Volume 2 Number 5 September/October, 1965

Information Display

Journal of the Society for Information Display

SID

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Information Display

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No charge to members of the Society for Information Display. All others $12 per year. $20 for two years. Payable in advance.

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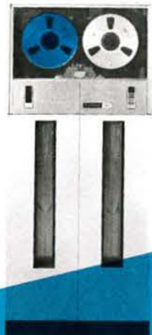
PHILCO READ*

provides real-time two-way communications and display for any data handling system

...and it's ready now!



* **R**EAL-TIME
ELECTRONIC
ACCESS AND
DISPLAY

Philco's **READ** provides:

- Instant graphic and alphanumeric communications
- Compatibility with any data processing system
- Hi-resolution flicker-free presentation of data processing input and output
- Up to 15 stations driven by one controller—displaying similar or dissimilar information

READ is available with direct view consoles, projected wall screen displays, and microfilm recording or hard copy equipment. Your request for technical information and a demonstration of any unit will be handled immediately.

Communications and Electronics Division, Willow Grove, Pa.

PHILCO®
A SUBSIDIARY OF *Ford Motor Company*

Raytheon introduces a new, low-cost digital information display system

A completely new, low-cost digital information display system for instantly retrieving and displaying data stored in a central computer is now available from Raytheon. This is the latest of thousands of cathode ray tube displays that have been designed and produced by Raytheon during the past 20 years.

The new system, the DIDS-400, interfaces easily with any type of computer and with various types of remote communication lines. It significantly reduces time required by operators to retrieve and edit data.

Up to 1000 alphanumeric characters can be displayed instantaneously. Operators can add to, correct or erase displayed data before returning it to storage without need of card punching and other intermediary processing. Hard copies of the displayed information can also be obtained.

Each DIDS-400 display console contains its own bright display, character generator, refresh memory and power supply. By combining these items in a single, self-contained unit, console dependence on the control unit or computer is greatly reduced, cabling problems are simplified, reliability is increased and the system given greater overall flexibility.

Highly-legible characters and symbols giving a closed-curve appearance are easily readable in normally lighted rooms, offices, and production areas, thus reducing operator fatigue and providing more efficient, error-free operation.

A brochure describing in detail the Raytheon DIDS-400 Digital Information Display System is available. Write: *Manager of Industrial Sales, Dept. MEC-10E, Raytheon Company, Wayland, Mass. 01778.*

RAYTHEON

Volume 2 Number 5 September/October, 1965

Information Display

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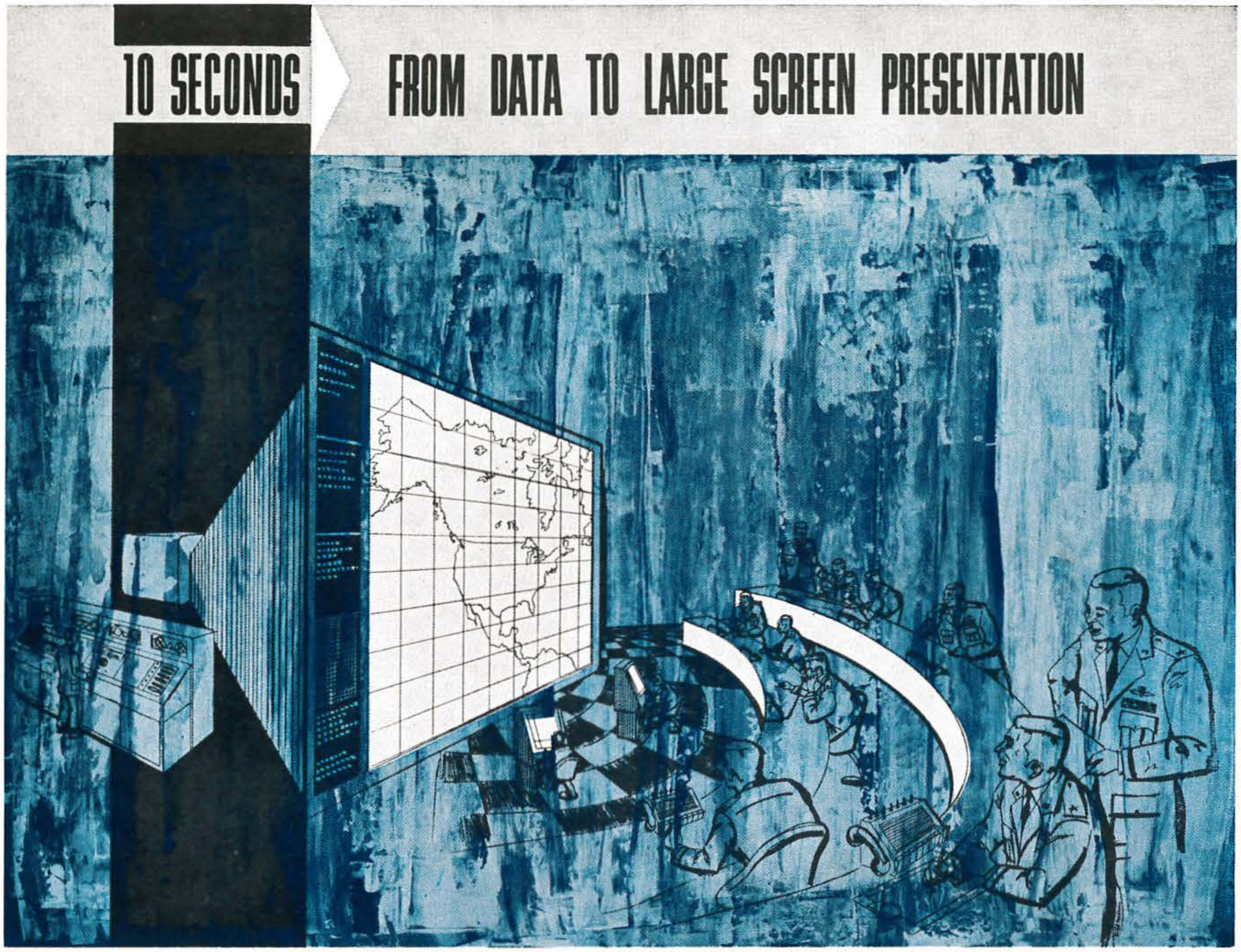
ARTICLES

FEATURES

THE COVER

"Historic Information by Display" concept of Artist Robert Shepard, TRW Systems, portrays methods used through ages to transmit information. Starting upper left, painting shows prehistoric Cave of Altamira painting; Egyptian tomb painting; Assyrian wing-headed Bull of Ashurnasirpal II; golden Vaphio cup from Aegean culture; crater vase from Greece; head and hand of Emperor Constantine, of Rome; corn stele relief from Mayan civilization; (below) panel by Pisano, from north doors of baptistery, in Florence; (above) medieval woodcut of royal hawking party from 17th Century England; Toulouse Lautrec poster, from France; a 19th Century Indian chest from Alaska; and a contemporary computer display.

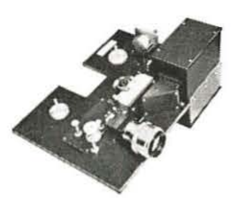


Full color data display with OPTOmechanisms rapid access processor/projection system

Only 10 seconds from computer to full color data display—front or rear projection. This advanced OPTOmechanisms' rapid up-date system delivers vital data for Command and Control Centers on theatre size screens with a symbol brightness of over 20 foot lamberts. The system processes film images by direct reversal and provides extremely high resolution presentations, at short throw distances, for group viewing. No dark room is required. OPTOmechanisms' compact Camera-Processor-Projector is completely self-contained and self-programmed. A fully detailed bulletin of this unique data display system is available.

BLACK AND WHITE CAMERA/PROCESSOR/PROJECTOR

OPTOmechanisms' black and white data display systems feature negative or direct positive film processing with a resolution range of 50-80 lines per mm. These compact, flexible, and fully self-contained systems record, process and project data in only 8 seconds. They are easily integrated with electronic sub-systems. Typical applications: data and instrumentation display, radar, air traffic control, radiological and other medical applications.



PATENT NOS. 2,981,170 and 3,115,079

OPTOmechanisms Inc.

ENGINEERS HILL, PLAINVIEW, L. I., N. Y. • (516) GE 3-8100 TWX: CODE 516-433-9690

SPECIAL CAMERAS — PHOTOMETRIC DEVICES — OPTICAL TACHOMETERS — RAPID FILM PROCESSORS — PROJECTORS — OPTICAL TRACKERS
STEREO VIEWERS — SATELLITE DETECTORS — MEASURING INTERFEROMETERS — STEREO COMPARATORS — LINEAR MEASURING TABLES
STAR SIMULATORS — NEGATIVE TO POSITIVE FILM VIEWERS — ANGLE GENERATORS — FIBER OPTICS APPLICATIONS — RANGE FINDERS

Circle Reader Service Card No. 8

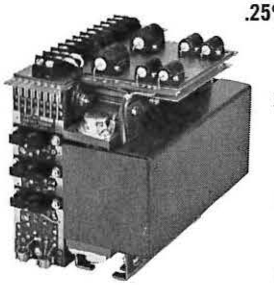
Circle Reader Service Card No. 10

Celco

X-Y DEFLECTION AMPLIFIERS

AND SOLID STATE DEFLECTION CIRCUITRY

X-Y Deflection Amplifier
.25% Linearity



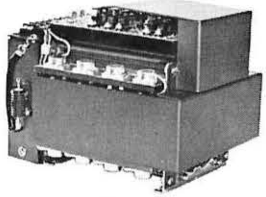
DA-PP2B
± 1.5 amp
(shown)

DA-PP3B
± 3.0 amp

DA-PP6B
± 6.0 amp

For Yokes over 100 μh

X-Y Deflection Amplifier
.25% Linearity



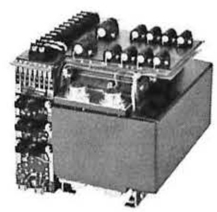
DA-PP2C
± 1.5 amp

DA-PP3C
± 3.0 amp

DA-PP6B
± 6.0 amp
(Shown)

For Yokes under 100 μh

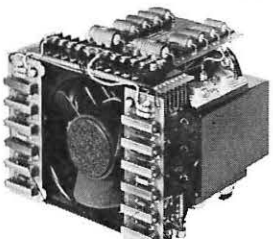
Ultra Linear X-Y Deflection Driver
.05% Linearity



DA-PP3D

For High Precision Displays

Linearity Correction for Flat-Faced CRT
Use with CELCO Field Corrector
for absolute linearity



DA-PP3L

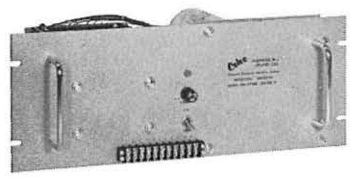
All Silicon NPN Deflection Driver

DA-PP3N
± 3.0 amp
(Shown)

DA-PP6N
± 6.0 amp

For Highest Precision Displays

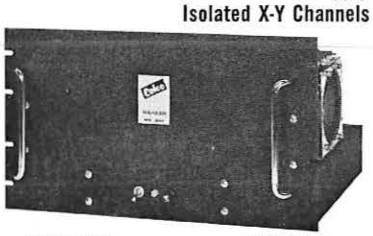
Rack Mounted X-Y Deflection Amplifier
Unregulated Power Supply



PDA-PP2BR
± 1.5 amp

PDA-PP3BR
± 3.0 amp
(Shown)

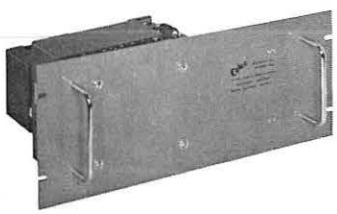
Rack Mounted X-Y Deflection Amplifier
Regulated Power Supply
Isolated X-Y Channels



RDA-PP3B
±3.0 amp
(Shown)

RDA-PP6B
±6.0 amp

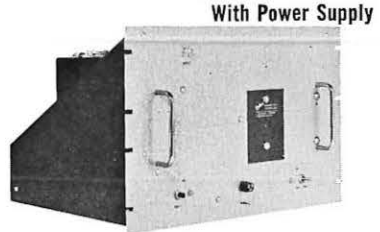
All Silicon Deflection Amplifier
Regulated Power Supply



RDA-PP3N
± 3.0 amp
(Shown)

RDA-PP6N
± 6.0 amp

High Speed Deflection Driver
Single Axis Push-Pull
With Power Supply



1-PDA-PP 18N

18 KV
Accelerating Potential

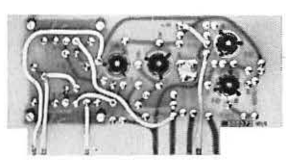
10 μs
70° Deflection

Constant Current Sources
0.1% of Range

CR-104
4.0 amp 10.0V
(Shown)

CR-510
10.0 amp 5.0V

Vidicon Driver and Sweep Generator
for Hybrid Tube Type 8134



DA-V1

Use with Celco Vidicon Yoke Type HV

Sawtooth Signal Generator SG1
Ramps from 20 μs to 100 ms

Triggers in and out

Celco

Constantine Engineering Laboratories Company

MAHWAH, N. J.
201-327-1123
TWX 201-327-1435

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714-982-0215
TWX 714-556-9550

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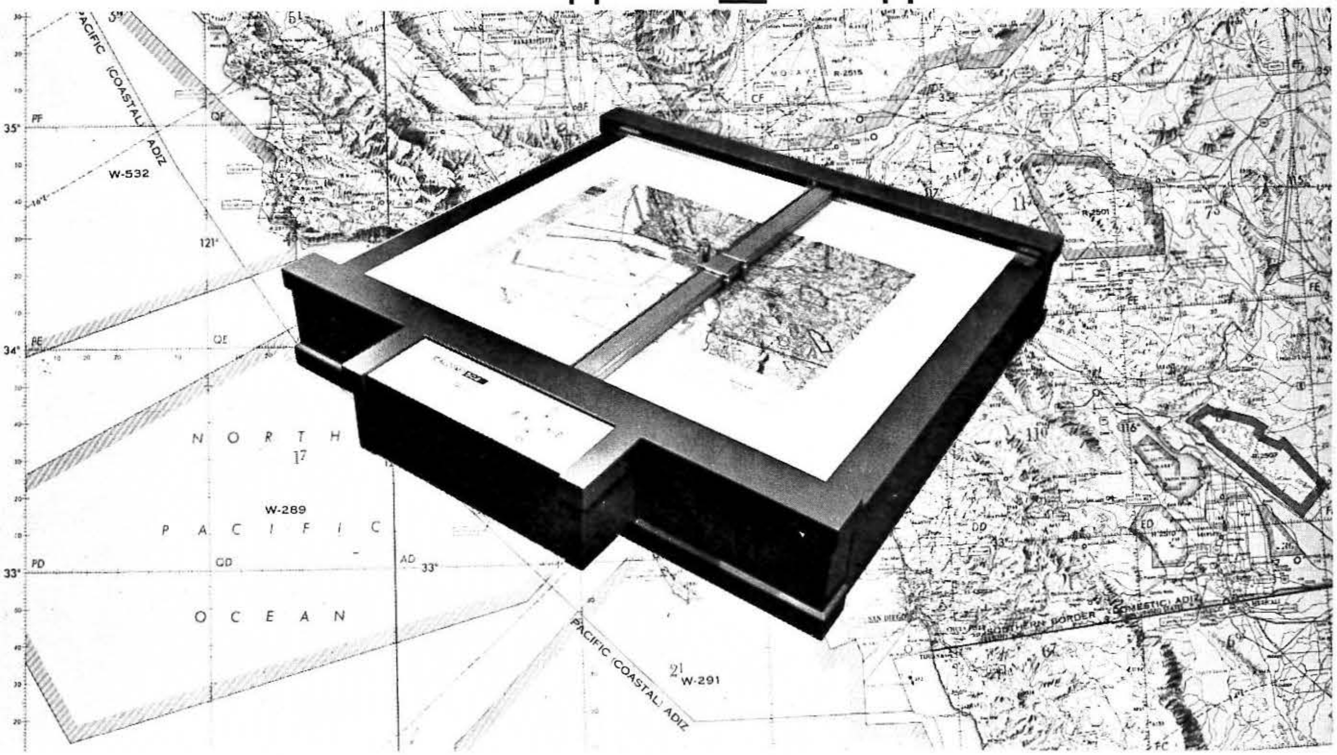
FOR DECISION MAKERS:

A Digital Plotter That Lets You Watch It Happen...As It Happens



Now you can navigate . . . test the endurance of an engine . . . track an aircraft, spacecraft or submarine—all in real time and with digital accuracy.

Model 502 Flatbed version of CalComp's line of digital incremental drum plotters introduces high speed, high resolution plotting of digital computer output—on a 31" x 34" area that lets you watch everything that happens . . . as it happens.

A few advantages of the digital incremental principle in general, and the Model 502 Flatbed in particular, are listed below.

• You are sure of long term, stable, drift-free operation • Alphanumerical and special symbols may be drawn at full plotter speed (18,000 steps/minute—.01 inches/step) • There are no scale factors to adjust, and origin setting is completely under program control • A wide range of existing charts and maps (up to size 34" x 38") may be used • Unique "Cal-Hold" holds or releases most papers at the flick of a switch • The 502 Flatbed accepts all 500-series drum plotter programs without modification • You can operate it on-line or off-line with most digtal computers.

For additional advantages, write "Marketing".

CALCOMP

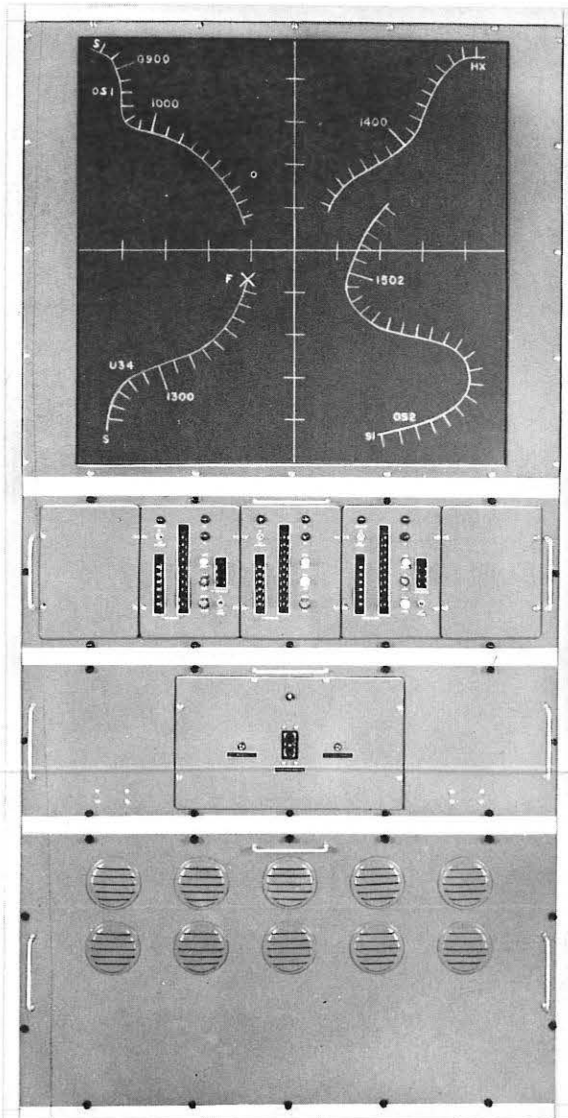
STANDARD OF THE PLOTTING INDUSTRY

CALIFORNIA COMPUTER PRODUCTS, INC.

305 Muller Avenue, Anaheim, California • (714) 774-9141

Circle Reader Service Card No. 13

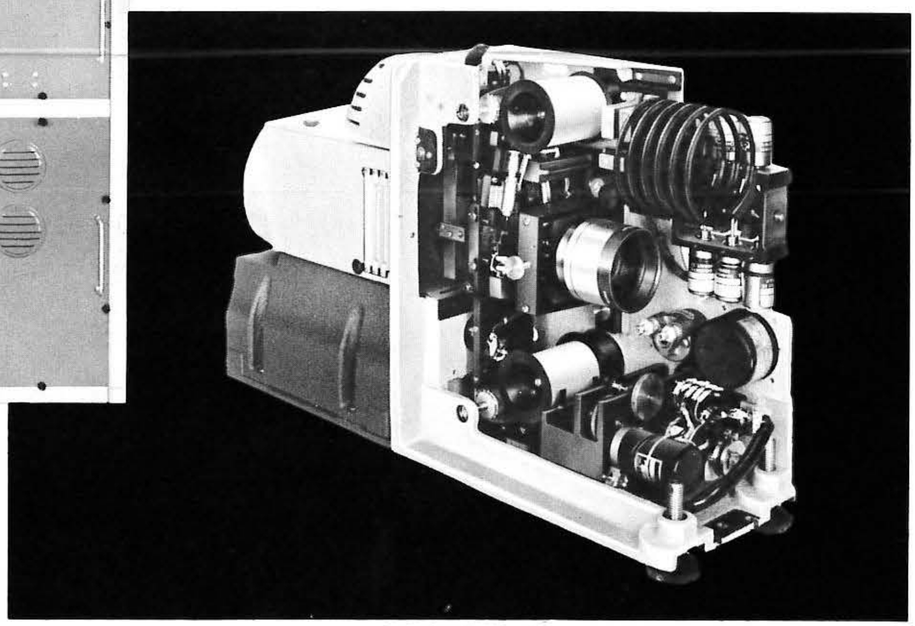
for HIGH SPEED film plotting projection–performance–reliability–and low cost displays... focus on **BELOCK**



CABINET DISPLAY

At last . . . a high-speed Scribing Projection Plotter featuring a low-cost, non-breakable plotting material. The BELOCK SCOPUS-II®P has drastically cut operational costs and simplified logistics considerations through the use of spooled 70MM stabilized polyester film. The film is a transparent base for a non-chipping scribable coating available in a wide range of opacities and with pre-recorded background reference data. Also available are spotting and reference projectors, character generators, computer interfaces and manual input equipment. Large or medium sized rear and front projection screens or folded optics consoles are provided with input data from either analog or digital computers, keyboards, or manual control panels.

Whatever your projection display requirements . . . general purpose computer output display . . . training devices . . . aerospace tracking . . . command and control or management data (PERT) . . . write, call or TWX.



SCOPUS II PROJECTOR

BELOCK
INSTRUMENT
CORPORATION
College Point, New York 11356

Attention: DISPLAY DEPARTMENT

Phone area code 212, 445-4200

TWX: Area code 212-539-7680

REPORT CARD

NAME: 801 Data Display System

ADDRESS: c/o Telemetrics
2830 South Fairview Street
Santa Ana, California

PHONE: (714) 546-4500

SUBJECT	COMMENTS	GRADE
Reading	Reads and accepts digital inputs in parallel form at a selected or programmed up-date rate.	A
Writing	Most flexible in its class; uses beam-pencil to write 12 "pages" or levels of information each with 12 lines of data at 32 characters per line.	A
Arithmetic	Memorizes and handles large masses of any kind of data (does not really perform computations as such).	A+
English	Uses real language, not wiggly lines; very easy to see, analyze, or filter processed data.	A+
History	Repeats itself every 16 milliseconds; uses own buffer memory to up-date data.	A
Science	Performs well in any area of investigation, industrial research, experimentation, or process control.	A

ELECTIVES

SUBJECT	COMMENTS	GRADE
Art	Draws maps, charts, graphs, curves, etc.	A
Shorthand	Abbreviates as required by the programming.	A
Economics	Considerably less expensive to operate and maintain than a family of strip-chart recorders.	A+

PERSONAL

Work Effort - Capable of very hard real-time work when asked; applies own buffer memory and character generation memory to reduce the work load on any computer by a factor of 20,000; will work in an off-line situation.

Cooperation - Plays well with the Telemetrics 670 Data Processing System, but will also play with any general purpose computer when so instructed; will not interfere with the playing of permanent read-out devices.

