest in high reliability silicon logic circuits.

- **Truly off line—does not require expensive computer tape transport**
- **Through-put—120 frames per minute for both 556 and 800 bpi tapes**
- **64 character selection with 128 character option**
- **Vector line drawing and axes line drawing**
- **Handles either 16mm or 35mm monocromatic film**
- **Tape transport compatible with all 7-track, ½-inch magnetic tapes or 9-track, ½-inch magnetic tape**
- **Optional "Quick-Look" hard copy-exposure simultaneous with film**

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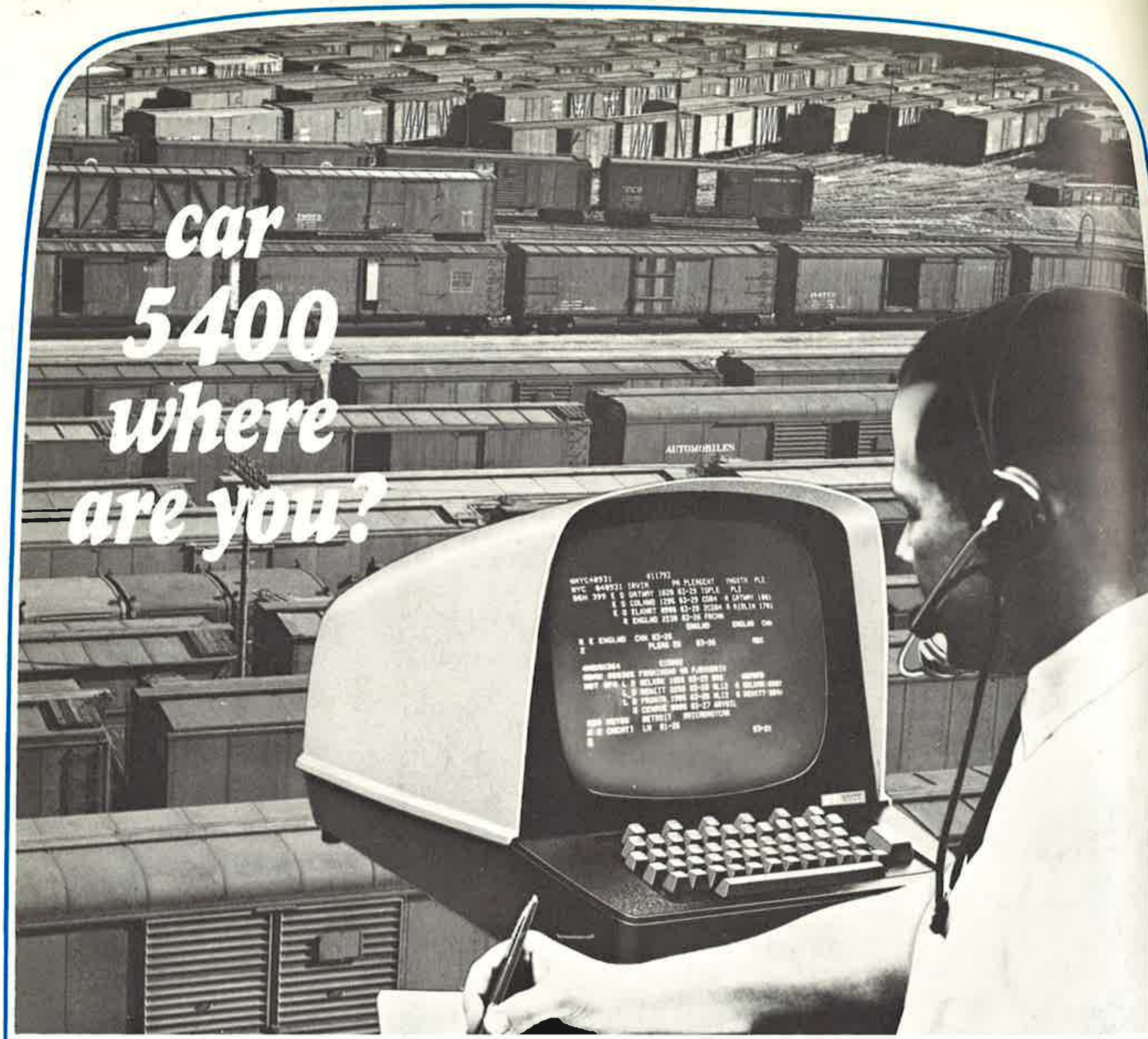

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via Control Data® 210 remote data entry and retrieval!

The exact whereabouts of 125,000 railroad freight cars can be pinpointed from second to second by New York Central's Car Tracing Center. Clerks at Control Data 210 Computer-Remotes like the unit shown here simply type in a query, press their transmit key, and see the answer flash on the screen. Access time — about 140 milliseconds — virtually instantaneous! Answers that previously required up to several hours to obtain.

The 210 operates like an ordinary alpha-numeric typewriter, with video-screen display of input and output taking the place of "paper" for both query and response. Screen can display 1000-character messages. Control unit logic handles in excess of 20,000 entries an hour. Up to 63 stations can be tied into the system and provide simultaneous access for all. And any typist can use a 210 after just minutes of instruction.

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