Application - Shows strong tendency to replace as many as 4,608 conventional single-character read-out devices at one time; is also capable of one or more remote displays.

Overall Work Habits - Very reliable; always turns in neat, readable work, is very attentive to instructions; changes its values and data very easily.

Appearance - Very neat, as may be expected from an off-the-shelf item; occupies only 23"x 32" of floor space.

TELEMETRICS DIVISION
TECHNICAL MEASUREMENT CORPORATION

HOME OFFICE *2830 S. Fairview Street Santa Ana, California Phone (714) 546-4500 TWX: 910-595-1135* / BURLINGAME, CALIFORNIA *(415) 697-7774* / SEABROOK, TEXAS *(713) 222-9624* WINTER PARK, FLORIDA *(305) 647-0220* / WASHINGTON, D. C. *(703) 533-0373* / CANADIAN HEADQUARTERS *Allan Crawford Associates, Ltd. 65 Martin Ross Avenue Downsville, Ontario* / FRENCH HEADQUARTERS *22 Avenue Thierry, Ville d'Avray Paris* / UNITED KINGDOM HEADQUARTERS *C. M. Instrumentation, Ltd. 52 Broadway Bracknell, Berkshire*

Now she reads information from stored computer records (or adds it)... instantly.

Suddenly... a clerk or teller has at her fingertips the ability for high-speed handling of business data. It took her only a few minutes to learn. The "missing information link" is provided by the new Stromberg-Carlson S-C 1100 Inquiry Display System. It is designed for banks, insurance companies, utilities, airlines and other organizations which must refer frequently to stored data.

Simple as a typewriter: When the operator receives an inquiry concerning an account or record she uses the keyboard to enter account number and appropriate computer code. She then visually verifies the complete entry on the cathode ray tube screen. By depressing the "transmit" key, she sends the message to the computer memory in a fraction of a second — and the S-C 1100 immediately displays the requested data on the screen. Entries can also be made by the operator and added to the stored record automatically.

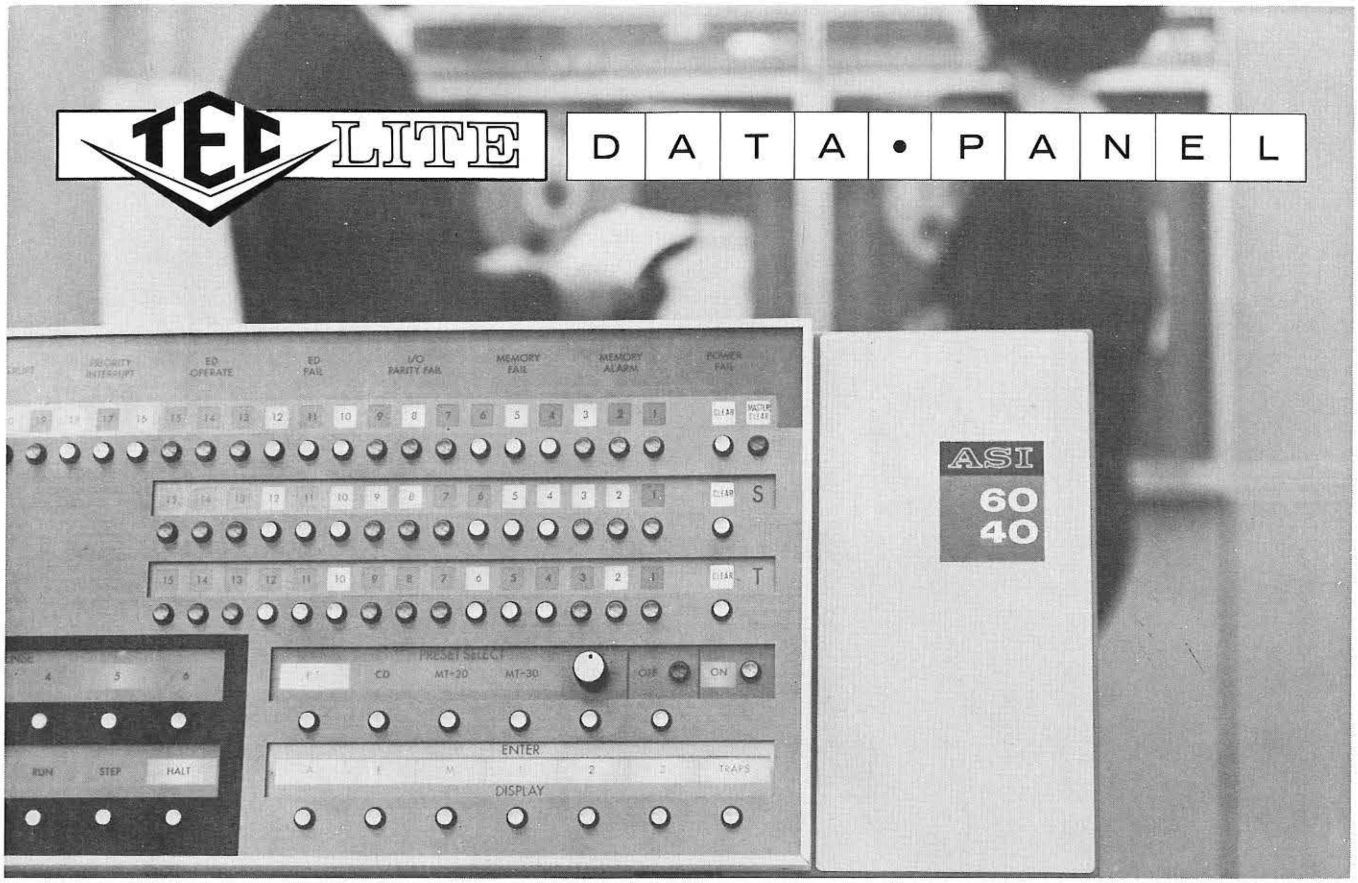
Multiple units: Over 400 of these desk-top units may be used to work with a centralized data processing system. Two models are available — one displays up to 100 characters; the other up to 500 characters.

Benefits include: Increase of computer efficiency, better budget and inventory control, reduction in external and internal telephoning, manpower savings, greater personnel efficiency and better morale because of faster availability of information.

For complete details on the new S-C 1100, write: Stromberg-Carlson Corporation, Data Products—San Diego, Dept. F-39, P.O. Box 2449, San Diego, California 92112.

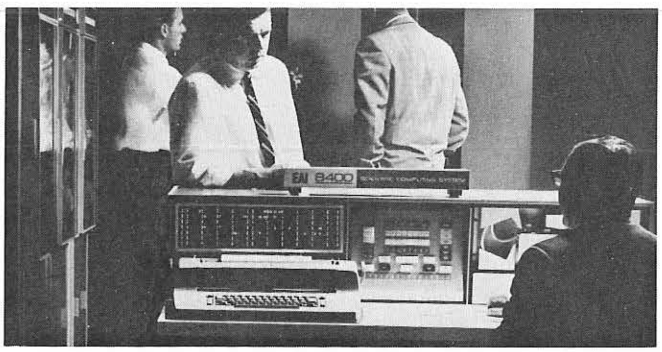
STROMBERG-CARLSON
CORPORATION
DATA PRODUCTS-SAN DIEGO

Circle Reader Service Card No. 18

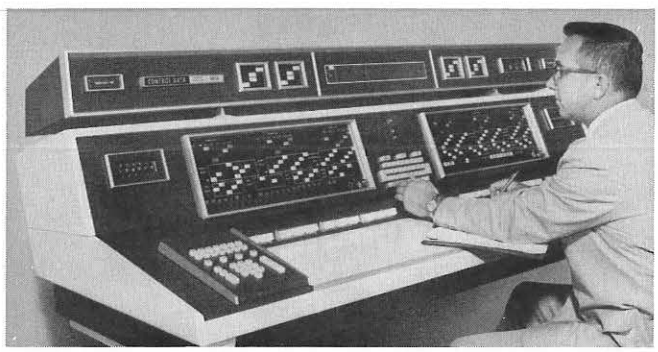


Advanced Scientific Instruments uses DATA·PANEL for complete display and control console of their new ASI ADVANCE Series 6040 Computer.

NEW CONCEPT OF INFORMATION DISPLAY AS DRAMATIC AS TODAY'S COMPUTER DESIGN!



DATA·PANEL indications are visible only when illuminated in EAI 8400 Scientific Computing System by Electronic Associates, Inc. ▲



▲ Two computers are operated from this Control Data Corporation Console which uses six DATA·PANEL Information Displays.

Leading designers of modern computers specify TEC-LITE DATA·PANEL for its dramatic new appearance in operator consoles and maintenance panels. DATA·PANEL offers a new concept of display versatility and visual impact, in addition to greatly increasing operator accuracy.

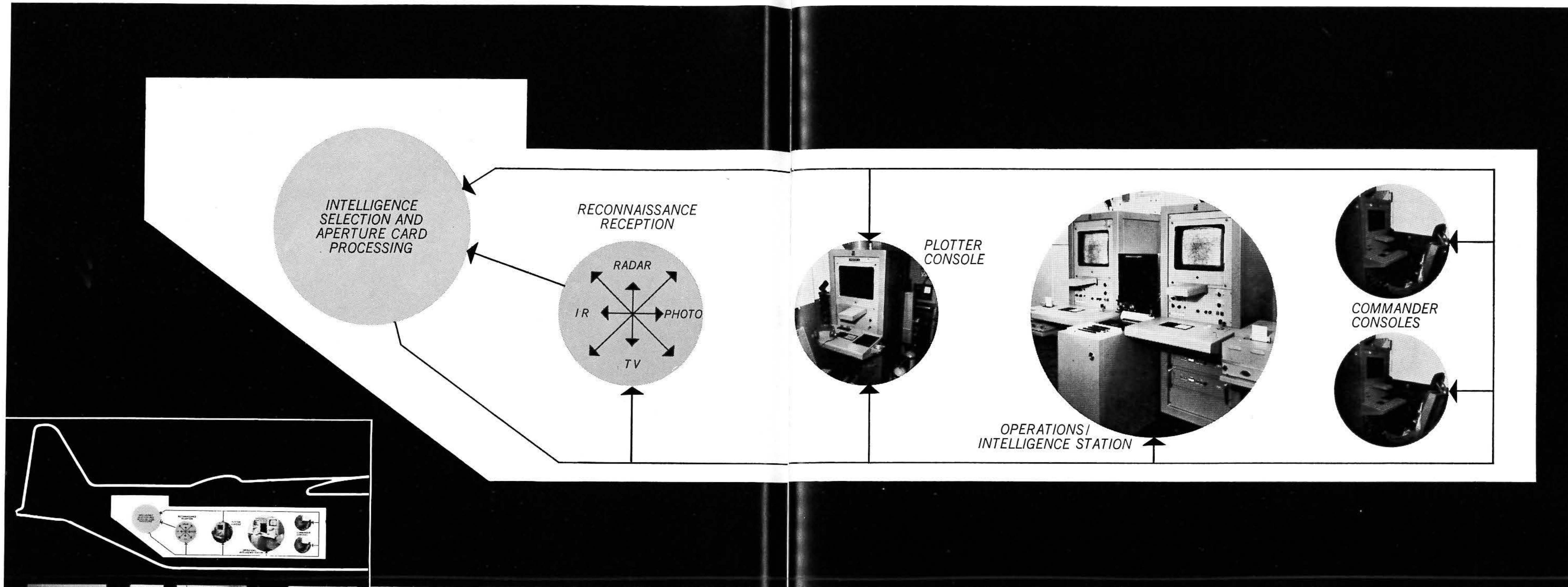
Extremely flexible visual and mechanical parameters of DATA·PANEL give designers display freedom never before available. There are no restrictions, within practical limits, to the shape, color, size or arrangements of the information displayed. Indications and digital readouts stand out emphatically in color behind smooth planes of glare-free black glass. When "off", legends and indications can be totally invisible until illuminated. For control, complete range of switch actions can be an integral part of DATA·PANEL design.

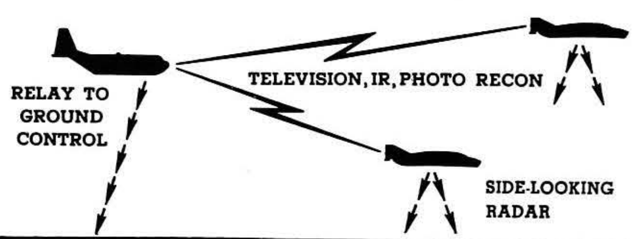
Write for full-color brochure, specifications and ordering information.

TEC LITE
INDICATING DEVICES

INDICATORS	DATA•PANEL	READOUTS	TEC-SWITCH

Transistor Electronics Corporation
Box 6191 Minneapolis, Minnesota 55424 Phone (612) 941-1100





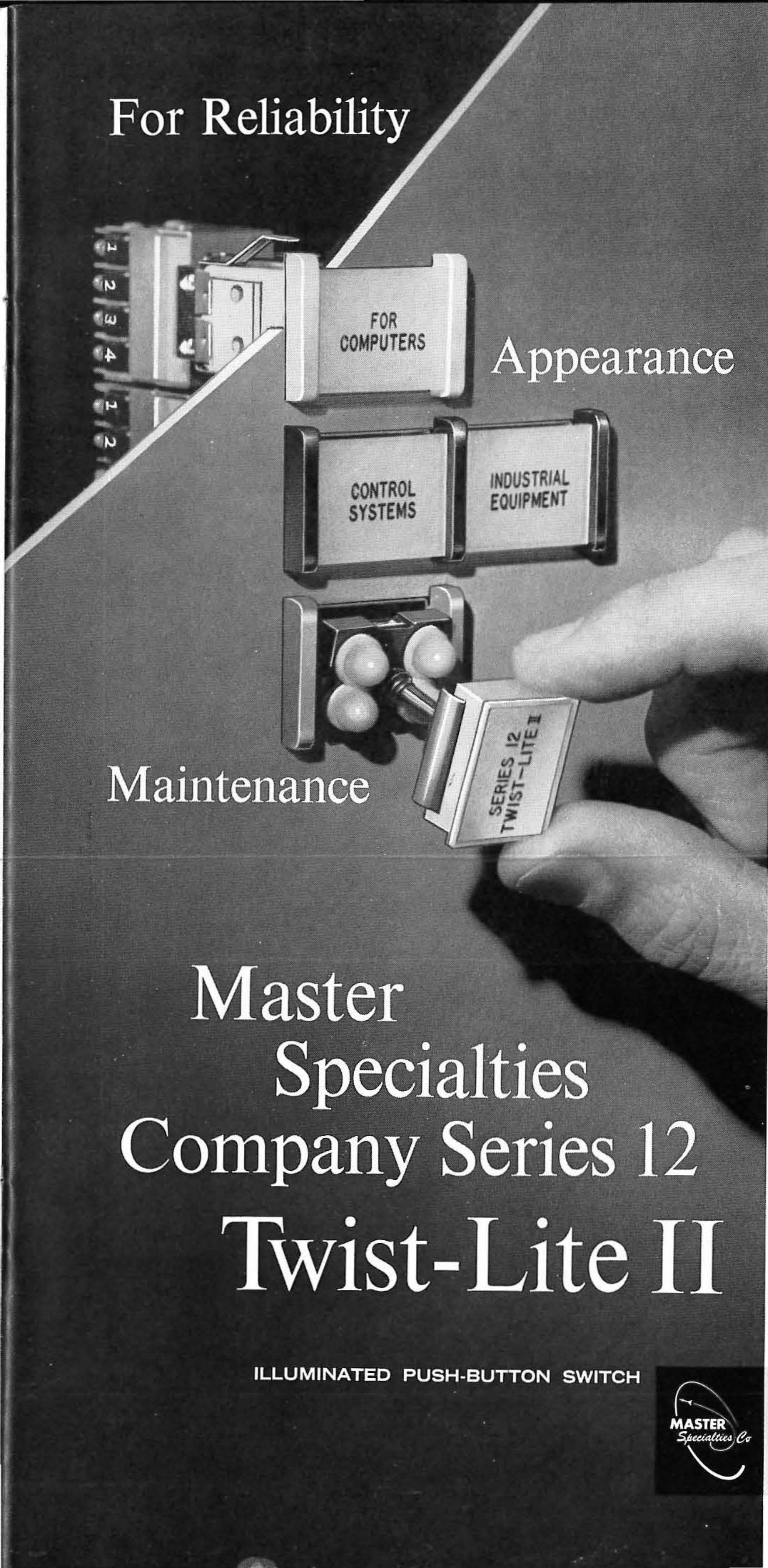
THE SKY'S NO LIMIT ON GPL COMMAND & CONTROL SYSTEMS

Information and display systems are our business, and we've carried their sophistication sky-high. Our PARD (Precision Annotated Retrieval Display) airborne data storage, retrieval and display system is a case in point. It presents real-time television displays of all reconnaissance/surveillance information received from sensor aircraft criss-crossing a combat area. It integrates this information with maps, charts, and up-to-the-minute radioed data. It carries a library of intelligence information at its heart, stored on 5000 rapidly accessible microfilm aperture cards. The result is a complete picture of "what's going on" at any moment over an area which may cover hundreds of square miles. You can enlarge any part of the image on the high-resolution TV displays up to 250 times...always in focus. Write and erase on the display. Obtain hard copies in seconds. Urgent requirements? We delivered the complete PARD system in just 58 days. GPL can put together a system to suit your needs...simple manual to complex computer display, plus remote data handling. The system can grow as your requirements evolve. Let us show you how we've solved display problems...perhaps similar to yours. Write: GPL Division, Dept. ID95, General Precision, Inc., Pleasantville, New York 10570.

GPL DIVISION
GENERAL PRECISION INC.
AEROSPACE GROUP

 Circle Reader Service Card No. 20

Circle Reader Service Card No. 21



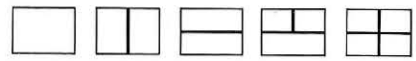
Time-Tested Reliability . . .
Twist-Lite II Series 12 indicators, switch-lites and holding coil units are produced to the same Master Specialties standards of reliability as their military/aerospace counterparts, and have been recognized as acceptable under the Underwriters Lab. Components Program.

Wide Choice of Switching Assemblies . . .
Select from snap-on 2PDT or 4PDT subminiature switches, in momentary or alternate action, rated to 5 amps at 125-250VAC or 30VDC, or momentary switches with magnetic holding coils for electrical inter-lock or lock-in.

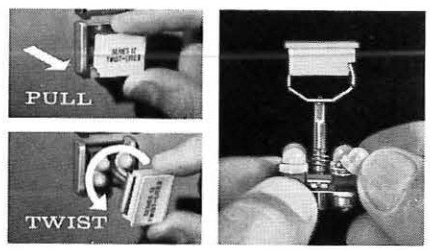
Internally Bussed Lamp Circuits . . .
Optional circuits for 6, 12 or 28 volt incandescent lamps or 115VAC neon lamps include internal bussing of common terminals to reduce soldering . . . simplify installation.

12 Mounting Options for Design . . .
Rectangular, flush-mounted Twist-Lites offer wide flexibility in panel design. Three panel mounting methods, each with two design variations, permit mounting in horizontal or vertical rows or stacks . . . with or without barriers . . . without tools! Select from red, gray, black or white barriers to complement your design.

4 Lamps. Individual Color Control . . .
Colored lamp filters, in five standard colors, fit over individual lamp sockets for quick and easy installation or change to fit your needs.



Full to 4-way Split Display Lenses . . .
Choose from one or two-color full, vertically, horizontally, 3 or 4-way split display lenses. Legend engravings to your requirements . . . shipped with your order!



NO TOOLS REQUIRED
for switch mounting, color filter change, legend change or relamping!
A simple twist lets you remove and return the lens/lamp assembly from the panel front during operation . . . without special tools . . . without the hazard of accidental switching . . . and there is ample room for easy lamp, filter or lens change!

Complete Specifications are Detailed In 20-Page Catalog 2001

MASTER SPECIALTIES COMPANY

15020 South Figueroa Street, Gardena, California Telephone: 213-321-8450

Regional Offices and Telephone

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Syracuse, New York	315-479-9191
Valley Stream, L.I., New York	516-561-2334
Huntsville, Alabama	205-536-7415

Circle Reader Service Card No. 22

Here's the only advice you need to design your own on-line system: don't

Designing on-line systems is tricky. Nevertheless, do-it-yourselfers often try it, taking twice the time to do it wrong at triple the cost of doing it right. Nobody has that sort of money. Or time. That's why you need an expert to put your system on line. Which expert? We have some advice on that subject, too.

by Richard H. Hill

Would you pilot a commercial jet from Los Angeles to Bangkok? Would you take your wristwatch apart and repair it? If the answer is "Yes" and you aren't a pilot or a watchmaker, read on at your own risk. We're about to shoot do-it-yourselfers right out of the on-line systems design business.

SAYS WHO?

First off, our credentials: At Informatics Inc., we think we have every right to speak on the subject of on-line computer systems. Our justification is simple: we've probably done more work in on-line software than any other group in the field. Fact is, we seem to be the only major programming firm anywhere *specializing* in on-line computer systems implementation. And much of our work has been conducted at the furthest extension of the art (National Military Command System, the RADC on-line computing system and the Mobile Wing Reconnaissance Technical Squadron are a few examples). Do we know what we're talking about? We'd better.

THE MISSING LINK: SOFTWARE

At Informatics, we believe that the computing system exists for the user, not *vice versa*. Consequently we are convinced that the directions of the future point inevitably to direct, on-line user/computer communication. But, if you accept this fact, you also have to accept the problems of putting the user and the computer in direct dialog. How do you do this? It's not easy. Nevertheless, a lot of well-meaning users have tried. And a lot of amoebic monsters have been spawned—so divided and subdivided that any semblance of direct access to the system is lost. That's why the job has to be done by an expert—someone who's had the course in the complexities of on-line programming. Right now, today, all of the equipment and technology exists to put even the most sophisticated system on line. The only missing ingredient is on-line software.

THE WAITING GAME

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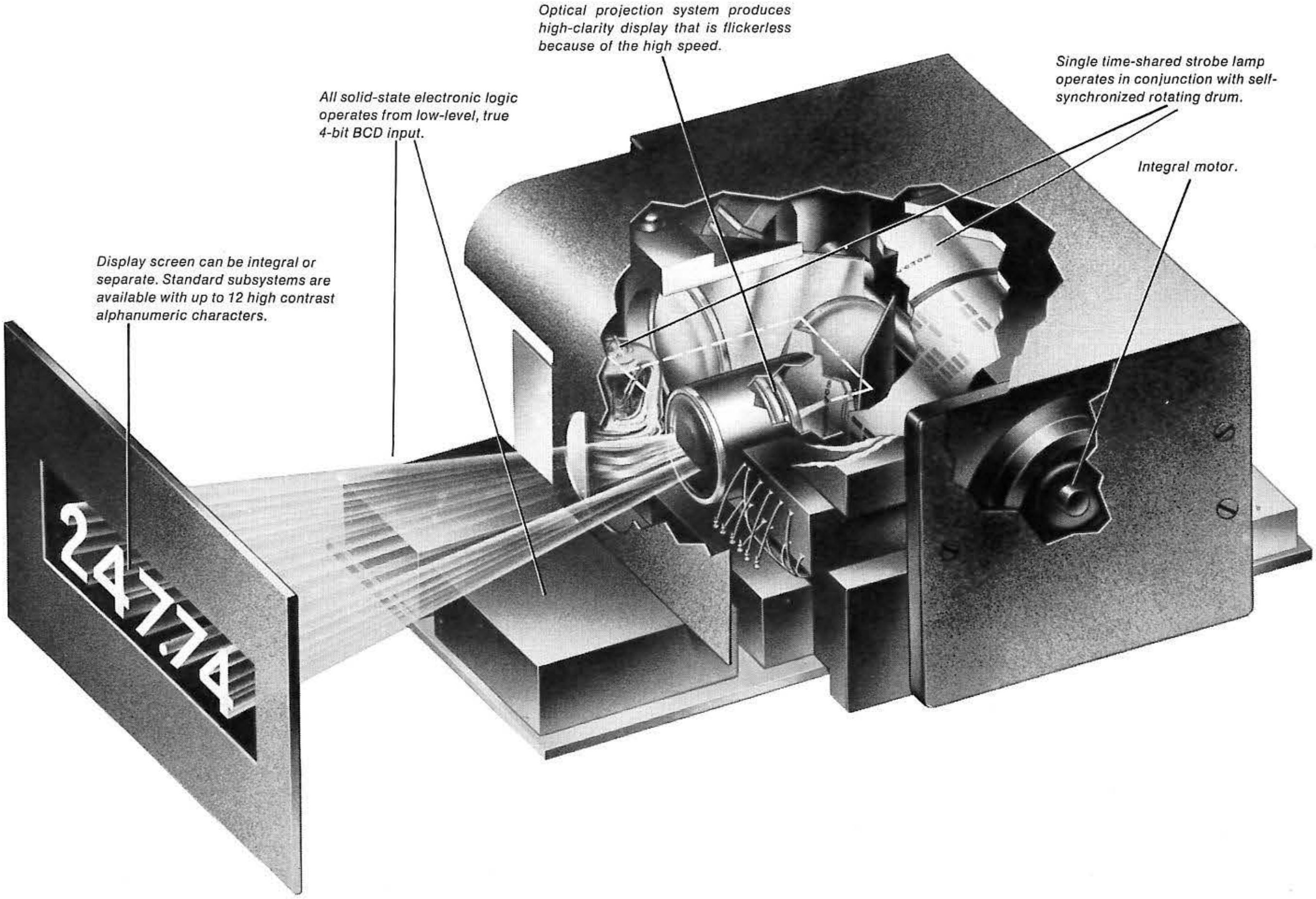

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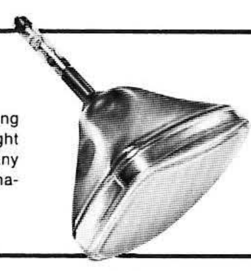

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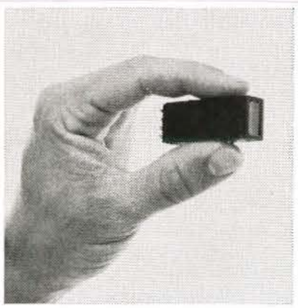

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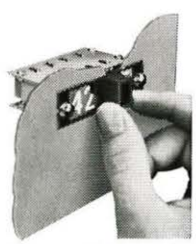

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EDITORIAL

SYSTÈME INTERNATIONAL d'UNITÉS

Since the introduction of the decimal, or metric system of measurement there has been a periodic movement to replace the English system and all its attendant clumsiness. In recent years an increasing awareness has been evident in the scientific, engineering, and lay communities that an ultimate discarding of English units must take place. Now is an opportunity for those engaged in the field of display to assume an important role in establishing a new consistent system.

The General Conference on Weights and Measures met in Paris in October 1960 and officially defined the International System of Units (designated SI for Système International d' Unités). The SI is similar to the MKS in that it utilizes the meter as the unit of length, the kilogram as the unit of mass and the second as the unit of time. SI units also include the ampere for electric current, the degree Kelvin for temperature, and the candela for luminous intensity. Of these units, the ampere and candela involve other units in their definitions. Mass, length, time, and temperature are independently defined. A distinct advantage of the SI is that one and only one unit is designated for each quantity. Multiples and submultiples may be obtained by the use of approved prefixes (most of which are in common usage).

Review of previous issues of *Information Display* clearly indicates the difficulties that can be encountered when more than one system of units is employed. The latter is particularly true in an interdisciplinary science or technology such as displays. Lens and certain other optical dimensions are generally metric, but screens, equipments, and room distances are measured in feet, inches, or yards. Illuminance may be stated in foot-candles or in lux (meter-candles). Ambient temperatures are often given in degrees Fahrenheit, but equipment temperature rise or exhaust temperature may be in degrees Centigrade. It is certainly true that many units are easily converted from one system to another. Conversion factors, however, leave much to be desired. There exists always the potential error due to an extra manipulation. Theoretical and experimental inconsistencies may make conversion more complex than may be superficially evident. Finally, a considerable practical expense is encountered in standards, equipment, and time loss when maintaining a multi-system set of units.

One might legitimately ask how investigators and designers in display can influence such a fundamental problem as systems of units and quantities. The answer is based quite simply on the fact that a language is only as powerful as the extent of its utilization. The task is not to create or standardize a new system, but to use one which has already been internationally sanctioned and has been adopted in this country by no less an organization than the National Bureau of Standards for use by its staff.

The question concerning the SI is not "if", but "when". Every scientist and engineer engaged in the display field has an opportunity to assist in an early general acceptance of the International System of Units.

RUDOLPH L. KUEHN
Publications Chairman, SID

Energy Transfer from CRT To Photosensitive Media

by Leo Beiser

Summary

A method is presented for determining the degree of "fit" to be expected between the cathode-ray tube, as the source of radiation, and a photosensor for subsequent display or data processing. Four most prominent photo-recording phosphors have been matched with the two basic emulsions to derive a set of transfer indices from CRT to film. Similarly, two of the phosphor types have been matched with two prominent photocathode types to yield similar transfer indices from CRT to photomultiplier. Specification incompatibility and uncertainty have been eliminated by stepping back to the power input to the cathode-ray tube as the source of energy, and tracing the power losses through the phosphor and the optics in corresponding units.

Precaution regarding phosphor decay rates, spectral incompatibility, and intervening elements has brought to light the danger of neglect of such factors. Power transfer equations are developed having indices which may be directly extracted from several tables. The ease with which reliable design conclusions may be reached is demonstrated.

Introduction

Photosensitive elements are of two forms: For recording or image transfer, such as photographic film and Kalvar; or as active elements of the system, such as phototubes and photomultipliers.

Both problems of achieving useful energy transfer are closely related: For film, adequate density beyond fog; for photosensors, adequate signal beyond noise. To the communications specialist, this is really one concept: Achievement of adequate signal-to-noise ratio. In the following analysis, we shall attempt to predict this important parameter.

Although the combination of CRT and photographic films appears to blend so well[(1)], new system demands of speed and resolution are constantly penetrating into unknown prior art. The long history of photo-recording from the CRT has only recently provided a unified approach to this energy transfer problem[(2)]. This process will be traced, always keeping in mind that we are neither referring to a particular CRT, nor to a particular sensing medium. The approach is sufficiently general to permit application to any new radiation source and any new photosensitive element. It is thus extended to predict the signal-to-noise ratio in CRT-Photomultiplier "flying-spot" scanning.

Photographic Emulsions

Any attempt to estimate film sensitivity to radiation from a CRT is seriously hampered by specifications of both CRT or film: The earlier definitions (lumens, lamberts, and candles) were related to response of the human eye. Since most useful instrumentation spectral regions are outside this limited range, the cathode ray tube luminance, in *foot-lamberts*, and the photographic exposure, in *meter-candle-seconds*, are incompatible. Instead, a set of power or energy units is required.

Some film sensitivities have been rated in ergs per square centimeter of spectral radiation necessary to raise the emulsion density[(3)] above the residual film fog[(4)] by a specified amount. This energy rating may also be derived from the "Spectral Sensitivity Curve" now available for many film emulsions. This

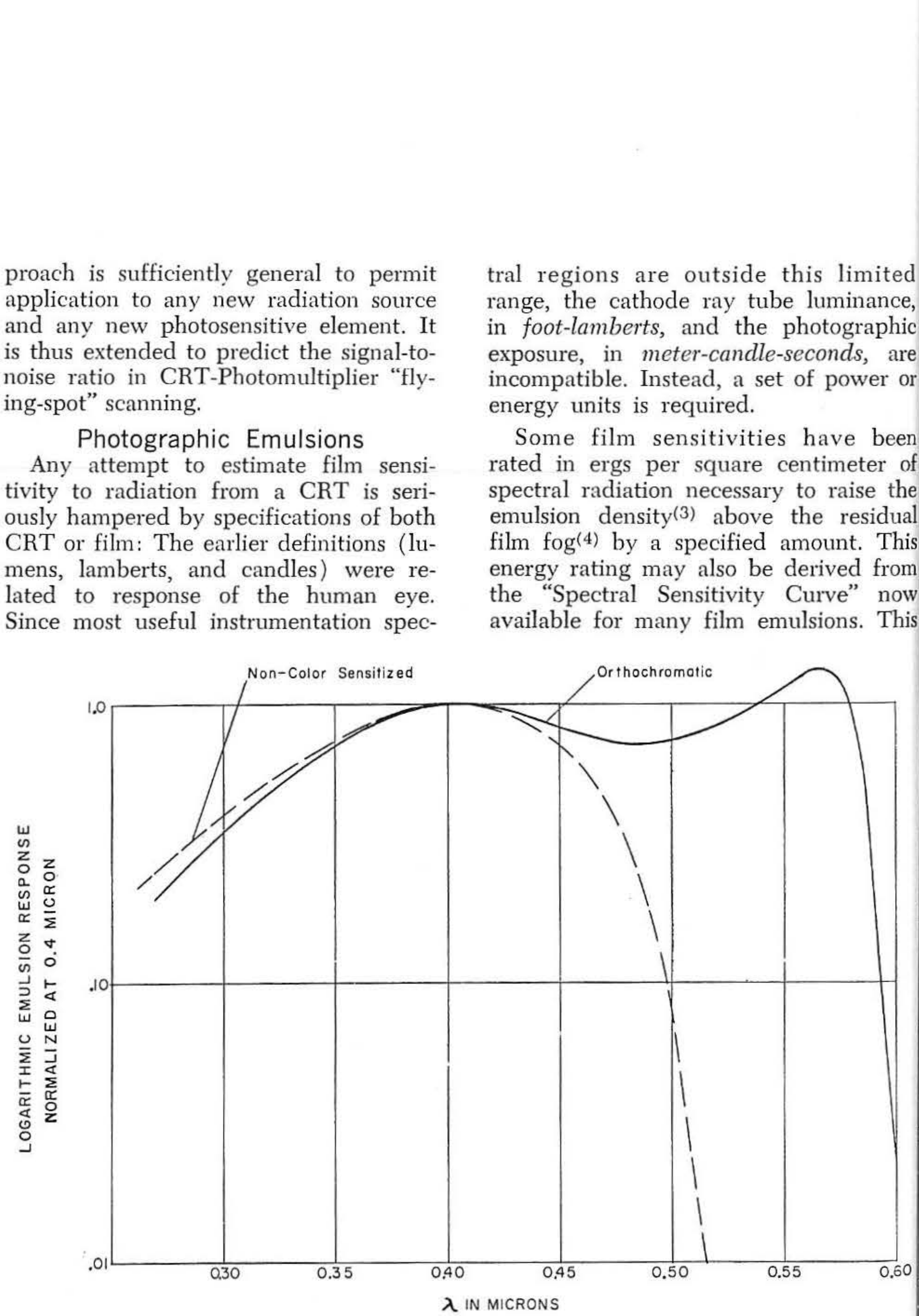


FIGURE 1: Relative emulsion response.

(1) Kalvar and diazo processes require approximately 1 million times the energy of silver halide emulsions to achieve adequate exposure.

(2) L. Beiser, "A Unified Approach to Photographic Recording from the Cathode-Ray Tube," Photographic Science and Engineering, Vol. 7, No. 3, pp. 196-204, May-June, 1963.

curve plots the reciprocal of Exposure (in $ergs/cm^2$) vs. wavelength, typically for a density $D = 1$ above gross fog. Since density is a logarithmic value, a density of 1.0 above fog represents a 10:1 range of opacity, or contrast.(5) Since higher gamma(6) is generally achieved at the expense of processing time, it is important to provide sufficient actinic energy to the emulsion to penetrate beyond the "toe" of the low-level non-linear portion of the transfer characteristics.

The basic sensitivity of silver halide photographic films is in the blue-violet region of the spectrum. (Non-Color Sensitized Response, Figure 1.) It extends from 0.34 μ to 0.50 μ and includes almost all the energy radiated by the P-16 phosphors. By sensitizing the silver halides with selected dyes, the spectral response is extended to the longer wavelength, resulting in two general new classes: Orthochromatic and panchromatic.

The typical orthochromatic (ortho) response extends to about 0.59 μ (Figure 1) and, therefore, includes almost all the energy radiated from our selected phosphors. Most valuable for human use, but not for CRT recording, is the panchromatic (pan) emulsion which exhibits a relatively smooth response well out to 0.65 μ, thereby, including most of the reds.

Photosensors

We shall now extend our analysis to energy transfer from CRT to the photomultiplier. This combination is frequently employed in "flying spot" scanning applications in which a uniform CRT raster is imaged on a transparency. In this "transmission" mode, condensing lenses collect the intensity-modulated light and transfer it to one or more photo multipliers. Or, when imaged on an opaque surface, in their "reflective" mode, the uniform light is re-radiated (generally diffusely) with corresponding intensity-modulation and again collected and transferred to one or more photomultipliers.

It is worthwhile, at this point, to review the optical system considerations which determine application of "transmission" modulation or "reflection" modulation. It will be clarified, from subsequent signal-to-noise analysis, that there are fundamental constraints which must be satisfied for either case. In the transmission" mode, almost all the light flux which is transmitted by the "film" surface may be collected by a condensing lens and transferred to a photocathode for conversion of the intensity-modulated radiation to a corresponding current variation. In the opaque "reflective" mode, the re-radiation is generally diffuse, requiring another large-aperture optical system to collect a new solid angle of radiant flux. The difference in efficiency is analogous to the more commonly-experienced distinction between optical projection of transparencies and opaque projection.

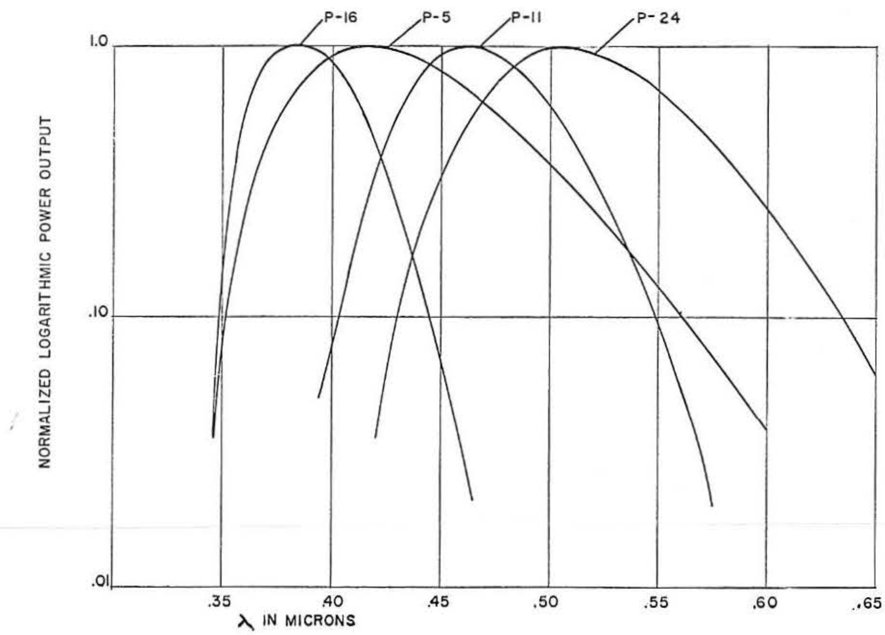
Subsequent discussion regarding optical transfer will assign quantitative values to this factor.

System Integration

Film Recording

In Figure 2 are plotted the normalized relative responses of four phosphor types

FIGURE 2: Phosphor spectral power output.



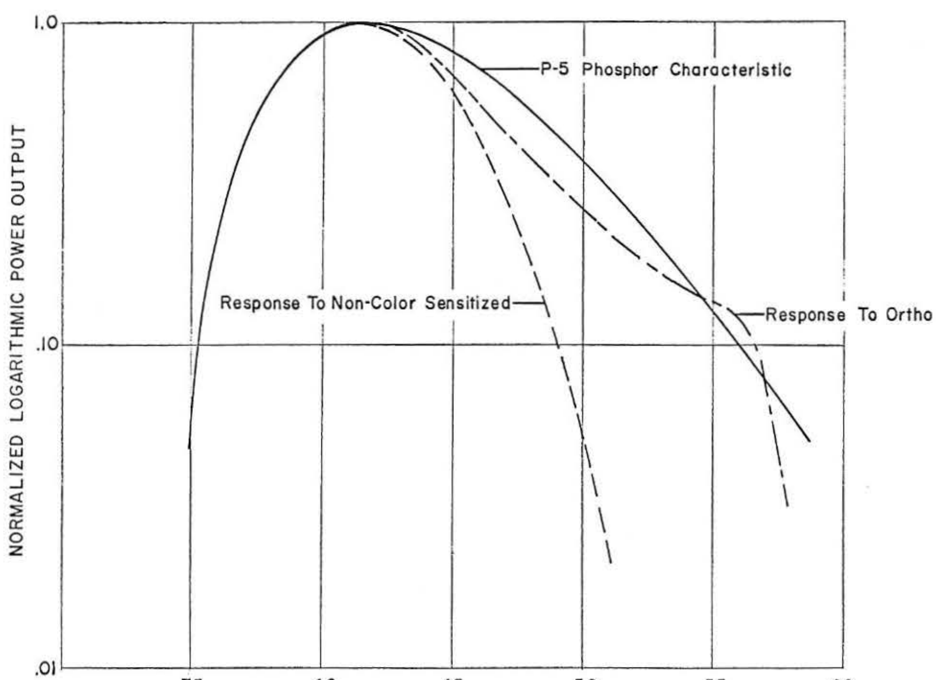


FIGURE 3: Relative spectral responses, P-5 phosphor as modified by non-color sensitized and ortho emulsions.

(3) Density = $\log_{10}$ opacity = $\log_{10} \dfrac{\text{intensity of incident radiation}}{\text{intensity of transmitted radiation}}$

(4) Fog = residual opacity of unexposed emulsion after development.

(5) Contrast is generally an arithmetic ratio. If given in logarithmic terms, then difference between maximum and minimum density is the contrast.

(6) Gamma (γ) is the slope of the straight-line portion of the D log E characteristic, or $\dfrac{d(D)}{d(\log E)}$ max; where E is defined in energy units.

useful for film recording. Since most of their radiant energy is confined to the 0.36 to 0.60 micron region, we narrow our interest to the non-color sensitized and orthochromatic emulsions.

If both emulsion curves are normalized at their most prominent common maxima of 0.4 microns, this group of 6 characteristics (4 phosphors and 2 emulsions) describes the major problem.

If $\frac{A_\lambda}{A_{max}}$ = relative phosphor radiation at wavelength λ,

then, $N_A = \int_0^\infty \frac{A_\lambda}{A_{max}} d_\lambda$ = relative radiant power over all wavelength.

Similarly, if $\frac{B_\lambda}{B_{max}}$ = relative emulsion sensitivity at wavelength λ,

then, $N_B = \int_0^\infty \frac{B_\lambda}{B_{max}} d_\lambda$ = relative emulsion response over all wavelength.

The relative transfer of radiant energy from phosphor to emulsion may be expressed as

$$\alpha = \frac{\int_0^\infty \frac{A_\lambda}{A_{max}} \frac{B_\lambda}{B_{max}} d_\lambda}{\int_0^\infty \frac{A_\lambda}{A_{max}} d_\lambda}.$$

Although the phosphor radiation may be approximated by a Gaussian distribution, no simple analytic expressions exist for the emulsion responses. The integration will, therefore, be numerical as follows:

$$\alpha = \frac{\sum_{i=1}^{n} A_i B_i}{\sum_{j=1}^{m} A_j}, \quad (m > n)$$

over all equal significant wavelength increments, $\Delta\lambda$.

When each phosphor response is multiplied by a selected emulsion response for all combinations of four phosphors and two emulsions, eight new curves are

TABLE I

Phosphor Emulsion Transfer Efficiency, α

Phosphor Type	P-16	P-5	P-11	P-24
α_{nc}	0.95	0.68	0.50	0.15
α_{oc}	0.93	0.87	0.87	0.81

α_{nc} = transfer efficiency with non-color sensitized emulsion

α_{oc} = transfer efficiency with orthochromatics emulsion

(All values based upon normalized emulsion response at 0.4 micron) derived, illustrated in Figures 3, 4, and 5. Figure 3 shows the effect of the two emulsions upon a P-5 phosphor; Figure 4 illustrates the modification of P-16 and P-11 phosphors; and Figure 5 the effect upon P-24 phosphor response by the same two emulsions. Table I summarized the results.

When α is multiplied by other transmission efficiencies, by input power density, and by the time of exposure, the product yields the energy density available for photorecording:

$$E = \frac{\eta \alpha \beta K P \tau}{A} \times 10^7 \text{ ergs/cm}^2$$

Where,

η = phosphor conversion efficiency (Table VI)

α = spectral transfer efficiency (Table I)

β = optical transmission efficiency (Section 5)

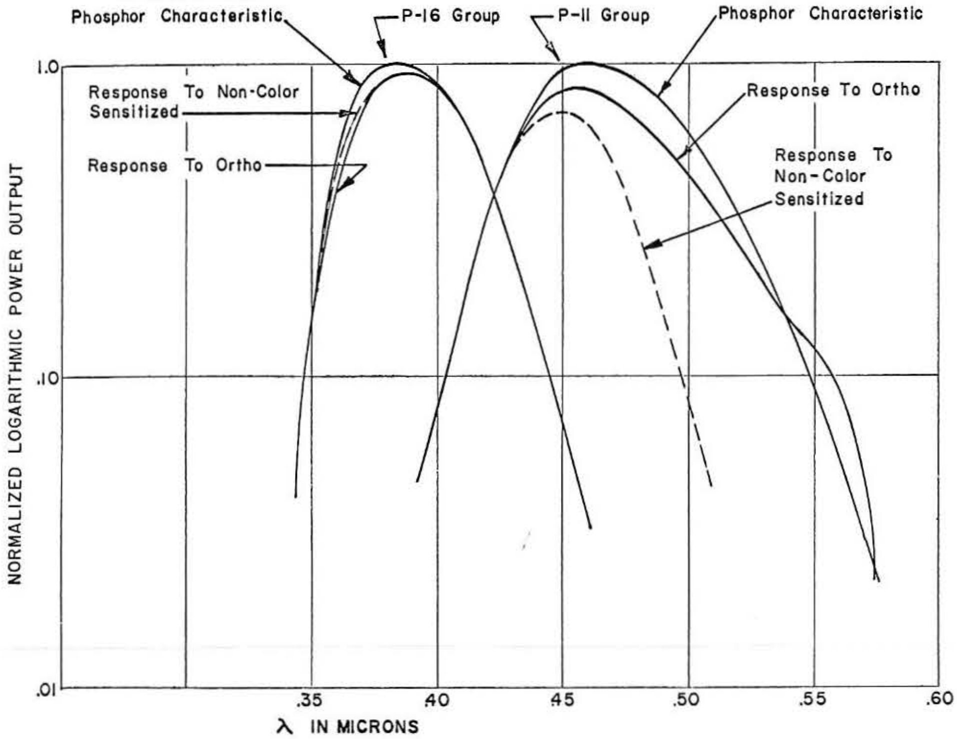
K = screen utilization factor (Table VII)

P = exciting beam power, watts

τ = time over area A, seconds

A = scan area on phosphor, cm^2

FIGURE 4: Relative spectral responses, P-16 & P-11 phosphors as modified by non-color sensitized and ortho emulsions.



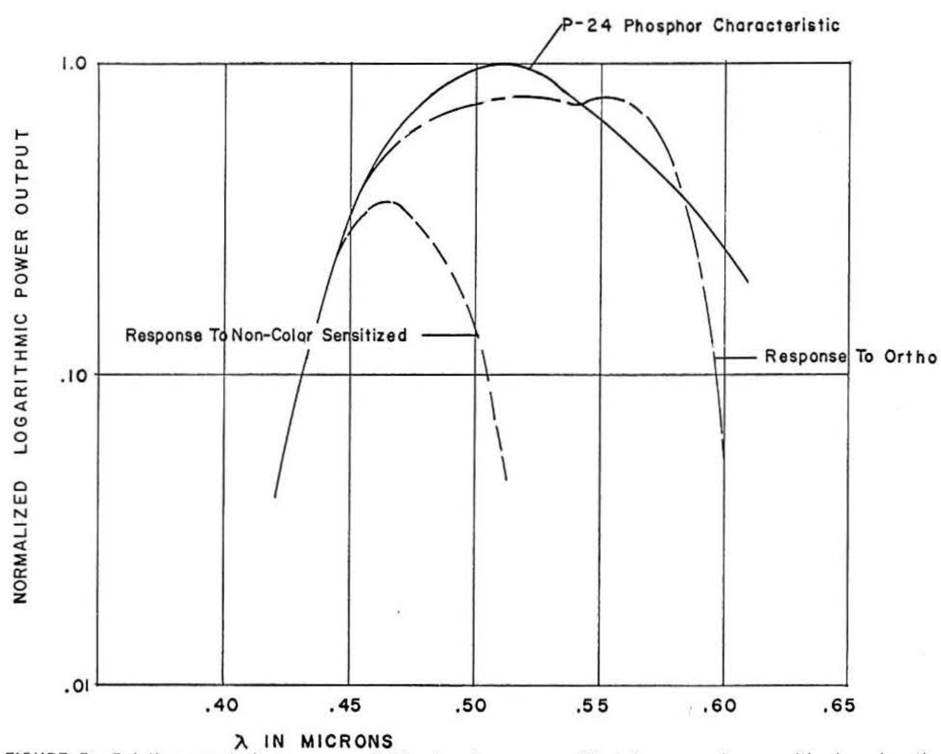


FIGURE 5: Relative spectral responses, P-24 phosphor as modified by non-color sensitized and ortho emulsions.

This available energy is then compared with that required for achieving a particular optical density for a selected emulsion. Several interpretations of T and A may be employed:

1. If a line-scan application, then T may be the time for one active line and the A may be the length times effective width of the line.
2. For a raster scan (array of lines), the T may be the total frame time (excluding blanking) and A, the total raster area (if the raster is composed of merged lines). If the raster lines are not merged, then account must be taken of the reduction in active area for increased "space" between lines.
3. If a single impulse is to be recorded as a "dot," then T is the time of application, and A is the area of the dot.

The phosphor rise and decay times do not appear in this expression, for the radiation derived from an element of phosphor is to dwell on the elemental emulsion during the entire rise and decay interval, integrating radiant energy over the exposure period. One should, therefore, choose a phosphor having decay time which is small compared to the entire exposure interval; a criterion which is readily satisfied. All other factors in this expression are subsequently discussed and evaluated.

Photomultiplier Signal

The CRT phosphors employed for photomultiplier signal extraction are generally required to exhibit a rapid decay-time characteristic to permit following the intended rapid intensity variations. The P-16 and P-24 types are representative of these fast-decay phosphors.

It is fundamental that the photocathode responses generally fall around the shorter wavelength regions of the spectrum, providing reasonable compatability with the radiation from fast phosphors. The S-11 and S-20 types are representative of these high sensitivity photochthodes which are specified and designed with light-transmitting glass entrance windows.

Again, we construct a transfer efficiency factor, α, this time between phosphor and photocathode, as follows:

$$\alpha = \frac{\int_0^\infty \frac{A_\lambda}{A_{max}} \frac{C_\lambda}{C_{max}} d_\lambda}{\int_0^\infty \frac{A_\lambda}{A_{max}} d_\lambda}$$

and arrive at a numeric approximation for non-analytic expressions:

$$\alpha = \frac{\sum_{i=1}^{n} A_i C_i}{\sum_{j=1}^{m} A_j}, \quad (m \geqslant n)$$

summing over all equal significant wavelength increments, $\Delta\lambda$. The A's again represent phosphor radiation, while the C's now represent the photocathode sensitivities.

Illustrated in Figure 6 are the responses of S-11 and S-20 photocathodes, while Figure 7 demonstrates the effect upon P-11 and P-24 spectral outputs by each of the photocathode spectral responses. Again, the area under the modified curve divided by the area of the original curve represents the transfer efficiency, α.

TABLE II

Phosphor-Photocathode Spectral Transfer, α

Phosphor Type	P-16	P-24
α_{11}	0.85	0.70
α_{20}	0.90	0.73

α_{11} = transfer efficiency with S-11 photocathode

α_{20} = transfer efficiency with S-20 photocathode

(all values referenced to maximum radiant sensitivity of photocathode)

When α is multiplied by other transmission efficiencies and by the input power, we obtain the power delivered to the photocathode,

$$P_p = P_o \, \alpha \, F \, K$$

Where

P_o = phosphor radiant power, watts

α = phosphor-photocathode spectral transfer

F = system optical transfer efficiency

K = screen utilization factor

Since, as before,

$$P_o = \eta \, P$$

where

η = phosphor conversion efficiency

P = exciting beam power, watts

then we obtain

$$P_p = \eta\alpha FKP \times 10^6 \text{ microwatts}$$

Since the radiant sensitivity (S_r) of photocathodes is typically specified in microamps per microwatt at peak sensitivity, the photocathode current is thus directly obtained. Although we have not yet evaluated F or K, the course for determination of the signal current is now clear. This signal current may then be compared with the significant noise currents to establish a signal-to-noise ratio.

Photomultiplier Signal-to-Noise Ratio

Photomultiplier Noise

Photomultiplier noise power may be expressed as

$$N = N_s + N_t = 2eB \frac{\delta^n (\delta^{n+1} - 1)}{\delta - 1} RI_o + 4KT$$

where,

N_s = amplified shot noise power

N_t = thermal agitation (Johnson) noise power

e = charge on electron = 1.6×10^{-19} coulomb

B = signal bandwidth, cycles/second

δ = secondary emission ratio

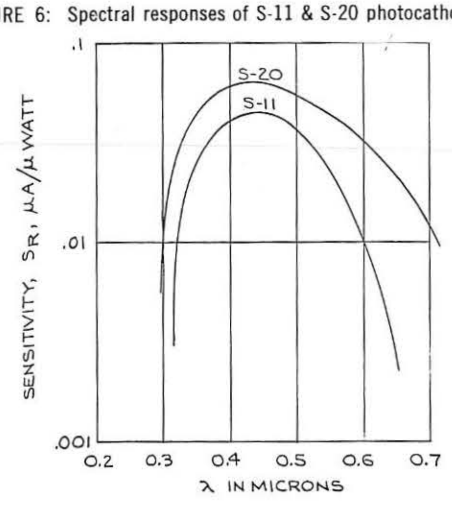
n = number of stages of multiplication

R = load resistance

I_o = photocurrent

K = Boltzmann's constant = 1.38×10^{-23} watt-sec/degre

FIGURE 6: Spectral responses of S-11 & S-20 photocathodes.



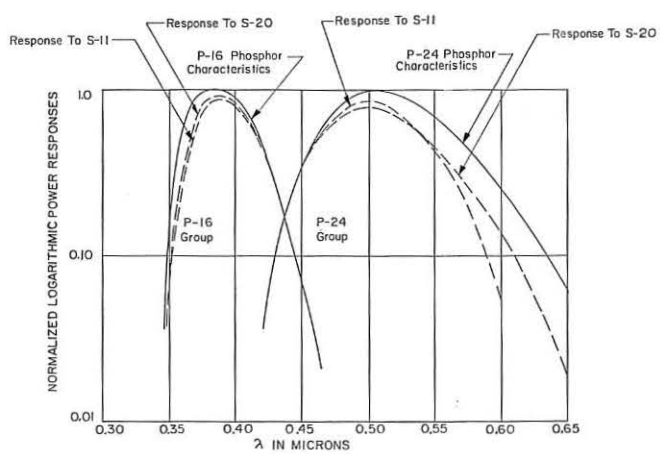


FIGURE 7: Relative spectral responses, P-16 & P-24 phosphors as modified by S-11 & S-20 photocathodes.

An evaluation of N_t, the Johnson noise component, reveals that its magnitude is generally insignificant compared with the amplified shot noise. A typical value of N_t (for T = 300°K and B = 6 mc) is 3.3 x 10^{-14} watt, while N_s, the shot noise power is, therefore, discarded compared to the dominant amplified shot noise, yielding,

$$N = N_S = 2\ eB\ \frac{\delta^n\ (\delta^{n+1} - 1)}{\delta - 1}\ I_o R$$

$$\cong 2\ eB\ \frac{\delta^{2n+1}}{\delta - 1}\ I_o R$$

$$\left[\text{ since } \delta^{2n+1} \gg \delta^n \text{ for } \delta > 2 \right]$$

Signal-to-Noise Ratio

The signal power into the load resistance, R, is

$$S = (\delta^n\ I_o)^2\ R$$

When divided by the above-derived noise power, we yield the signal-to-noise ratio

$$\frac{S}{N} = \frac{\delta^{2n}\ {I_o}^2\ R}{2\ eB\ \frac{\delta^{2n+1}}{\delta - 1}\ I_o\ R}$$

$$\text{whence, } \frac{S}{N} = \frac{I_o}{2\ eB}\ \frac{\delta - 1}{\delta}$$

The signal-to-noise ratio is shown to be independent of the magnitude of the load resistance and directly proportional to the power available to the photocathode.

Since I_o = radiant sensitivity of photocathode (S_r) x power available to photocathode (P_p)

Then, in terms of known transmission constants,

$$\frac{S}{N} = \frac{\eta \alpha F K S_R P}{2\ eB}\ \frac{\delta - 1}{\delta}$$

where,

S_R and P are expressed in equivalent power units;
$F = F_f \beta_v$, defined under Lens Transmission and Absorption. All other terms as previously defined.

Expressed in decibels,

$$N_{db} = 10\ \log_{10}\ \left(\frac{S}{N}\right)$$

The radiant sensitivity (S_r) of the two selected photocathodes, S-11 and S-20, are listed in Table III.

TABLE III

Radiant Sensitivitoy of Photocathode, S_r

Photocathode	S_r, uA/u watt
S-11	.05
S-20	.064

We can compress the signal-to-noise expression further by combining the product of three terms into a new transfer constant. The phosphor conversion efficiency, η, the phosphor-photocathode spectral transfer, α, and the photocathode radiant sensitivity, S_r, may be expressed as a new factor, the phosphor-photocathode transfer efficiency,

$$T_{a-b} = \eta_a\ \alpha_{a-b}\ S_r\ \frac{\text{amps (through load)}}{\text{watt (electron beam)}}$$

were, subscript
a = phosphor notation
b = photocathode notation

For example, the P-16, S-11 combination yields,

$$T_{16-11} = .049 \times 0.85 \times .05 = 2.08\ 10^{-3}\ \frac{\text{amps}}{\text{watt}}$$

With this notation, the signal-to-noise ratio becomes

$$\frac{S}{N} = \frac{T_{a-b}\ FKP}{2\ eB}\ \frac{\delta - 1}{\delta}$$

where T_{a-b} = phosphor-photocathode transfer eff (Table IV)
F = optical transmission eff (Section 5B)
K = screen utilization factor (Table VII)
P = exciting beam power, watts
δ = photomultiplier secondary omission ratio
e = charge on electron = 1.6 x 10^{-19} coulomb
B = signal bandwidth, cycles/second

Table IV summarized this new constant for our selected combinations of phosphor and photocathode. (*n* from Table VI, α_{a-b} from Table II, and S_r from Table III).

TABLE IV

Phosphor-Photocathode Transfer Efficiency, T_{a-b}

In Amperes (x 10^{-3}) through Load per Electron Beam Watt

		Phosphor Type	
		P-24	P-16
Photocathode	S-11	$T_{24-11} = 0.88$	$T_{16-11} = 2.08$
Type	S-20	$T_{24-20} = 1.02$	$T_{16-20} = 2.83$

Lens Transmission and Absorption

Between the phosphor and the photosensor are optical elements whose sole purpose is to economically direct the maximum available energy to the object plane with acceptable aberration.

This optical transmission efficiency is composed of two factors: A wavelength-insensitive transmission factor and a wavelength-dependent transmission factor.

Let: β_f = fixed or wavelength-insensitive factor (for photorecording)
F_f = fixed or wavelength-insensitive factor (for flying spot signal extraction)
β_v = variable or wavelength-dependent factor for either case.

Then, for photorecording,

$$\beta = \beta_f \beta_v$$

and for signal extraction,

$$F = F_f \beta_v$$

The transmission loss which determines β_f and F_f is considered here due to collecting a finite portion of the radiant flux.

Although a limited optical aperture is the primary cause of this loss, in wide-angle applications, two additional factors become significant: Reduction of illuminance off axis, and vignetting. The reduction of illuminance off axis varies approximately as $\cos^4\ \theta$ where θ is the angle off axis, while the vignetting must be determined from the particular physical configuration of lens and barrel assembly.

The complete transmission factor is represented by:

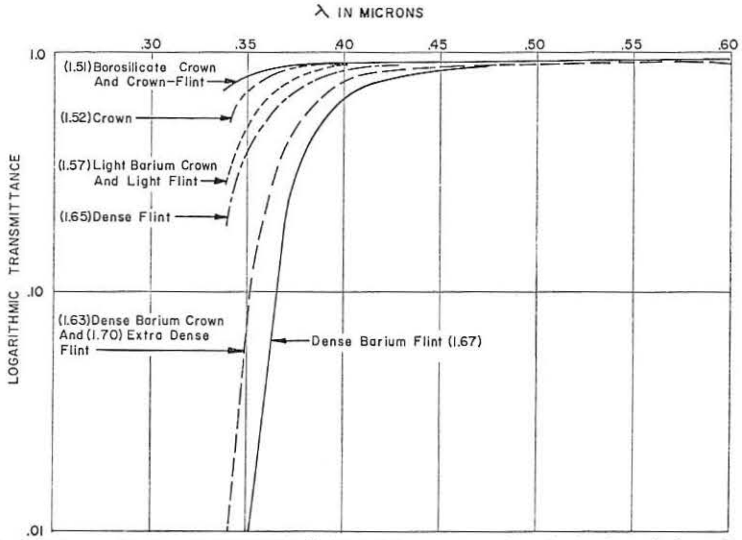


FIGURE 8: Typical transmittance of uncoated ½-in. thick samples of optical glass (index of refraction in parentheses).

A. For photorecording

$$\beta_f = \frac{\cos^4 \theta \, V_\theta}{1 + 4f^2(M+1)^2}$$

where θ = off-axis image angle
V_θ = transmission factor due to vignetting
f = optical f-number
M = magnification, image/object

B. For flying spot scanning,

$$F_f = \frac{\cos^4 \theta \sin^2 \phi \, V_\theta}{2}$$

where
ϕ = off-axis lens angle subtending object space.

When the lens subtends a small angle, such that $\sin \phi \approx \phi$,

$$\text{Then, } F_f = \frac{1}{2} \cos^4 \theta \, \phi^2 \, V_\theta$$

In terms of lens f-number and magnification,

$$F_f = \frac{\cos^4 \theta \, V_\theta \, M^2}{8f^2 (M+1)^2}$$

The distinction between β_f and F_f is that between radiant density (β_f) in power per unit area, and the radiant flux (F_f) in power units. For photorecording, it is the power density which exposes the elemental emulsion area, while for flying spot scanning, it is the total power which determines the signal current. They are related as,

$$F_f \cong \frac{M^2}{2} \beta_f$$

For photorecording, the composite optical transfer is

$$\beta = \beta_f \beta_v$$

while for flying spot scanning, the optical transfer is

$$F = F_f \, \beta_v = \frac{M^2}{2} \beta_f \beta_v$$

The wavelength-variable transmission components β_v is determined from characteristics of several representative optical glasses (½" thick) plotted vs. wavelength in Figure 8. A "corrected" lens assembly is composed of compounded elements of assorted indices of refraction for the control of monochromatic as well as chromatic aberrations. Hence, high index of refraction glass (having poor violet transmission) must be used. As a result, some "quality" lens assembly transmissions are similar to that of the Dense Barium Flint response of Figure 8. The substantial thickness of "fast" lenses degrades transmission as the power of the multiple of (½") thickness. For example, a lens composed of 2" of glass on axis suffers a loss of $(\beta_v)^4$.

Any new lens design should take advantage of those factors which simplify the assembly. The system acuity, in terms of resolvable subtended angle of arc may be more lenient in CRT optics than in photographic optics. Hence, corrections for aberrations may be achieved with simpler lens assemblies with less total glass in the optical path. Furthermore, some 50% advantage may be derived from correcting for chromatic distortions only over the limited range of wavelength operation, rather than the full spectrum. Finally, "anti-reflective" coatings must be optimized in the transmission band, for they are typically reflective in the blue and violet regions when coated for visual optics.

Conservation of Energy At the CRT Screen

An electron beam impinges upon a fine deposit or luminescent material. Upon impact and deceleration, the phosphor is stimulated into luminous radiation (fluorescence), which generally persists after the excitation has ceased (phosphorescence). Only a small percentage of this cathode-derived electron beam energy is converted into light flux (cathodoluminescence) while the balance dissipates mainly as heat. Light flux, measured in lumens, is energy per unit time passing through a surface; dimensionally equivalent to power.

Conservation of energy establishes this radiant light flux. Over a given period of time, the power which originates in the electron beam of a given current, accelerated through a given potential, is also conserved. The potential difference determines the final velocity, hence, the impact conditions which establish radiation.

TABLE V

Efficiency Factor, η_a, as Fraction of Beam Energy Transmitted through Aluminized Coatings of Varying Thickness, for Three Values of Beam Voltage

		Aluminum Film Thickness, Å			
		500	1000	2000	5000
Beam Voltage in Kilovolts	30	0.98	0.96	0.93	0.85
	20	0.97	0.93	0.86	0.70
	10	0.87	0.77	0.57	0.15

In aluminized screens, some energy is absorbed at this fine reflective coating, while a residue of the electron beam penetrates the phosphor and dissipates in the glass wall. Over a given set of operating conditions, these two factors are relatively constant, since high resolution cathode-ray tubes operate at potentials which are confined to a narrow range.

A conventional (visible) phosphor surface is diffuse due to the random settling of the particles which scatter and reradiate the light from the bombarded point. In extremely high resolution applications, where scattering cannot be tolerated, a "vapor-reacted" phosphor is formed directly on the faceplate, and is homogeneous and invisible when polished. However, in the 'transparent" screen, much of the light flux is edge-conducted by the glass walls, draining radiation from the point source.

TABLE VI

Radiant Equivalents for Four Selected Phosphors

Phosphor Type	Luminous Equivalent (Radiated lumens per radiated watt)	Absolute Efficiency, η (Radiated watts per watt excitation)
P-16	2.5	0.049
P-5	90	0.025
P-11	140	0.10
P-24	360	0.025

TABLE VII

Typical Screen Utilization Factors, K, of Four Screen Processes

Screen Process	Utilization Factor, K
Coarse Settled Aluminized Screen	1.0
Fine-Grain Settled Aluminized Screen	0.5
Vapor-Reacted Screen — unpolished	0.3
Vapor-Reacted Screen — polished	0.1

Phosphor Efficiency

The electron beam imparts its total energy to the phosphor area. The fraction which dissipates as heat in the fine aluminum coating may be derived from Table V.

Since the aluminized surface can reflect a maximum of 50% of the total luminous radiation, the aluminum electron transmission efficiency must be greater than 0.50 to be useful. The cross-over in efficiency by virtue of aluminizing is rapid, and the shaded area of Table V denotes the combinations of thicknesses and potentials which will yield no practical gain by aluminizing. On the other hand, operation between 20KV and 30KV with aluminum thicknesses between 500 Å and 200 Å results in excellent transmission of energy, and hence, a gain of almost 2 in useful radiation.

The electron penetration into and beyond the phosphor layer must also be controlled. If the phosphor layer is too thick, no energy will be lost in the glass, but light flux will be absorbed by phosphor. If the layer is too thin, almost all radiated flux will be useful, but much electron beam energy will be dissipated as heat in the glass.

Since electron beam penetration varies almost as the square of the accelerating potential, a relatively narrow range of potentials exist over which maximum phosphor efficiency may be achieved.

When the CRT is designed for a particular range of operating potentials, and the optimum screen thicknesses are maintained, we can predict luminous output for a given power input by considering phosphor efficiency constant over the limited operating range.

The straight line equation for luminous output is, therefore, $L = \eta I (V_o - V_a)$,

where,

η = intrinsic luminous efficiency, lumens/watt

I = beam current, amperes

V_o = operating potential, volts

V_a = potential at which output approaches zero due to loss in aluminum film, volts

In a well designed tube, V_o is chosen so that at least 90% of the beam energy penetrates the aluminum, while V_a is that potential at which penetration is about 50%. (Cross-over of aluminizing usefulness.) A significant uniformity of data permits the application of a simple efficiency index over a wide range of conditions.

Table VI presents the corrected phosphor efficiency (η) directly in watts radiated per watt excitation[7] for the four selected phosphors. This is the factor which is to be inserted into the energy transfer equations for photorecording and for photomultiplier signal extraction.

The Luminous Equivalent (tabulated in lumens per radiated watt) is derived from the experimentally established spectral response.[8] It indicates the correspondence between the radiated spectral energy and the spectral response of the human eye; the ratio of the luminous equivalent to 680 denotes the proportion of radiant energy to which the human eye will respond. Note that P-16, with its major contribution at the short wavelength end of the spectrum exhibits less than 1% of luminous equivalent of the clearly green P-24 phosphor.

The mechanical application of the phosphor screen material often determines radiation efficiency. A polished transparent "vapor reacted" screen radiates about one tenth of the useful light or the conventional settled phosphor screen. If left unpolished, this figure may be trebled. These screens exhibit high overload resistance due to the intimate contact between the phosphor and the glass, providing high thermal conduction. But much of the light is totally reflected between the polished surfaces of the phosphor layer and the glass.

Furthermore, the extremely small crystal size yields a reduced number of impurities or lattice defects per crystal, offering fewer radiation-producing recombinations at these luminescent cen-

(7) "Typical Absolute Spectral Response Characteristics of Aluminized Phosphor Screens," Components and Instrumentation Laboratory, ITT Industrial Labs.

(8) JEDEC Publications No. 16, "Optical Characteristics of Cathode-Ray Tubes," JEDEC Electron Tube Council, June 1960.

ters. Although these screens achieve a finer spot, with less loss from scattering and multiple reflections, reduced radiation is derived in the direction of interest. Table VII lists the screen utilization, *K* of four typical screen processes.

Limits of Linearity

The linear energy transfer equation $L = \eta I (V_o - V_a) = P$ has been investigated, in view of the following experimental and theoretical limitations on the range of linearity:

1. With beam current and anode potential hold constant, (constant beam power) luminous output is often a function of spot focus; the defocused raster yielding a higher luminous output. Thus is indicated a variation of efficiency with power density.
2. A plot of luminous output vs. beam current tends to saturate at higher currents, and yields lower output as scan time is increased. Thus, is developed a variation of efficiency with exposure (energy density, $\eta = f(E) = f(p,t,A)$.
3. A steady state characteristic called "aging" is demonstrated, having the form

$$L = L_o \frac{1}{1 + CN}$$

where, L_o = initial luminosity
L = aged luminosity
C = burn parameter, cm^2
N = number of electrons deposited per cm^2 = $f(T), (T > t)$.

Thus, is developed a variation of efficiency with long exposure time, $n = f(N) = f(T)$.

In cases (1) and (2), the efficiency is modified by instantaneous temperature, in which higher bombarding energy tends to reduce luminous output. The familiar darkening after extended use, along with a corresponding loss in light output, also demonstrates case (3). It is interesting to note that aging characteristics have been shown to be related directly to exposure, validating accelerated tests to hasten experimental data.

Although high resolution cathode-ray beams are accelerated through potentials which approach the magnitude of projection CRT beams, their current densities are far below those of projection technology. Where projection tubes attain average currents in hundreds of milliamperes, the photorecording CRT rarely exceeds currents of a hundred microamperes. In order to achieve the high resolution demanded of photorecording, the typical 1-mil diameter beam seldom exceeds currents of 10 microamperes.

On the other hand, a projection CRT having a 10-mil diameter beam may well attain 1 ampere of peak current. This represents a change in power density of about 1000 to 1. Of course, when the recording situation demands extremely high radiation from the CRT at relatively low resolution, then allowance must be made for reduction in efficiency due to phosphor heating. The data provided here assumes operation on new screens below the temperature of phosphor saturation. Note, too, that the beam power is determined by beam current; not by cathode current.

The cathode current is often considerably larger than the beam current due to losses in limiting aperture which shape and reduce the size of the emerging beam. Some high resolution CRT's have electron guns which operate at almost 100% efficiency; the fine beam cross-over at the cathode is imaged, rather than an extruded bundle at a limiting aperture.

Choice of Phosphor

The Luminous Equivalent listed in Table VI (in radiated lumens per radiated watt) is significant if the CRT must be viewed or displayed. Then a high Luminous Equivalent (such as that from the P-11 and P-24) is favored. It is the product of Luminous Equivalent and Absolute Efficiency which provides an index of visual luminous efficiency. For example, the (blue) P-11 radiates 140 x 0.1 = 14 lumens per watt, while the (green) P-24 radiates 360 x 0.025 = 9 lumens per watt (at low excitation densities).

Application of the P-16 or equivalent phosphor is almost mandatory when an extremely fast decay time is demanded for photomultiplier signal extraction. (Note that the phosphor rise time is generally an insignificant proportion of its radiation time, T). An added advantage of this blue-*uv* phosphor is the adaptability to non-color sensitized emulsions and their attendant freedom from ambient exposure (fog). The non-color sensitized emulsion permits this advantage even with the P-5 and P-11 phosphors, but represents too drastic a loss for the P-24. For quantitative values, see a_{nc} of Table I.

The P-24 provides a unique freedom from burn damage. This heartiness is demonstrated by test data which indicates that 90% of the initial intensity is available from the P-24 after 1 coulomb/cm^2 exposure, while only 25% of the initial intensity is available from the P-16 after a comparable exposure. After 100 coulombs/cm^2, the P-24 yields 40% of its initial output, while the P-16 only 5%. For this reason, the P-16 is sometimes burned-in to permit operation over its more stable, longer-term interval. Such considerations will markedly affect the effective value of efficiency, η, which has been specified in Table VI for fresh phosphor.

To provide quantitative values for relative stability, the number of coulombs/cm^2 necessary to reduce L to ½ L_o (aging characteristic) are as approximately as follows:

P-16, 0.1; P-11, 17; and P-24, 34

These are the equivalent values of amperes per second, over the scanned area of one cm^2. For example, 1 μA beam current over 1 square cm for 1 million seconds (about 5 weeks at 8 hours per day) would represent 1 coulomb/cm^2 of exposure.

APPENDIX

The Quantum Yield Factor

Planck's radiation law states,

$$E = h\upsilon = \frac{hs}{\lambda}$$

where h = Planck's constant
υ = frequency of radiation
c = velocity of light
λ = wavelength of radiation

In terms of electron-volts of energy, eV, it should require $V = \frac{hc}{\lambda e}$ volts per photon* to stimulate a phosphor into radiation at wavelength λ.

Substituting for known constants,
$h = 6.625 \times 10^{-27}$ erg-sec
$c = 3 \times 10^{10}$ cm/sec
$e = 1.6 \times 10^{-12}$ erg

we find that for every micron of radiation, we require an input energy of $\frac{1.24}{\lambda\mu}$ electron volts per photon eV liberated.

where $\lambda\mu$ = wavelength in microns.

Conversely, if the radiator were absolutely efficient, it would liberate

$$\eta \text{ max} = \frac{\lambda\mu}{1.24} \text{ photons per eV.}$$

Fo rexample, the P-11 phosphor with peak radiation at 0.64 μ should liberate

$$\eta \text{ max} = \frac{0.46}{1.24} = 0.38 \text{ photons/eV.}$$

Table VI indicates, however, that only 0.038 photons per electron volt are liberated, denoting an absolute efficiency of

$$\eta = 0.038/0.38 = 0.1,$$

corresponding to the value listed for η in the same Table.

Multiplication of the quantum yield factor by the accelerating potential in volts results in an efficiency rating of quantum yield in photons per electron. This, in turn, may be interpreted in terms of measurable quantities by applying the conversion,

1 amp = 1 coulomb/sec = 6.28×10^{18} electrons/sec.

whence,

1 μA = 6.28×10^{12} electrons/sec.

For V = 27KV, the P-11 phosphor yields $27 \times 10^3 \times .038 = 10^3$ photons/electron.

At 2 μA beam current, it will radiate $6.28 \times 10^{12} \times 2 \times 10^3 = 12.6 \times 10^{15}$ photons/sec.

A given exposure in seconds then yields the total energy radiated by the phosphor in photons.

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*The photon is the plane-wave quantum (hv) of radiant energy.

(Continued on page 75)

Applications Guide to Display Storage Tube Parameters

Summary

Display storage tubes are finding wide use in military and commercial applications because of their unique advantages over cathode ray tubes. The parameters used to describe display storage tube performance are defined and the inter-relations between the different parameters are examined. The three features of display storage tubes: brightness integration, controlled display persistence, and high display brightness are explained in terms of tube parameters and system requirements.

by F. N. Ingham

Introduction

This article deals with tube parameters of display storage tubes utilizing nonequilibrium writing by means of secondary emission and transmission-controlled viewing.

The display storage tube is a device which utilizes a dielectric surface, one or more write guns to store, and a viewing gun to display intensity and deflection modulated signals. The dielectric surface, deposited on a metal mesh, called the backing electrode, is the vital tube element. Its secondary emission ratio is the phenomenon upon which tube operation depends. Figure 1 is a cross section of a typical display storage tube showing the physical location of the various tube elements. Figure 2 is the secondary emission curve for magnesium fluoride, one of the commonly used dielectric surface materials.

Writing is accomplished by scanning the dielectric surface with a modulated electron beam of an energy such that the dielectric surface secondary emission ratio is greater than one, thus storing a positive pattern.

The viewing or flood gun is usually operated continuously with the cathode slightly negative to the backing electrode potential; electrons from this gun are modulated by the stored pattern on the dielectric surface to produce a corresponding brightness pattern on the phosphor viewing screen. This mode of operation is known as transmission control and is used in the majority of currently available tube types.

Erasure of the stored charge pattern is accomplished by either bringing the backing electrode to collector potential (priming) or by applying a positive pulse train of low amplitude to the backing electrode. Either method will bring

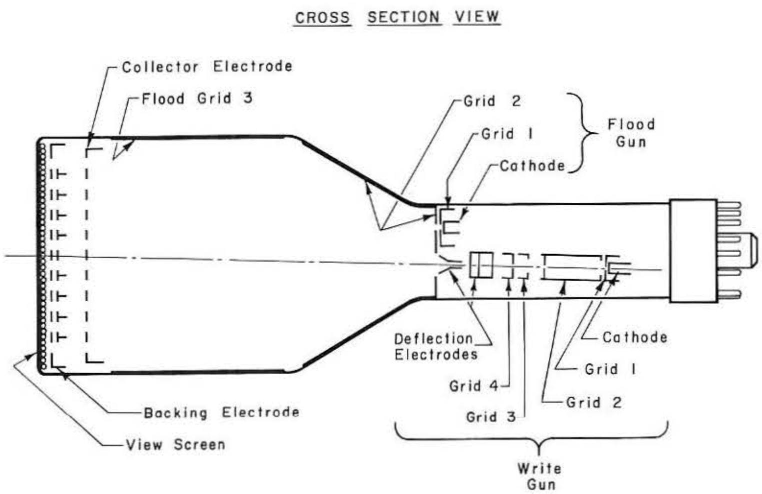


FIGURE 1: Cross-Section View.

the dielectric surface to viewing cathode potential through the mechanism of secondary emission.

Three features which give display storage tubes an advantage over cathode ray tubes are: first, brightness integration of repetitive signals for signal-to-noise improvement and threshold determination; second, controlled display persistence; and third, high display brightnesses for viewing in high illumination ambients and for use in projection applications.

To fully explore the features above it is necessary to review the various tube parameters and their inter-relationships:

Writing Speed

Writing speed is the maximum scanning speed at which a raster can be written to a specified brightness in one frame. A complete specification of writing speed will contain the measured value in inches per second, the written brightness level and the beam current or grid drive used. Writing speed is a function of the dielectric thickness, the writing beam density, and the transmission of the collector electrode.

Saturation Brightness

Saturation brightness is the maximum display brightness that can be obtained with a given tube at the specified screen voltage. Written brightness is usually expressed as a percentage of saturation brightness. Saturation brightness is a function of flood beam density, the collector and backing electrode transmission, and the screen voltage.

Erase Time

Erase time is the length of a single rectangular pulse of an optimum amplitude that is required to erase the tube from saturation brightness to a given percentage of saturation. This parameter is directly related to the controllable persistence feature of display storage tubes. Erase time is a function of the dielectric thickness, flood beam density, and the transmission of the collector electrode.

Storage (Viewing) Time

Storage time is the time for the screen brightness to go from cutoff to some specified percentage of saturation brightness. Storage time is limited by ion bombardment of the dielectric surface and represents the maximum useful persistence under the normal mode of operation. Storage time can be extended up to several hours through different modes of operation although any increase in storage time is accompanied by a corresponding decrease in writing speed and saturation brightness and an increase in erase time. Storage time is a function of tube vacuum, dielectric thickness, flood beam density and collector electrode transmission.

Resolution

Resolution is the maximum number of raster lines that can be distinguished per inch. Write gun spot size and the collector and storage electrode pitch (mesh lines per inch) affect resolution. In general, an increase in mesh pitch or a decrease in write gun spot size will improve resolution. A change in mesh pitch, however, is usually accompanied with a change in mesh transmission so that all the above parameters (*i.e.* writing speed, saturation brightness, erase time and storage time) are affected.

A complete specification of resolution will contain the measured value and the brightness at which this value was measured.

Uniformity

Uniformity is a measure of the difference in writing brightness across the display area for a given writing speed and grid drive; the I.R.E Standards define two types of non-uniformities: disturbance and shading.[1] Uniformity is affected by mechanical alignment of the mesh screen section of the tube and by the electron optics of flood gun collimation. Non-uniformity is greatest for very high writing speeds and large display diameters.

Usable Levels

Usable levels are brightness levels, each related to a different input, that can be distinguished from one another regardless of location on the storage surface.[1] The number of usable levels is limited by the tube uniformity and system operation.

For applications where the maximum number of usable levels is desired, the writing speed should be specified as the minimum value necessary for system operation so as to optimize the useful writing control grid range.

Recent development of a high contrast display storage tube has increased the maximum number of usable levels by a factor of two so that quality TV displays may now be obtained with display storage tubes.[2]

Display Diameter

The display diameter is the maximum display that can be obtained with a given size tube (*e.g.* a 5 inch storage tube usually has a 4 inch display diameter). The specification of the display diameter is fully determined by system requirements.

In general, as the display diameter is increased, resolution, uniformity, saturation brightness and environmental limits are decreased.

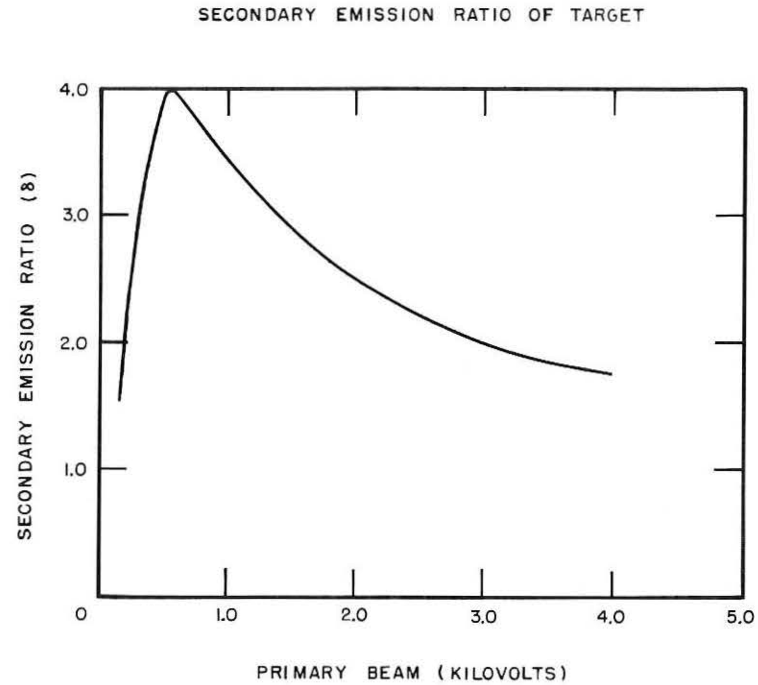


FIGURE 2: Secondary emission ratio of target.

Because many of the above tube parameters have common independent variables (*e.g.* dielectric thickness) or are dependent variables of another parameter (*e.g.* usable levels is dependent upon uniformity), a change in one variable to optimize any given parameter will necessarily affect several other parameters. Table 1 lists all display storage tube parameters that are affected when any other parameter is optimized. The majority of these trade offs are not serious unless the optimized parameter is to be a "state of the art" value. The ranges of various parameters, indicated by current data sheets, is summarized in Table 2.

The three advantages of display storage tubes: brightness integration, controlled display persistence, and high display brightness can now be examined to show how to specify the various tube parameters to satisfy system requirements.

Brightness Integration

During the integration process the information element is first written to a given fraction of saturation brightness:

$$B/SB = (1 - e^{-kt})$$

where t is the dwell time on each element per frame and k is a constant which can be expressed in terms of writing speed. In most applications using the integration capability of the display storage tube, the time between successive writing of an information element is much less than the controlled persistence of the tube so that the signal, when rewritten, is sum integrated.

The envelope of an integrated brightness curve can be represented by the formula:

$$B = SB\,[1 - e^{IF \ln(1 - y/100)}]$$

where B is the integrated brightness, SB is saturation brightness, y is the percent of saturation brightness to which writing speed was specified and IF is the brightness integration factor.

The brightness integration factor is a function of display sweep speed and is equal to:

$$IF = (t)\ (\text{writing speed})/\text{line width}$$

where t is the dwell time or writing time per information element, and line width is the reciprocal of resolution. For pulsed systems the dwell time per element is equal to the received pulse width, for continuous systems the dwell time is equal to line width/ sweep speed.

Figure 3 is a plot of integrated brightness (B) versus the brightness specified for a given writing speed(y) for brightness integration factors of one through six. This figure and the original formula have been found accurate for values of y greater than 30.

From the formula or Figure 3, the display systems engineer, knowing the required time base speeds and display brightness desired, can calculate the minimum writing speed required of the display storage tube.

Controlled Display Persistence

After an element is scanned and written to some level, the decay in brightness is a function of the erase time of the tube. Using a rectangular pulse train of the same amplitude as the single pulse used to measure erase time, the persistence is very nearly:

Persistence = erase time/pulse train duty cycle

For small values of duty cycle (*i.e.* less than .01), the amplitude of the pulse train must be increased to achieve the persistence given in the formula as ion bombardment of the dielectric in the interval between pulses raises the dielectric level significantly. Low duty cycle pulse trains are desirable as written information is lost during erase pulse up time.

For different modes of operation, the persistence can be varied by programming either the pulse train duty cycle or amplitude. The former is more easily controlled and is recommended where practical. The effect of varying the amplitude of the erase pulse train upon persistence is decidedly nonlinear.[2] When the minimum erase pulse amplitude is used, the maximum writing speed of the tube can be realized.

Where it is desirable to present both smear free TV type displays and long persistence displays by programming the erase pulse train duty cycle, the erase time must be specified as the minimum value possible. With current erasing techniques, a smear free TV display can be obtained with tubes having erase times as high as 6 milliseconds. To obtain a 4 second persistence with the same tube the erase pulse duty cycle required would be:

$$\text{duty cycle} = \text{erase time}/\text{persistence} = .006/4 = .0015.$$

TABLE 1

Effects from Optimizing Any One Parameter

Desired Parameter		Affected Parameters	
Writing speed	(maximum)	Erase time	(decrease)
		Storage time	(decrease)
		Uniformity	(decrease)
		Useable levels	(decrease)
		Brightness	(decrease)
		Resolution	(decrease)
Brightness	(maximum)	Storage time	(decrease)
		Erase time	(decrease)
Erase time	(minimum)	Writing Speed	(increase)
		Storage time	(decrease)
		Brightness	(increase)
Storage time	(maximum)	Erase time	(increase)
		Brightness	(decrease)
		Writing Speed	(decrease)
Resolution	(maximum)	Brightness	(decrease)
		Writing Speed	(decrease)
Display diameter	(maximum)	Uniformity	(decrease)
		Useable levels	(decrease)

Note: This table lists all affected parameters. Since there are numerous ways to optimize any one parameter, the degree of change in the affected parameter may or may not represent a "trade off" for a given application.

The erase pulse frequency should always be chosen greater than the flicker frequency for viewer comfort. If a 200 cps erase pulse frequency is chosen for the above case, then a 7.5 microsecond erase pulse of optimum amplitude would yield a persistence of 4 seconds.

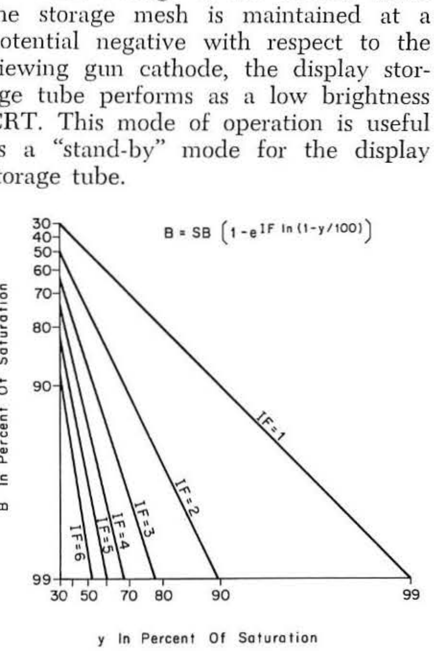
A method used to obtain extended persistence and to avoid ion spot buildup (corresponding to storage time) is to modulate the flood gun with a pulse train of a selected duty cycle. This mode of operation yields viewing times from several minutes to hours but sacrifices brightness in proportion to the duty cycle used. The long persistence feature of the display storage tube is particularly desirable for oscilloscope viewing of low frequency phenomena as flicker is eliminated and the storage tube replaces film as the integrating medium. The display brightness of display storage tubes in an extended persistence mode is quite adequate to permit viewing in a bright room.

Display Brightness

The display storage tube is essentially an image amplifier in that the beam current required to write the information on the storage surface is less than the beam current used to present the

written in milliseconds and can be viewed for several minutes, the gain in work obtained is in the order of 10^6. [3]

The brightness levels of a display storage tube are dependent upon the viewing gun beam current, the storage surface control curve, and the post-acceleration voltage of the screen. When the storage mesh is maintained at a potential negative with respect to the viewing gun cathode, the display storage tube performs as a low brightness CRT. This mode of operation is useful as a "stand-by" mode for the display storage tube.



The brightness to be specified will depend upon the ambient in which the display is to be viewed, the size of the display, and the environmental tests which the tube must pass. Average tubes for viewing under high ambient conditions have saturation brightnesses in the order of 2000 – 3000 foot lamberts and written brightnesses in the order of 800 – 1200 foot lamberts at their specified writing speed. Due to environmental tests requirements, the screen voltages on these tubes are rarely above 10KV. Tubes that are to be viewed under low or controlled ambient lighting have display brightnesses in the order of 50 – 300 foot lamberts and most commonly use a 5KV screen voltage.

When brightness is specified the minimum contrast ratio under simulated operating conditions should also be specified. Since the background brightness of a display storage tube is a function of the erase pulse duty cycle:

Background brightness = Saturation brightness/Duty cycle, the contrast ratio of a display will change if different persistence modes are used in a system. An exception to this rule is the high contrast storage tube where the background brightness is constant regardless of the persistence mode.[2]

under high ambient lighting are specified between 5 and 10 to 1 with the tube operated so as to give a persistence compatible with system design.

Summary

The best results in specifying any display storage tube are obtained when the tube is desired. It is not usual that a standard type will satisfy all the parameters desired for an application or system other than the one for which it was originally designed, but often a standard type can be modified through variations in the manufacturing process to obtain the desired parameters with a minimum of development time.

To illustrate the interrelation of the different parameters, three Westinghouse display storage tube types are examined: WL 7268A, WX 5047, and WX 5314. The display characteristics of these types are tabulated in Table 3.

The WL 7268A is designed for a multimode airborne radar system. The

TABLE 2

Display Characteristics of Current Display Storage Tubes

Parameter	Range of Values
Writing speed 90 percent of saturation	20 - 100,000 in/sec
Resolution 90 percent of saturation	35 - 70 lines/in
Erase time	1 - 400 millisec
Saturation Brightness	150 - 20,000 foot lamberts
Storage time to 20 percent of saturation	10 sec - 5 min
Useable levels	2 - 7*
Display Diameter	1.8 - 18 inches

*Values above four are only obtainable with high contrast display storage tubes.

TABLE 3

Display Characteristics of Three Tube Types

	WX 5314	7268A	WX 5047	Units
Writing speed (min.)	5000	35,000	400,000	in/sec
% of saturation	50	80	40	
Brightness (min.)	200	2500	1200	foot lamberts
screen voltage	5	10	10	kv
Erase time (min.)	50	20	10	millisec.
Storage time (min.)	60	15	10	seconds
% of saturation	10	70	90	
Resolution (min.)	90	10	10	lines/in
brightness level	100	1000	—	foot lamberts
Useful levels (min.)	—	3	4	
Useful display	4	4	4	in. dia.
Erase uniformity	1.0	1.2	1.0	volts
No. of write guns	1	2	1	

Note: WX number indicates nonregistered tube type. Parameters indicated are customer specifications which are subject to change.

parameters desired for the tube are: writing speed compatible with the lowest range to be displayed, erase time compatible with a persistence range of 0.5 to 2.0 seconds, resolution high enough for mapping, saturation brightness and contrast ratio compatible with viewing under high ambients. The resulting specification was for a tube that had 2500 foot lamberts saturation brightness with a 10 to 1 contrast ratio, medium writing speed, erase time, and resolution.

Integration on this tube is accomplished by overlapping scans on a "B" sweep: in the longest range mode a tube resolution of 50 lines/inch resulted in an integration factor greater than 3; when the resolution of the tube was increased to 70 lines/inch the integration factor, and hence useful displayed range, was reduced. The 7268A has two writing guns so that radar information and system symbols can be written simultaneously.

The WX 5047 is designed for an air-to-ground radar system and optimizes resolution and uniformity. High writing speed is required for time shared writing with a single writing gun and for the general requirements of the system. The result of optimizing writing speed, resolution, and uniformity was the specification of a tube with a lower saturation brightness and erase time than the 7268A. The increase in uniformity for a high writing speed tube required a tightening of mechanical tolerances and an increase in cost per unit. The WX 5047 has also performed satisfactorily as an oscilloscope tube. By modulating the flood gun, saturation brightness was sacrificed for maximum storage time while retaining the high writing speed.

The parameters desired for the WX 5314 are slow erase time for long persistence displays, long storage time, high resolution, and good uniformity. The tube is viewed under controlled low ambient light levels. The optimization of the desired parameters resulted in the specification of a low writing speed, low saturation brightness tube. With the low writing speed, the uniformity requirement did not represent a critical mechanical problem.

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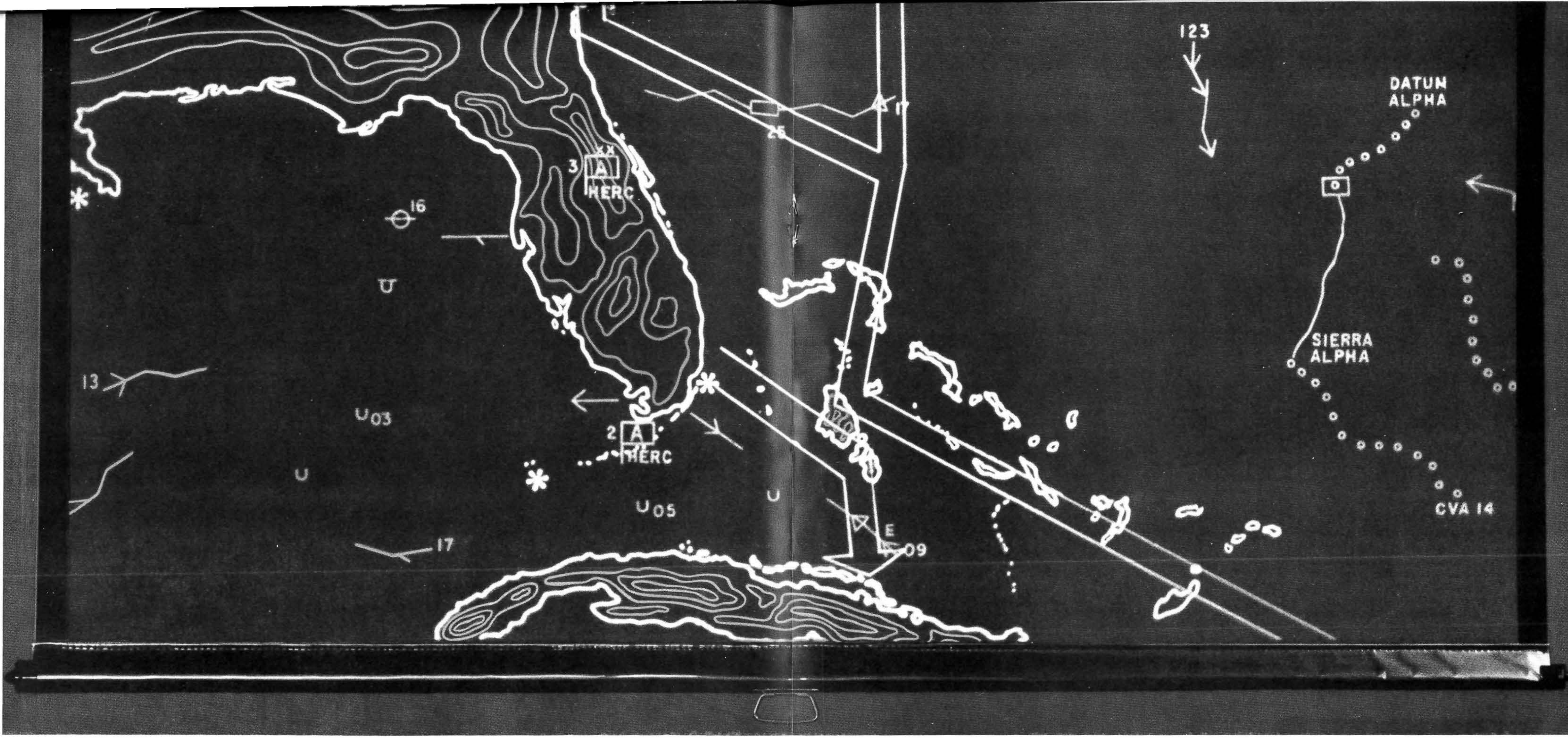

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NORTHROP

Color Vision

by R. L. Kuehn

Color Vision
A Brief Introduction

As an interdisciplinarian one typically finds oneself in the dilemma of seeking the optimum discourse level which is neither too superficial on the one extreme nor too confounding on the other. These pages have been since their inception dedicated towards the exposition of diverse developments concerned in one way or another with human vision. Here is a very brief introduction to vision itself particularly as it relates to color. The literature in the field is quite extensive, thus only a few central references are cited which in turn can lead to others. For those who have not had the opportunity to separtely investigate the visual mechanism the following material may hopefully provide some further insight in their daily endeavors. The already knowledgeable may read on with respectfully requested tolerance or turn their attention to other more promising pages.

The Physiological System

The classical human visual system consists of the eyes, certain areas of the occipital cortex, and the interconnecting neurological pathways. An important property of neural conduction which bears directly upon vision, and particularly color vision, is the limitation in the character of signal which a single axon may transmit. It appears that one, and only one, type of information may be transmitted along a single fiber. Impulse frequency may vary as a function of stimulus intensity in a non-linear manner. If the quality of the stimulus must also be transmitted, for example, the chromaticity of the stimulus, then signals along one or more additional axons must be included.

The retina, located in the focal plane of the geometric optics of the eye is a structure of individual nerve cells having an average thickness of about 300 microns. Near the posterior pole of the eye the retina is somewhat thickened in an area called the macula lutea. Centered in the latter is a small depression of somewhat less than ¼ mm in diameter known as the fovea centralis within which lies the most sensitive daylight vision in both recognition of fine detail and in the discrimination of color differences.

Ten layers can be microscopically distinguished in the cross section a human retina. The outermost extensions of the first layer of cells are shaped as either rods or cones. Although it may seem awkward that light imaged on the retina must pass through most of the structure to reach the rods and cones, the evidence that the latter are indeed the light sensitive receptors is quite complete.

The cones are the principal receptors in daylight, or photopic vision. Cones permit the recognition of fine detail, probably by serving as individual receptors largely independent of neighboring elements. The complete mechanism for color vision involves, most likely, only cone receptors, since such vision is excellent in the fovea where only cones are present. In the scotopic, or dark-adapted eye, only rods are effective and then only to produce a brightness sensation but not chromatic discrimination.

It has been the custom to postulate the existence of three varieties of cone receptors to conform to early color mixing evidence and consequent theories. Polyak in his *The Retina,* published in 1941 by the University of Chicago Press, concludes from painstaking microscopic studies that all cones are essentially alike. He has, however, clarified the synaptic arrangement of the retina so that transmission of trimodal patterns of nerve impulses, originating from a single class of cones, becomes conceivable.

The Psychological System

The sensory and perceptual aspects of color vision are especially important in that psychophysical determinations depend upon conscious responses to permit the investigations to continue. Color experiences are not simply sensations but invariably take place in more complex perceptual form. The latter occur in varying modalities involving both temporal and spatial inhomogeneities. The processes of learning and conditioning contribute to the production of color associations with feelings, emotions, and meanings.

Color sensation may be defined as the primary conscious response to excitation of the visual mechanism. Each of the characteristics of light—luminance, dominant wave-length, purity, extent, and duration — has complex effects on each of the attributes of color sensation — brightness, hue, and saturation.

Luminance

Brightness is correlated significantly with luminance through most of the range of responsiveness of the visual mechanism (about 10^{-5} to 10^{5} foot-lamberts). Additionally, several noteworthy effects may be observed at different levels of luminance.

If the luminances of chromatic stimuli are reduced gradually enough to permit corresponding adaptation through mesopic[1] levels, the brightnesses produced by long-wave stimuli decrease more rapidly than those of short-wave stimuli. The peak of the luminosity function moves from about 555 millimicrons to 510 millimicrons. The absence of discontinuity in the shift indicates that the rod and cone brightnesses are additive. In addition to this systematic shift in relative brightness of red and blue, there is a progressive decrease to zero in saturation for all spectrum colors except extreme red, which disappears completely. With full scotopic adaptation all hue and saturation vanishes except for the slightly bluish or greenish-blue cast often noticed in night vision. The characteristic brightness shift in the luminosity function is known as the Purkinja phenomenon. Since the latter is influenced by both rod and cone receptors, the Purkinje effect is observed with perifoveal vision and does not normally appear if the test stimuli are confined to the fovea.

At higher luminance levels wholly within the photopic range another hue shift known as the Bezold-Brücke phenomenon occurs. When luminance is increased, all chromatic colors except a certain invariable blue, yellow, green, and red appear increasingly like blue or yellow and decreasingly like green or red. A method of demonstrating the hue change experimentally is to alter by a factor of 10 or 20 the luminance level of one of a juxtaposed pair of spectrophotometrically matched colors. The magnitude of the shift may be equivalent

[1] The transitional region between photopic (daylight) adaptation and scotopic (night) adaptation.

to as much as a 10 or 20 millimicron change in dominant wave-length.

The influence of luminance on saturation is pronounced, even with pure cone vision and spectrum stimuli. At and close to the aboslute threshold all chromatic colors except red elicit achromatic sensations. The difference between the absolute (achromatic) luminance threshold and the luminance at which each hue is just perceived is called the photochromic interval. Wavelengths longer than 650 millimicrons evoke both saturation and brightness at the luminance threshold. There is no photochromic interval for reds in the latter category. As luminance is increased above the chromatic threshold an increase in saturation is experienced, however, the required luminance for maximum saturation varies with the wavelength. In general, the greater the saturation normally elicited by a color, the lower the luminance which arouses the maximum saturation in that color. Blues, reds, and purples which typically evoke strong saturations appear most saturated at relatively low luminances. Yellows and green-yellows appear most saturated at relatively high luminances.

If the luminance of a color is increased progressively beyond the optimum, the saturation will start decreasing and continue to do so to a marked degree. At extreme abnormally high luminances, total desaturation or achromaticity may be approximated, especially in the case of the less effective spectrum colors or with impure colors.

Wavelengths

In the visible spectrum and the extra-spectrum purples, four stimuli evoke psychologically simple blue, yellow, green, and red hues, respectively. Unlike cyan, magenta, or most of the discriminable hues, the latter are unmixed in the sense that no one partakes of the nature of any other.

The dependence of brightness on wavelengths is represented by the luminosity function which is ordinarily plotted as the reciprocal of the threshold energy versus the wavelength. At ordinary photopic luminances the maximum luminosity (at about 555 millimicrons) is 680 lumens per watt. Beyond 390 and 720 millimicrons it is less than 1/1000 of the maximum. The curve giving the CIE photopic luminosity function for the standard observer is presented in Figure 1. For comparison the curve for a scotopic adapted eye is also shown.

The luminosity curve for the standard observer does not represent all the facts of cone vision. For example, an increase in stimulus area results (even within an anatomically homogeneous retinal area) in a decrease in threshold for a given wavelength. In addition, with small foveal areas, the shape of the curve depends on the position of the proximal stimulus within different parts of the fovea.

Purity

The main response correlate of purity is saturation. The greater the purity, the greater is the saturation. A certain minimum purity is required to arouse any sensation of saturation Colorimetric purity is defined for a mixture of spectrum color and white as

$$p = \frac{B\lambda}{B_w + B\lambda}$$

where $B\lambda$ is the luminance of a spectrum color and B_w is the luminance of the white with which it is mixed. It is not possible on the basis of the above definitional equation to assign different values of colorimetric purity to different spectrum colors since it is apparent that $p = 1$ for all spectrum colors.

Experiments on colorimetric purity ordinarily have employed two photometric fields, both initially equal in luminance, B, and in spectral composition. The fields contain either a white alone ($B = B_w$) or a white used with a given amount of spectrum color ($B = B\lambda + B_w$). In either case it is possible to determine a just noticeable difference Δp in purity between two fields.

Extent

The spatial characteristic of the color stimulus commonly known as retinal extent, or angular size affects the color response in a number of ways, perturbing hue, saturation, and brightness. For an observer viewing a uniform chromatic surface large enough to fill his entire visual field, or nearly so, the hue, saturation, and brightness of the area are substantially uniform. If the stimulus surface is reduced to near a degree in diameter, the hue, saturation, and brightness will vary consideraby according to the retinal region affected. Extreme size differences within a dark field produce pronounced brightness variations as a consequence of adaptation and contrast. A small area will appear much brighter then a very large area of identical luminance.

In the photopic condition there is evidence of systematic variations in both hue and saturation, starting with a stimulus size of about one degree and increasing toward a maximum determined by the retinal perimeter. With larger angles, and whether or not central fixation is maintained, regional effects contribute to any results due to area. In a range up to subtended angles of about 15 degrees, comparisons of surface colors reveal a proportional increase in saturation with area.

When sufficiently reduced in size (under 10 minutes of visual angle), a centrally fixated yellow test object becomes white or gray in appearance; a blue object becomes gray or black. At even smaller sizes, red and green colors also appear achromatic. Since yellow and blue are least distinguishable from white or gray under all conditions, their chromaticity should disappear first with a reduction in field size. This effect has been demonstrated in both peripheral and foveal vision.

Duration

The retina displays temporal integration within some finite limits. Threshold excitation can remain unchanged with decreasing luminance of the stimulus if the time of presentation is increased, such that

$$BT = K$$

where B is the stimulus luminance, T is the duration of the stimulus, and K is a constant threshold value. The preceeding equation is known as the Bunsen-Roscoe law and is strictly applicable only for short durations of the order of 50 milliseconds.

Chromatic color sensations elicited by achromatic intermittent stimuli are known as Fechner's colors and are readily demonstrated by Benham's top. The latter is a disk, half black and half white, with some concentric black arcs on the white sector. When the disk is spun or rotated under moderate illuminance at about five revolutions per second, a number of weak chromatic rings appear. A large variety of chromatic responses have been reported, ranging from graduated saturation of a single hue to a continuous sequence of different hues in normal spectrum order.

Adaptation

Sensory adaptation is an adjustive response of the organism to its environment. By its effect on the receptor, any stimulus modifies its own effectiveness. At any particular time the eye is at some general level of sensitivity depending in a complex manner upon the results of recent past stimulation. The adaptation level restricts and determines the range of responsiveness. The overall range within which the optimally adapted eye is effective is from about 10^{-5} to 10^{5} foot-lamberts. The scotopic eye cannot discriminate any luminances less than the lower limit (absolute threshold), nor can the photopic eye discriminate above the upper value (terminal threshold).

When a fully light-adapted observer is shielded from all light, measurements taken at intervals of time indicate that the absolute cone threshold for luminance falls noticeably for only five minutes, whereas the rod threshold falls for about 35 minutes. When the rod and cone data are plotted together as a time dependent function, the minimum cone threshold may appear as a discontinuity on the combined curve shown in Figure 2.

Whereas progressive dark adaptation is accompanied by increasing rod re-

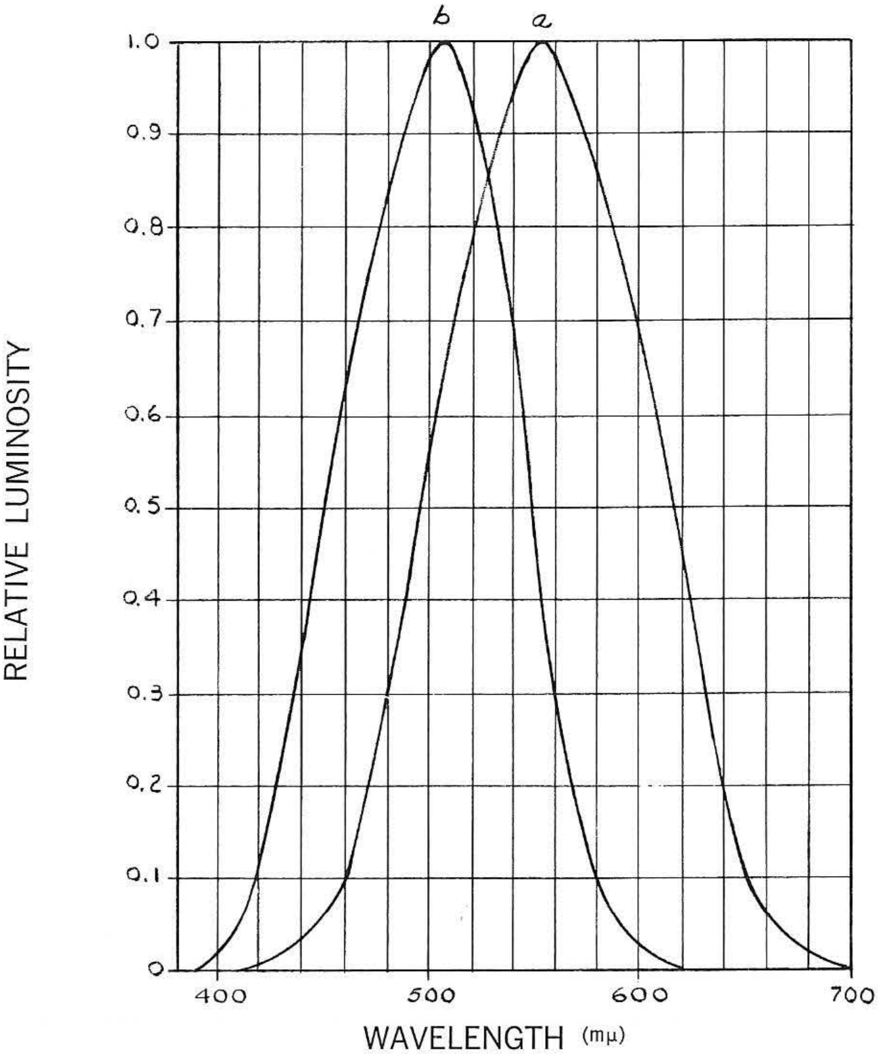

FIGURE 1: Standard luminosity function. a.—Photopic. b.—Scotopic.

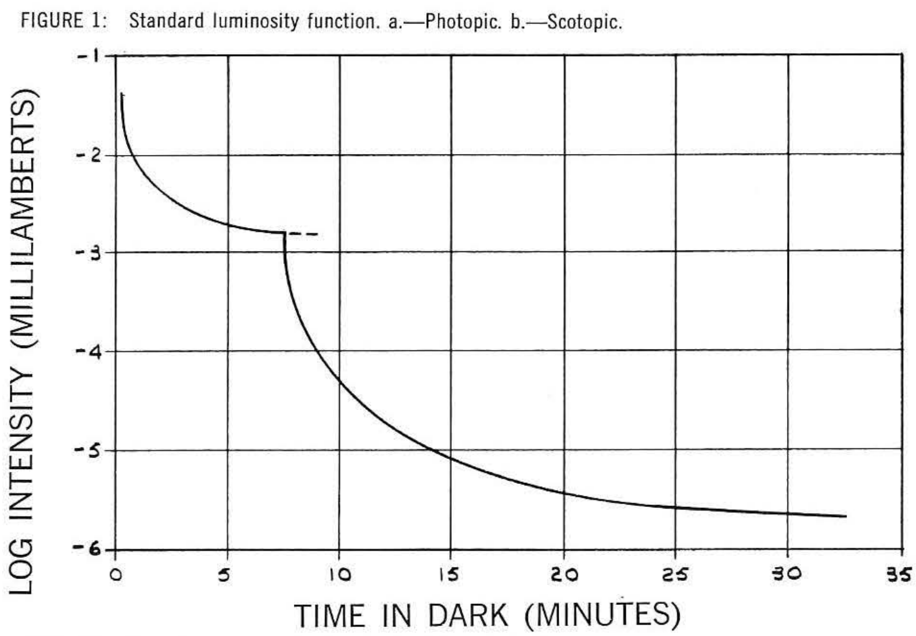

FIGURE 2: Combined cone and rod dark adaptation (typical).

sponse, the progressive desensitization to light known as light adaptation results in predominance of cone response. The most striking temporal feature of light adaptation is the suddenness and extent of the initial phase, being complete in about 0.2 second and nearly so in 0.05 second. Photopic adaptation has significant effects on brightness and on luminance discrimination. Ordinary vision is a compromise between complete adaptation and lack of adaptation to any particular stimulus. The general adaptation level keeps changing in a manner such that departures of similar subsequent stimuli from the adaptation level are approximately statistically minimum. The result is to maintain maximum discrimination of most-probable stimuli and satisfactory sensitivity for moderately probable stimuli.

Changes in chromatic sensation are ascribable to chromatic adaptation. The response to an unvarying chromatic stimulus incident upon the fovea at first decreases noticeably in saturation, in addition to adaptive changing in brightness. The reduction in saturation proceeds exponentially for one or two minutes until an almost constant saturation is reached. Complete loss of saturation and hue by adaptation does not seem possible with a central stimulus of high purity. There is no difficulty, however, in achieving total desaturation with a stimulus of relatively low purity. Total desaturation may also be observed with stimuli of high purity applied to the peripheral region. The color of the surrounding field is important and considerable hue shifts occur in the periphery.

Adaptation to a chromatic color followed by viewing an achromatic color of comparable luminance generally results in a complementary color sensation, or afterimage. Adaptation to a chromatic color followed by viewing a nearly complementary color results in an even closer complementary color sensation of increased saturation. Adaptation to a chromatic color followed by viewing a related hue tends to decrease the latter's saturation and to shift the hue still further from that of the adaptation color. An achromatic color sensation can be experienced if the chromatic adaptation is followed by viewing a color of the same dominant wavelength but of lower purity just sufficient to cancel the complementary effect of the adaptation.

Since chromatic adaptation depends on luminance, dominant wavelength, and purity as well as on duration, general statements can under certain circumstances be misleading. Nevertheless, such statements are basically sound because they depend on the influence of adaptation on sensitivity. Thus red adaptation depresses red sensitivity and suppresses red in the perceived effect, and similarly for other colors.

Many different spectral energy distributions, or metamers, are capable of producing identical foveal color sensations. A metameric colorimetric match is invariant even after prolonged adaptation or preadaptation to the metamers or almost any other color, although a pronounced hue difference from the adapting color may transform the matching color sensations in the latter case. Strictly speaking, the preceeding statement applies only to matches made under maximally sensitive conditions. Chromatic discrimination varies with chromatic adaptation in a manner similar to, though less pronounced then that in which luminance discrimination varies with light adaptation. It appears that the more closely the eye is adapted to the chromatic components of the color, the better the differential sensitivity with respect to hue and saturation.

After-Images

Visual sensations after removal of intial stimuli are known as after-images and may be due to two conditions: (1) the external stimulus induces a state of local adaptation of the retina which temporarily produces contrasting responses to contrast-free stimuli, and (2) localized excitation in the retina or elsewhere in the visual mechanism persists and produces a sensation pattern resembling the original stimulus configuration. In general, the colors and the spatial and temporal arrangements of both the initial stimulus and the subsequent viewing situation are factors determining hue, saturation, and spatial and temporal patterns of the observed after-images. The latter are characteristically transient and filmy, being much less objective and commanding than the original perception.

If a light figure on a gray ground is fixated for about 30 seconds under normal illumination, and then the eyes are shifted to a uniform part of the gray field a dark figure which gradually fades out may be seen. Such a negative after-image is the most common and is explained by the relative desensitization of the retinal region stimulated by the light figure. Now, if the light figure is momentarily viewed under intense illumination, a less common fleeting image bearing the same lightness relationships as the original may be seen. This positive after-image may be due to a continuation of the excitation underlying the original sensation, although there are other more recent hypotheses.

There are chromatic after-images which are analogous to either negative or positive after-images. If a chromatic figure is substituted for the light figure during a long central fixation, a complementary after-image will probably appear against the gray ground. Such after-images approximate the hue complementary to that of the original sensation and are usually more effective with moderate luminance and neutral after-field. The usual explanation of the complementary after-image is in terms of relative desensitization to the stimulus color. With brief intense stimulation a brief after-image with approximately the same hue as the original may be perceived. Such an image is called homochromatic. Where controlled laboratory conditions do not occur many striking combinations and variations of after-images can take place.

Ordinarily after-images are not noticed except as occasional aftermaths of some accidental glare too disturbing to escape notice. The most important reason why after-images pass unnoticed is that they do not provide a consistent basis for action and therefore fail to receive attention. The frequent shifting of attention usually prevents the development of after-images in any strength. The latter are often very brief and are usually out of focus. Specifically directed attention is an important condition of after-image identification.

A negative or complementary image is most likely to show a latency of about one second and a duration of about a half minute. However, the image duration can be observed to increase with the duration of the pre-exposure through the approximate range of 0.05 second to several minutes. A first positive or homochromatic image has a latency of a fraction of a second or else merges with the terminal lag of the original sensation.

Contrast Enhancement

Color contrast produces an enhancement or intensification of perceived difference between neighboring colors. Juxtaposed colors of relatively high and low luminance appear respectively lighter and darker then if they were viewed separately. Similarly, adjacent colors of relatively high and low purity appear respectively more and less saturated than if they were separately viewed. The less saturated color may be reduced to achromaticity or even converted to the complementary hue. Complementary or nearly complementary pairs when viewed together appear more saturated. When chromatic and achromatic colors are juxtaposed, contrast tends to induce a complementary hue on the latter. In the case of non-complementary colors, contrast increases existing hue differences because of the tendency of each color to induce its after-image complement; thus the proximity of red and yellow might make the red seem bluish red and the yellow seem greenish yellow.

The cause of contrast enhancement is imperfectly understood. The observed effects have been variously attributed to central factors of suggestions, to retinal or central interactions from adjacent stimulations, and to the operation of more or less rapid retinal adaptation. When two colors are compared the eyes tend to glance back and forth permitting the comparison and fulfilling the requirements of more or less rapid adaptation and recovery. Hence a dark color appears darker due to the desensitization produced by looking at the light color, and the light color looks lighter because of the resensitization which occurs while looking at the dark color.

Ordinarily it is assumed that contrast enhancement typically affects figures to the exclusion of ground or surround. Usually, however, the surround is so large relative to the figure that such a one-way induction is to be expected on classical principles. On the other hand, it seems certain that active viewing of juxtaposed colors does not necessarily yield classical contrast enhancement because the perceived color of a central sample can be varied through neutral from one extreme to the other by merely adjusting the reflectance of the surround while holding the illuminance constant. When a series of chromatic samples of the same dominant wavelength are arranged on a neutral ground in order of purity, the purest, or end, sample is likely to look considerably more saturated than if it were followed by still purer samples.

Very simple changes in borders and boundary lines can produce striking changes in perceived colors. Sharp, definite boundary lines tend to produce maximum contrast enhancement. Set or direction of attention can result in psychophysical conditions which have some bearing on contrast interpretations. Familiar object-perceptions are known to exhibit strong constancy, though a disintegration of a conflicting object-perception might in some circumstances permit contrast enhancement to appear.

Theories of Color Vision

Ideally, a color theory should describe all the phenomena of color vision within a set of relations which are self-consistent and coherent. Although no completely satisfactory formulation presently exists, with few exceptions the important theories may be classed in the trichromatic tradition of Young or in the opponent color process approach of Hering. In 1801 Thomas Young suggested that since it is impossible to conceive of each sensitive retinal point to contain an infinite number of color sensitive particles, it becomes necessary to assume a limited number, say the three principal colors, red, yellow, and blue. In 1802 Young revised his estimate of the basic colors because of an error discovered in Wollaston's description of the spectrum. The basic colors now were red, green, and violet.

Young's ideas were forgotten for about 50 years and were rediscovered by Maxwell and Helmholtz at nearly the same time. The Young-Helmholtz development of the theory depends importantly upon the data of color mixture. Maxwell's experiments verified that a spectrum color can be represented as mathematically equivalent to a mixture of three primaries, one (in the case of spectral primaries) having a negative coefficient. The fact of trichrometicity easily blended with the concept of three principal colors, and trichromatic theory was established on a reasonably firm foundation. The central concept of the Young-Helmholtz theory is the existence of three sets of sensory mechanisms, cones and their connections, whose quantitative characteristics provide a basis for different color vision discriminations.

Helmholtz wrote his quantitative treatment of color vision shortly before his death in 1894. The precise hypothesis has not lasted as a plausible description of color vision data, but its mathematical treatment of a brightness-color space has persisted. At the risk of oversimplification it may be said that the latter is concerned with an isomorphic relation between visual data and a mathematical space with little reference to intervening variables. More recently Hecht has developed Young's theory as a mathematical account of component physiological processes. The theory supposes that there are three kinds of cones present in the retina and that they exist in the fovea in approximately equal numbers. The sensations arising from response of these cones are qualitatively specific and may be tentatively described as being blue, green, and red, respectively. Regardless of the method used in stimulating these cones, regardless of the wavelength of the stimulating light, and regardless of the nature of the photosensitive substance, an impulse proceeding along a "blue" nerve will register blue in the brain, and similarly for the other two principal colors.

In general, experimental work in the tradition of the Young-Helmholtz theory has concentrated on stimulus thresholds or matches based on judgments of equality or difference. Little attention has been paid to qualitative estimates or introspective reporting in the absence of a comparison standard. In the work associated with the Hering theory, however, considerable attention has been paid to psychological variables. Emphasis has often been given to absolute judgments as when a subject may be asked to vary the intensities of two "opposed" colors until he reports that the mixture does not exhibit the hue of either component. In contrast with the Young-Helmholtz approach of emphasizing the effects of a subject's adjustments to physically specificable differences beween stimuli, the Hering philosophy stresses the importance of statements that a subject makes about stimuli. It may be readily seen why the Young-Helmholtz theory has been favored by physicists, whereas the Hering theory has appealed to instrospective, though not necessarily to objective, psychologists.

Hering's theory is based upon the fact that subjects instructed to select or designate unique colors, choose primarily the invariant blue, green, yellow and red mentioned earlier in the discussions pertaining to luminance. The action of light according to the Hering school depends not only on its physical characteristics, but also upon the condition of the visual mechanism. The Bezold-Brücke effect can be attributed to conditions of adaptation. Simultaneous color contrast is described in terms of antagonistic processes set up in areas adjacent to a simulated zone.

The first quantative statement of an opponent-colors theory has been recently stated by Hurvich and Jameson.[2] Fundamental to this theory is the concept of physiologically based opponent chromatic induction. Experiments have been reported in which a color-matching technique was used to compare the chromatic responses to focal stimuli seen first in isolation and then in the presence of surrounding stimulus arrays of specified luminances, chromaticities, and of various degrees of complexity. Chromatic inductions have been shown to decrease systematically with decreasing contiguity of central and surround areas of stimulation. For given degrees of juxtaposition, induced chromatic responses are opponent to but proportional in magnitude to the mean chromatic level of the inducing field, wherein the constant of proportionality decreases as a function of decreasing contiguity.

Helson[3] sought an answer to the question: "Given any object as stimulus, what will be its hue, saturation, and lightness when viewed on any background under any illuminant?" His experiments ranged over a period of five years, employing several experimenters and different sets of subjects. Helson concluded that, other things being equal, the background reflectance is the most important factor determining the adaptation level and therefore the colors of samples appearing on it. He formulated a general principle which states that "samples above the adaptation reflectance take the hue of the illuminant color; samples below it, the hue complementary to the illuminant hue; while samples near the adaptation reflectance are either achromatic or greatly reduced in saturation." The only assumption made with regard to the preceeding principle is that the eye is exposed to a single illumination which establishes an achromatic point of reference for the explanation of constancy, illuminant color, and complementary color. By means of his one principle, published in 1938, Helson argues for a simple mechanism underlying the varied phenomena of color vision in all conditions.

[2] Jameson, Dorothea and Hurvich, Leo M. Opponent Chromatic Induction: Experimental Evaluation and Theoretical Account. *J. Optical Society of America*. Vol. 51, No. 1, 46-53, January 1961.
[3] Helson, Harry. Fundamental Problems in Color Vision. *J. Experimental Psychology*. Vol. 23, No. 5, 439-476, November 1938.

As has been stated earlier, no theory exists today which is a completely satisfactory hypothesis for all color vision phenomena. More emphasis has been developing in the psychophysiological approaches in recent years. Boynton[4] attempts to reconcile some of the discrepancies in the Hurvich-Jameson formulation by accounting for the physics, physiology, and psychology of the color vision process. He assumes three types of photo-pigments to be distributed among five types of cones. Boynton suggests that color signals are initially an opponent-colors variety then coded in terms of the four psychologically unique colors. He feels that the process of color vision will not be understood "until the electrophysiologist, probing into the brain with his electrodes, has found the electrophysiological substrate of conscious color experience."

A theory has been proposed by Schroeder[5] which does not require different kinds of photochemicals or three different kinds of cones. Color discrimination is accomplished by at least three identical receptors positioned at appropriate points along the outer segment of each cone. When light (or any moving wave) is reflected by a surface, standing waves are set up by the interference of the reflected with the incident waves. For a given wavelength of light, the peaks and valleys of the standing waves have a fixed position relative to the reflecting surface. If three photosensitive devices are placed at appropriate distances from the reflecting surface, unambiguous information regarding the color of the light can be obtained in that a band of more than two to one in wavelength is covered. Schroeder's hypothesis is purely mechanistic and is illustrative of the application of physical principles, taking no account whatsoever of physiological and psychological influences.

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3. Davson, Hugh (ed.) *The Eye, Vol. 2 The Visual Process*. Academic Press, New York, 1962.
4. Graham, C. H. Color Theory. *Psychology: A Study of a Science*. Vol. 1, 145-287, (ed.) Sigmund Koch. McGraw-Hill, New York, 1959.
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[4] Boynton, Robert M. Theory of Color Vision. *J. Optical Society of America*. Vol. 50, No. 10, October 1960.

[5] Schroeder, Alfred C. Theory on the Receptor Mechanism in Color Vision. *J. Optical Society of America*. Vol. 50, No. 10, October 1960.

A Display Screen With Controlled Electroluminescence

by Herman Graff and Richard Martel

Abstract

This paper describes a two-electrode electroluminescent display screen which possesses the special property of controlled persistence. The simple multilayered structure of the screen is compared with the complicated structure of the prior art. The electro-optical performance characteristics of a typical screen are given. In general, the screen's light output is excited by incident ultraviolet radiation and is quenched by infrared energy. The persistence of the electroluminescent light output is a function of such parameters as material choice and intensity and background radiation level, and applied voltage and frequency. The latter two parameters are used to control the persistence of any given screen. Persistence times ranging from seconds to more than an hour are achieved. Screens are provided with characteristics to accept inputs from an electromechanically controlled light source or from an optic fiber-faced CRT.

Introduction

For many years various military agencies as well as industrial manufacturers have been engaged in an active search for a simple and economical display screen which exhibits controlled image storage capability. A desirable feature of such a screen is its adaptability to both small and large area displays.

Screens, possessing various characteristics associated with a whole class of materials, have been under intensive study and development. However, for the purpose of this presentation one specific screen will be described, which fulfills the foregoing needs. This display screen exhibits the following advantages over other display panels: (1) it is easy to fabricate; (2) its image does not spread; (3) it is a non-modular high-resolution screen; and, (4) it has a wide controllable range of optical persistence.

In the very early stages of development of this new screen, the limitation of the prior art was recognized and evaluated. Electroluminescent-photoconductive schemes were examined and subsequently rejected because the fabrication of these devices in a manner which solves the impedance matching and crosstalk problems proved difficult. Another class of devices which utilizes the electroluminescent-ferroelectric principle was also investigated. It was again discovered that these devices, being of a modular type, are difficult to fabricate and exhibit low resolution.

This review of existing image storage screens clearly indicated that a new approach was needed. Preferably, the device should be easy to fabricate and be composed of continuous layers for maximum resolution capability. The memory should not depend on light feed-back from the display layer, thus avoiding optical crosstalk problems and the need to create discrete cells or islands. The control layer should exhibit a significant volume-type impedance change when excited, in preference to a surface electrical change, because this would eliminate the need for complicated and expensive grooving methods.

Fundamentally, the screen should be a two-electrode device thus minimizing electrode interconnection problems. The display brightness should be controllable to permit viewing under various ambient light levels, including that required for normal reading. The screen should be capable of developing images exhibiting several "shades of gray".

Following several years of developmental effort in the display area, a new and novel display screen with unusual characteristics emerged from this laboratory. As will be shown, this unique screen with unusual characteristics emerged from this laboratory. As will be shown, this unique screen overcomes the limiting constraints of previous solid-state display screens, such as El-Pc and El-Fe.

A qualitative description of this screen, its mode of operation, some quantitative data on its performance, and a brief coverage of its unique characteristics and

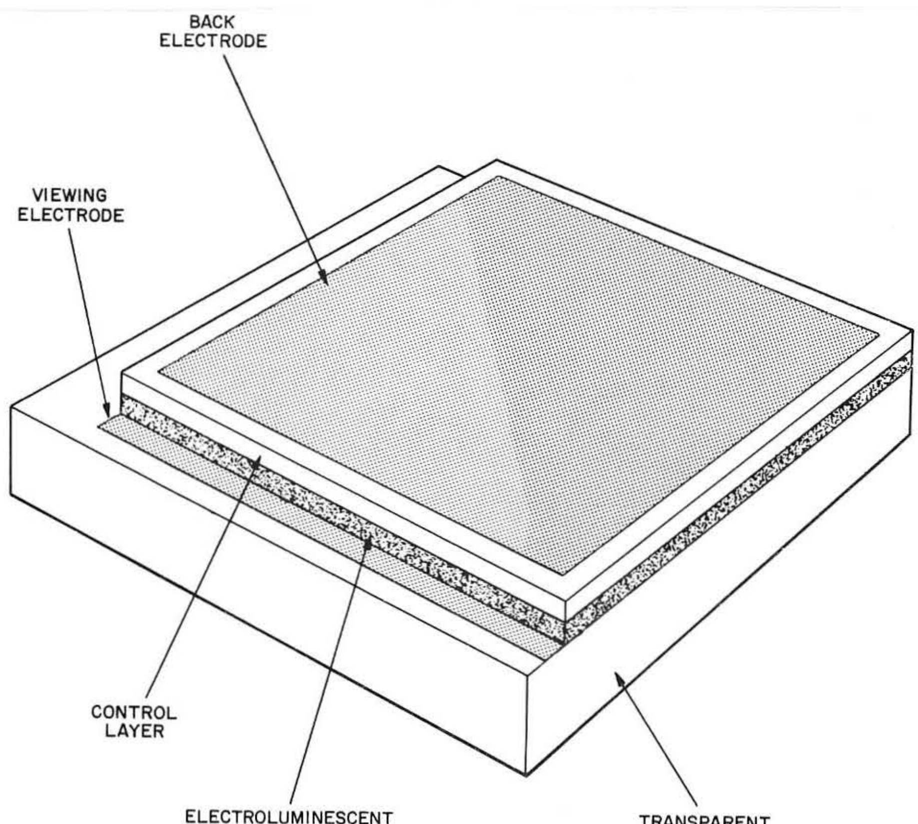


FIGURE 1: Typical structure of a controlled electroluminescent panel.

potential applications will be presented.

Fabrication

Fabrication Considerations

An isometric view of the screen structure is shown in Figure 1. It is a two-electrode device with a control layer and an electroluminescent layer sandwiched between the electrodes. Since the visible output emanates from the electroluminescent layer, the visible image is normally viewed through the substrate. It is therefore necessary that the electrode between the electroluminescent layer and the substrate be transparent.

If the input of writing is performed through the back side (or control layer side) of the panel, as is generally the case, it is then also necessary that the other electrode (directly on top of the control layer) be transparent. In practice, the viewing electrode has been transparent tin oxide, while the back electrode has been semitransparent thin gold.

The techniques used for depositing the materials between the electrodes are any of the numerous conventionally accepted practices such as spraying, silk screening, doctor blading, settling, and others. The electrodes are generally deposited by well-known vapor deposition techniques.

The entire fabrication process involves only "cold" practices – no sintering or high temperature baking is employed. Therefore, this type of screen can be and has been fabricated on a variety of substrate materials, including plastics. Furthermore, depending upon the choice of substrate, this screen can be made either rigid or flexible.

Operation of Screen

Referring to Figure 2, the principles of operation in a typical screen are described as follows.

When an electric potential (e. g., 100 volts, 400 cps.) is applied across the two layers (El and control layers) in the screen, a specific voltage pattern is effected across each layer. This voltage pattern is controlled by the localized impedances of the respective layers. In the absence of incident radiation on the control layer, the voltage applied to the El layer is uniform and is generally adjusted to provide a low level of background brightness.

Whenever ultraviolet light is permitted to strike any part of the control layer, the impedance of that exposed area is reduced. This results in an increased voltage applied to the corresponding area of the El layer, causing an increased brightness of that area. Thus, an image is produced. Upon extinction of the ultraviolet source, the new impedance of the exposed control layer will gradually return to its original value,

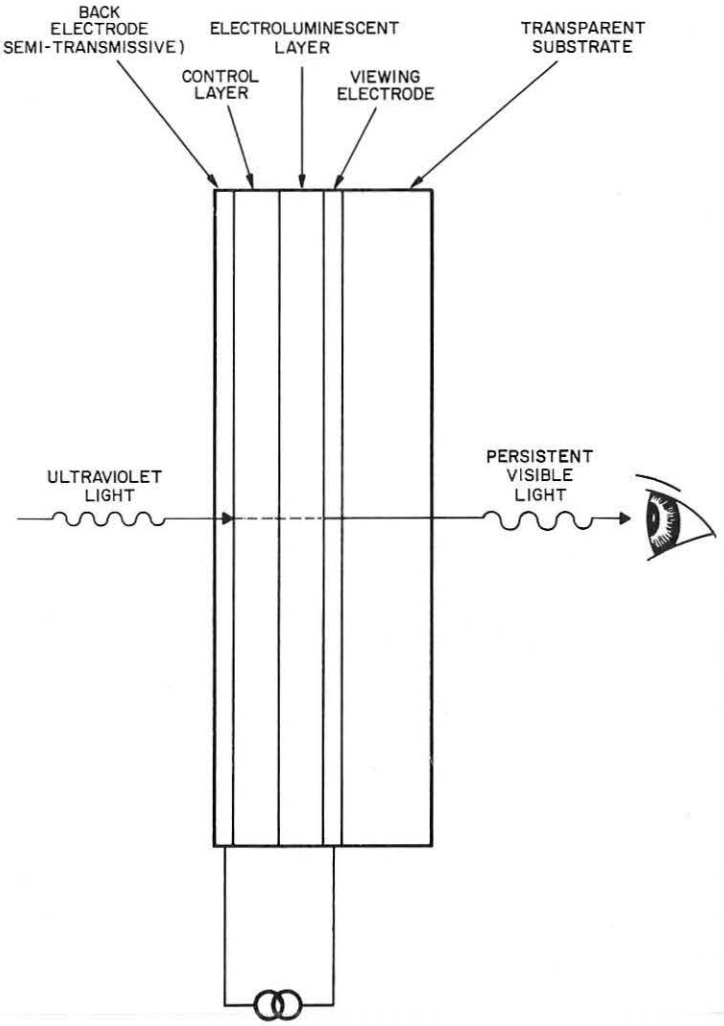


FIGURE 2: Operation of typical controlled electroluminescence panel.

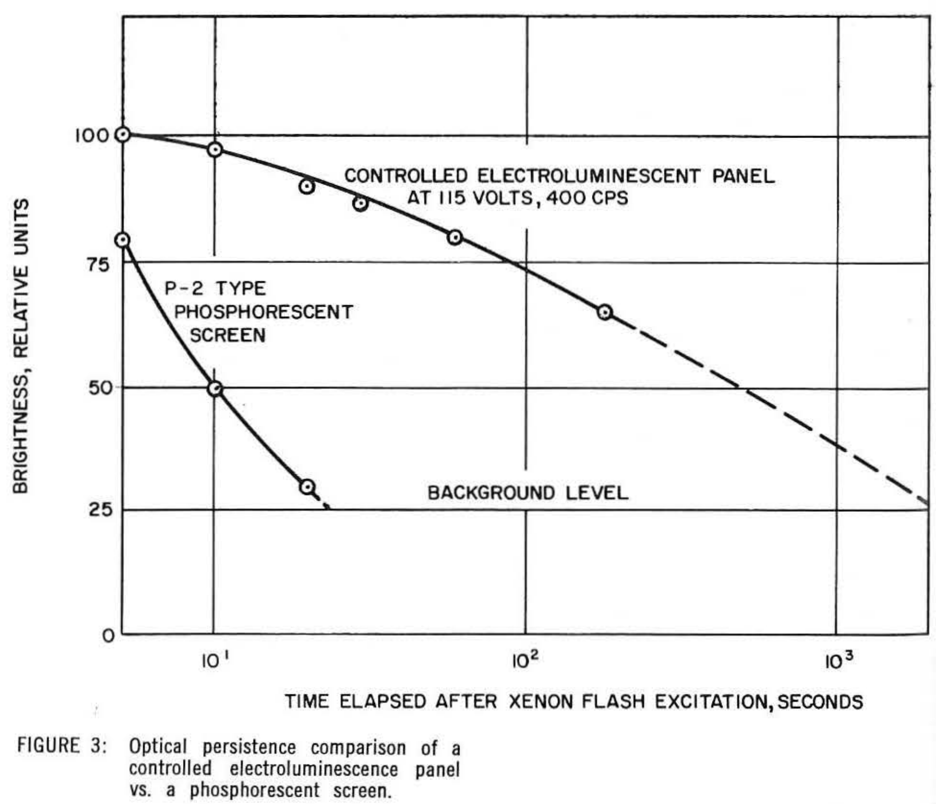


FIGURE 3: Optical persistence comparison of a controlled electroluminescence panel vs. a phosphorescent screen.

unless acted upon by some other energy source (e. g., near infrared). Similarly the light output of the El will diminish accordingly. The persistence of the El output, after removal of light excitation, can be adjustably controlled from an order of seconds to that of an hour or more.

A key feature of the panel is that the memory resides in the control layer relatively independent of electrical input. Thus, in the event of a temporary power loss, reapplications of the electrical power will restore the visual image. This is true of course only if the power is restored during the normal decay time of the control layer "electrical image." Since the storage and display characteristics are independently controllable, the display can be turned off at will by removing the electrical excitation.

Screen Performance

To date, the screen has been used in two distinct types of applications: (1) vehicular course plotting, where only two-tone information is required and (2) image reproduction where half-tone and picture-quality properties are required. Its performance in both types of applications will be discussed in turn.

Two-Tone Persistence Quality

A comparison of the optical persistence of a controlled electroluminescent panel with that of a typical long-persistence P-2 type phosphorescent screen after xenon flash excitation is shown in Figure 3. Peak sensitivity of both screens falls in the region between 3660 Å and 4000 Å.

It will be noted that the optical persistence of the controlled electroluminescent screen exceeds that of the phosphorescent screen by nearly two orders of magnitude.

Picture (Half-Tone) Quality

Shades of Gray

Two important considerations in evaluating picture or image quality are shades of gray and resolution. To determine the shades-of-gray capability of a controlled electroluminescence screen, a standard Kodak Photographic Step Plate was used. This step plate consists of a number of discrete areas of different light transmission related by the factor of $\sqrt{2}$. This plate was superimposed on an excited panel and the number of areas through which light was visible to the human eye was noted. The reference step was that step which had zero transmission when only background emission emanated from the panel. This test was performed at various periods following excitation of the controlled electroluminescent panel with approximately 800 μw/cm² of UV energy at 3660 Å. Typical values are: nine shades of gray, five seconds after excitation and four shades of gray, five minutes after exposure.

Resolution

The resolution of a controlled electroluminescence panel was determined by using a photographic negative with a pattern of equal opaque and clear lines of progressively diminishing widths. This pattern was produced on the display screen by contacting the negative to the control layer side of the panel and exposing the panel to UV (3660 Å). By definition, the two narrowest lines produced on the screen which are still visible as two lines (not blended into one line) is the limit of resolution. This test showed a screen line-width resolution of 0.003 inch.

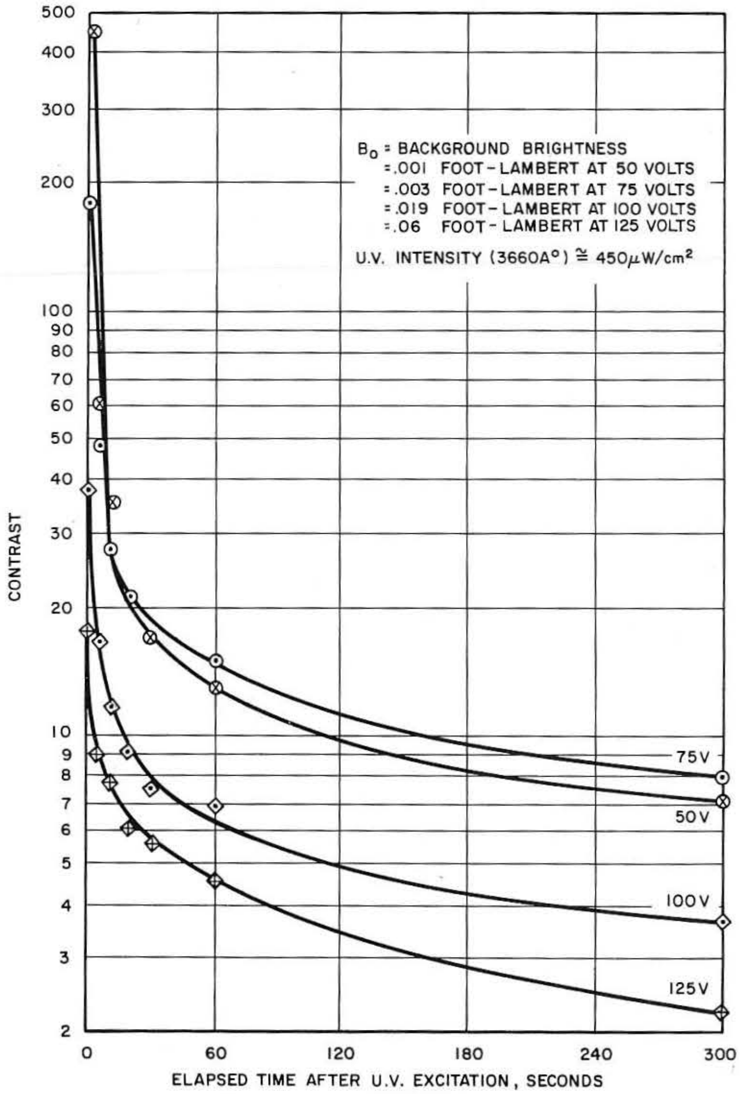


FIGURE 4: Optical persistence of a controlled electroluminescence panel vs. frequency at a fixed applied voltage.

Persistence Control

The optical persistence of this electroluminescence screen can be controlled by several means including variation of applied voltage and frequency and incident radiation input. The subsequent subsections summarize the salient data acquired to date.

Persistence Control by Applied Voltage at Fixed Frequency

Figure 4 depicts how the magnitude of the applied voltage governs total persistence time at a given frequency of 400 cps, and with an ultraviolet excitation intensity of approximately 450 μwatts/cm². Contrast values are plotted instead of brightness because they appear to be more meaningful to the human eye, which reacts to brightness differences rather than actual brightness level. Contrast is herein defined as follows:

$$C = \frac{B_a - B_o}{B_o}$$

where C = contrast
B_a = active brightness
B_o = background brightness

Note that background brightness changes for each applied voltage condition.

Using the B_o values listed and the contrast value at a given time, the actual active brightness on the screen can be calculated from the foregoing equation.

As shown in Figure 4, when operating at 400 cps there is maximum persistence with 75 volts applied.

Persistence Control by Variable Frequency at Fixed Voltage

It is shown in Figure 5 that for a given applied potential of 75 volts on the controlled electroluminescent panel, maximum optical persistence is obtained at the lower operating frequency of 60 cps. Note also, that the background brightness changes with a change in the frequency of the applied voltage.

Persistence Control by Variable Voltage and Frequency at Fixed Background Level

Figures 6a and 6b show the dependence of optical persistence on the operating frequency, if the background brightness of the electroluminescence output is maintained constant. It should be noted, that to maintain constant background brightness, it is necessary to readjust the applied voltage for each condition of operation frequency. In this case, a background level of 0.02 foot-lambert was selected on the basis of threshold visibility for a given relatively dark ambient condition in the laboratory when brightness measurements were made.

It is evident from both Figures 6a and 6b that there is a maximum in persistence and contrast in the region of 480 cps.

Persistence Control by Radiation Intensity and Frequency

The screen light output can be modified by variations of the intensity and duration of visible and ultraviolet incident radiation as well as by infrared radiation history. The persistence achieved depends on the light output level. This subsection summarizes the limited current data relevant to this subject.

Excitation saturation time as a function of UV intensity

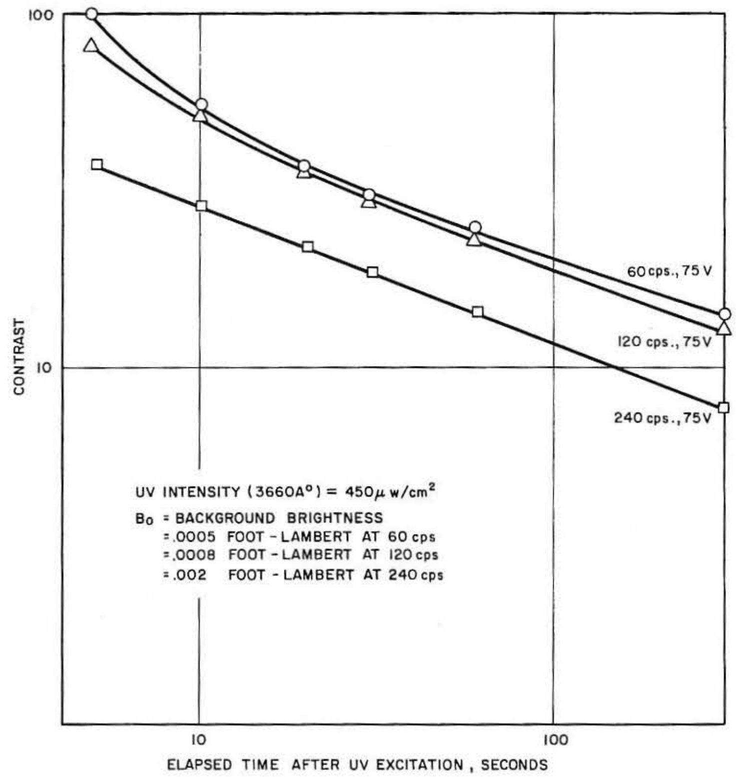


FIGURE 5: Optical persistence of a controlled electroluminescence panel vs. frequency at a fixed applied voltage.

Excitation to near saturation is achieved in less than 100 microseconds on a 12" x 12" screen with a 400-watt-second xenon flash source. Limited studies have been made in the process of adapting this display screen to the output of a P-16-faced or UV emitting CRT. It has been determined that the generation of a ½ mm spot exhibiting near saturation brightness can easily be effected in less than 10 msec. This is based on the ability to mate this display screen to a P-16 fiber optic faced CRT and the condition that serious losses in UV intensity are not incurred in the transmission through the glass fiber face.

Quenching time as a function of IR intensity

Experimentation with three infrared sources has yielded the following information:

(1) At a distance of 35 cm, a 250 watt infrared Sylvania lamp with a number 7-69 Corning filter will quench a small screen in 30 seconds.

(2) A 75-watt spot reflector, located 35 cm from the panel, will also quench in 30 seconds.

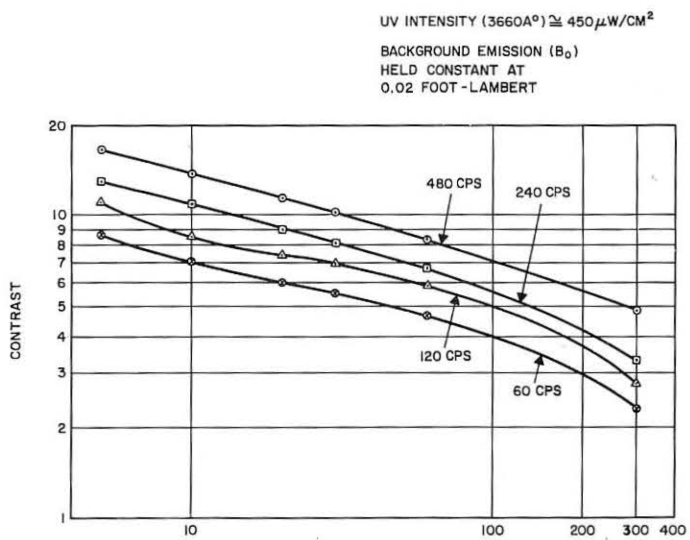


FIGURE 6a: Optical persistence of a controlled electroluminescence panel at frequencies from 60 cps to 480 cps.

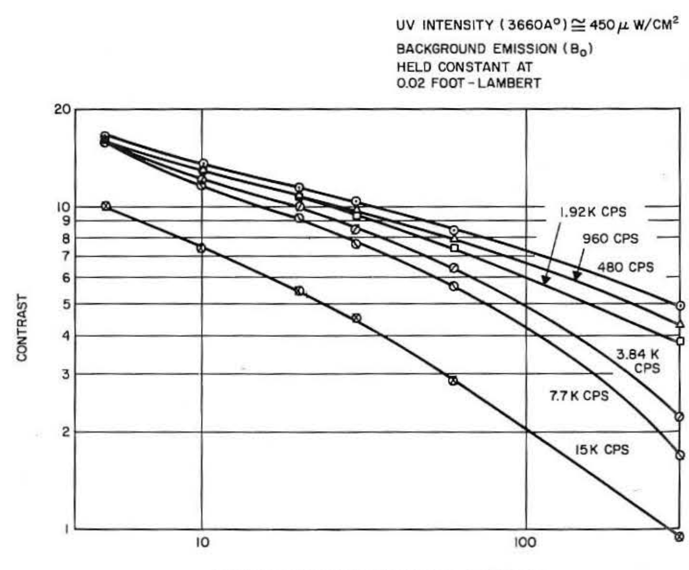


FIGURE 6b: Optical persistence of a controlled electroluminescence panel at frequencies from 480 cps to 15K cps.

(3) Localized quenching of the activated panel is accomplished with the radiant energy from a xenon flash lamp. A filter is used with a pass band from 0.65 to 1.0 micron and the unit is designed so that one flash of the lamp, applied to the viewing side of the screen, will normalize the impedance of the control layer.

Power Consumption

The typically low-power-consumption characteristic of a controlled electroluminescent panel, both with and without UV (3660 Å) excitation, ranges from 0.02 to 10 milliwatts per square inch.

Special Panel Characteristics

In addition to describing some of the more salient features of this display screen, it may be of general interest to briefly describe some of its other significant characteristics and potential applications presently under study. A unique characteristic of this panel is its non-destructive dual-persistence mode of operation as a function of applied frequency.

Recorded and displayed information, having a long history, can be totally suppressed by operating at frequencies in the neighborhood of 15 kcps. Only the most recently recorded information will be displayed at the higher frequency. However, in the event that a review of earlier recorded information is required, a decrease in applied frequency will visibly reinstate this earlier information as well as visibly retain the recent history. This phenomenon may find utility in heavy traffic-type plotting situations.

The ability to write negatively with infrared is still another interesting feature. It offers a means of producing instant photographic positives from film negatives.

This is readily accomplished by exposing the screen to UV light from the viewing side to produce a uniform light emission from the screen. A picture negative is applied to the rear side of the screen and the negative is exposed to infrared light. This diminishes the brightness of the screen in accordance with the light transmission of the negative thereby producing a positive picture on the screen.

Summary

The screen uses two active layers of material: the control layer and the electroluminescent layer. Both layers are continuous, thus avoiding the difficult problem of fabricating discrete elements.

The control layer is a polycrystalline semiconductor material whose impedance is a function of incident radiation history. Selection of appropriate materials avoids the spreading of the impedance pattern (the stored image).

Generally the control layer is excited by ultraviolet radiation, quenched by infrared radiation and is not affected by most of the visible spectrum.

The electroluminescent layer is standard and is readily fabricated from available materials.

The layers can be mounted on either hard or flexible substrates.

Achievable persistence times range from seconds to over an hour.

Non-persistent visible images can be superimposed on the same panel.

The persistence of the stored pattern can be controlled by the choice of:

(a) materials
(b) excitation radiation intensity and wavelength
(c) level and frequency of voltage applied across the panel.

The latent image remains stored upon removal of voltage across the panel.

Both two-tone and graded half-tone images can be stored and displayed. No optical feedback from the electroluminescent panel to the control panel is utilized in providing the storage capability.

This paper was selected by ID's Editorial Advisory Board from those presented at the Fifth National Symposium on Information Display held in Santa Monica, Calif., Feb. 25-26, 1965. Limited quantities of bound volumes of all technical session proceedings for this and other National Symposia are available, free to members, $10 a volume to others. Write: *Information Display*, 160 S. Robertson Blvd., Beverly Hills, Calif.

ID Readout

Chapter News

MID-ATLANTIC CHAPTER: The annual meeting was again held at Tarrytown House, Tarrytown, New York, on June 12. Members and wives spent the afternoon swimming, playing pingpong and tennis, bowling, etc., and generally socializing. A cocktail party and dinner preceded the business meeting which featured an address, "You Were There", by SID's National Vice President, William P. Bethke, Director of Engineering Div., RADC. Mr. Bethke delighted his audience with his humorous but accurate and perceptive examination of Command and Control Systems and the decision-making process. The Mid-Atlantic Chapter presented two major awards. G. Stone of Hazeltine Corp., won the Best Technical Presentation Award for his paper, "Application of Diffraction Phenomena to Modern Display Techniques". The Distinguished Service Award went to S. Sherr, of Sperry Gyroscope Co. The Nominations Committee announced the results of election for Chapter Officers of 1965-1966, and the new officers were installed. They are: Robert C. Klein, Kollsman Instrument Corp., Chairman; Leo Beiser, CBS Labs, Vice Chairman; T. T. Goldsmith, Jr., Fairchild Camera & Instrument Corp., Treasurer; I. Baumel, Sanders Associates Inc., Secretary. A special award was presented to Carl Machover, outgoing Chairman, by members of the Chapter in appreciation of his services.

Houston MSC Sees Color Track of Gemini 5

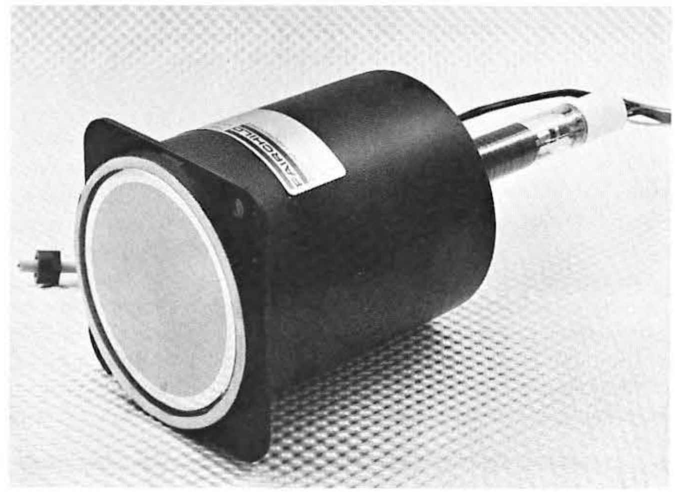
Gemini 5 was traced in color on a huge projection plotter in NASA's Mission Control Center at Houston during the recent 8-day flight. Installation of the 10- by 20-ft. projection plotter was completed after the Gemini 4 mission by Philco Corp. WDL Div., Houston Operations, prime contractor for the MCC with contracts of about $72 million. The plotter, called a Summary Mission Display, was developed by Ling-Temco-Vought under subcontract to Philco. Purpose of the Gemini 5 track was for checkout purposes in preparation for Gemini 6, the first Agena rendezvous and docking mission planned. In the latter operation, Gemini 6 will be displayed in one color, and the Agena track in another. Solid lines will indicate completed orbits, and broken lines will show projected orbits. The display is part of a massive expanse of rear-projection screens 10 ft. high and 60 ft. across at MSC's Mission Operations Control Room.

Large ASW Training and AUTEC Displays

Two large screen information display systems are being produced for the U.S. Navy by the Nortronics Div. of Northrop Corporation, Palos Verdes, Calif. One system will be used for the training of antisubmarine warfare students at the Pacific Fleet Task Force ASW Training Center, San Diego, as part of the ASW simulator being produced by Lockheed Electronics Co., Plainfield, N. J. The other system will be used in the Bahamas to graphically present missile and weapons testing both above and below the sea at the control center of the Navy's first underwater test range, the Atlantic Underwater Test and Evaluation Center (AUTEC), Andros Island, Northrop Nortronics' information display systems incorporate Vigicon projectors which depict action as it occurs in a range of colors and symbols. Each system is designed to perform specific display functions.

Fast-Erase Direct-View Storage Tubes

The Electron Tubes Div. of Fairchild DuMont Laboratories, Clifton, N.J., has announced a new 5-in.-diam. direct-view storage tube with what the firm claims is the fastest erase time of any similar tube type. Termed Type KS 2527, the new tube permits utilization for a combined radar and TV display.



The erase speed of 3 milliseconds maximum enables raster erasure to be performed during vertical flyback when used in the TV mode at maximum brightness. In the radar mode, persistence is controlled by the erase pulse duty cycle. The KS2527 features low magnetic deflection angle for high linearity. Resolution is 125 lines/in. at high brightness. The tube is magnetically deflected and focused with a P-20 aluminized screen. An on-axis writing gun is utilized for improved pattern geometry. Included is an integral, encapsulated magnetic shield, high voltage shielded lead and potted base leads. Pertinent performance characteristics include equilibrium brightness of 2000 ft.-Lamberts, writing speed of 300,000 in./sec. Specific application uses for tubes such as the KS2527 are for high brightness, high resolution individual or combined TV and radar displays, primarily designed for compact, rugged aircraft requirements, but applicable to all types of installations. Delivery is quoted at 6-8 weeks.

Business Notes and News

INFORMATICS INC. has received a $92,000 Navy contract to develop peripheral site computer programs at the Pacific Missile Range. Informatics will provide a peripheral site computer programming system at PMR Headquarters, Pt. Mugu, Calif. Making the site operational is planned in order to strengthen PMR test facility capabilities. The computers are part of the larger real-time data handling system at Pt. Mugu and San Nicolas Island, and in Hawaii, which serve the entire Range. Peripheral computers will reduce workload on centralized computers by permitting system tests, instrumentation control, local data recording, and data processing on UNIVAC 1218 computers. Informatics is a wholly-owned subsidiary of DATA PRODUCTS CORP. . . .

THE BUNKER-RAMO CORP. has installed the nation's largest electronic stock market quotation facility in the new Chicago office of PAINE, WEBBER, JACKSON & CURTIS. Equipment supplied includes a Teleregister display board 105 ft. long and a battery of 30 Telequote III desk-top devices which enable the firm's personnel to obtain individual quotations instantly on several thousand stocks and commodities. According to Bunker-Ramo, the new market information complex is nearly twice as large as any other brokerage office installation. All information displayed including full price range on 320 key stocks and last prices for 450 others, is gathered at Bunker-Ramo's realtime data processing center in New York and generated over a special communications network to brokerage firms across the country . . . WEIGHTMAN AND ASSOCIATES, Burbank, Calif., has been appointed representative for Southern California and Clark County, Nevada, for products of TRANSISTOR ELECTRONICS CORP., Minneapolis, Minn. The products include extensive lines of information display devices and controls for computers, industrial control and missile guidance systems. TEC is the originator of Tec-Lites, self-contained transistor-controlled indicators.

The acquisition of CPM SYSTEMS INC. by INFORMATICS INC. has been completed and CPM Systems has moved its facilities to the Informatics Building, Sherman Oaks, Calif. . . . BURROUGHS CORP. Electronics Components Div., Plainfield, N.J., has settled its infringement suit against AMPEREX ELECTRONIC CORP., Hicksville, N.Y., with an agreement permitting Amperex to market and sell biquinary numerical indicator tubes and other items in contention, on license from Burroughs . . . WILDING INC., Chicago, Ill., has received a contract from the LINK GROUP of GENERAL PRECISION INC. for development of film graphics for NASA's Apollo Mission Simulator . . . ILLUMINATION INDUSTRIES INC., Sunnyvale, Calif., has been formed to supply users of short arc lamps, both mercury and Xenon, and Xenon flash lamps . . . Five computer display consoles have been sold by STROMBERG-CARLSON CORP. to the UNIVAC Div. of SPERRY RAND CORP. for use in the Army Operations Center System (TARMOCS) installed in the Pentagon . . . CALIFORNIA COMPUTER PRODUCTS INC., Anaheim, Calif., has announced net income of \$446,751 on sales of \$4,089,000 for fiscal 1965, compared with \$459,391 on sales of \$5,157,000 the previous year. R&D expenditures amounted to about \$1 a share in the later period, more than double those of last year, a spokesman said.

SPERRY RAND CORP. has received a more than \$2 million contract from TELEDYNE SYSTEMS CO., for displays to be used in the Navy BuWeps' Integrated Helicopter Avionic System (IHAS). Sperry will deliver four prototypes of each of two displays. The first, called a Vertical Situation Display, offers pilot and copilot a choice of four modes: A flight data mode for flight control information only, a low-light-level TV mode, a shades-of-gray terrain avoidance mode giving the pilot straight ahead surveillance, and an E-scan mode in which a profile of the terrain appears. The second unit, called a navigation/radar tactical display, presents either a map or a radar picture with symbols superimposed representing such things as the aircraft position, direction of flight, and check points.

Display for Computer-Controlled Reactor

ITT Industrial Products Div. is supplying a three-color CRT alphanumeric display for a data-processing and control system in the nation's first computer-controlled nuclear reactor. The high-speed three-color display is contracted by Astrodata Inc., Anaheim, Calif., prime contractor to the AEC for the computer-controlled system. The display will include an alphanumeric character generator and a model KM-906 19-in. high-speed three-color computer-scope.

Management Display System

Up-to-the-moment company operating data can be presented on the recently developed Information Displays Inc. (formerly RMS Associates Inc.) Management Display System, IDI Type CM10009. Driven over Dataphone from a UNIVAC 490 computer, the system can be many miles from the computer. Interfaces for other computers are also available. A large (4096 x 30) core memory in the display refreshes the display rapidly at flicker-free rates, while at the same time, accepts low speed Dataphone signals from the computer. Profit and loss statements, break-even curves, sales data, and any other desired information can be shown on the 21-in. rectangular CRT in formats already familiar to management. Contained in the system are line, dot, character, and circle generators, all under computer control. Management-computer communication is made possible with the keyboard, light pen, and special pushbutton switches. "Gaming" with the company . . . such as investigating effects of inventory changes, cost changes, and the like . . . is made feasible by this versatile computer display system and appropriate programming. A unique "Jump To" feature allows selected portions of the memory to be displayed, thereby providing a page turning capability. Two cabinets comprise the CM10009 display system. The *display generator,* in a cabinet 69 in. H x 46 in. W x 24 in. D, contains the core memory, Dataphone-490 interface, function generators, miscellaneous logic, keyboard, and pushbutton controls. The *display console,* in a cabinet 53¾ in. H x 30¼ in. W x 32½ in. D, mounts the 21-in. CRT and includes the deflection circuits, and display power supplies. Mounted on casters, the display console can be readily moved, and can be operated up to 50 feet away from the display generator. To insure reliable, trouble-free operation, the CM10009 System is completely solid-state (except for the CRT). A wall size (12 ft. x 12 ft.) display can be operated in parallel with the 21-in. CRT using auxiliary outputs provided in the system.

Computer-Based Electronics to Aid Surgeons

A computer-based electronic "early warning system" designed to alert physicians in surgery to swift and subtle physiological changes in a patient's condition is being developed for the Presbyterian Medical Center, San Francisco. The Institute of Medical Sciences, a research affiliate of the center, and the International Business Machines Corp. have signed a joint study agreement to develop the patient monitoring system. During patient monitoring, data from physiological sensing devices will be relayed to an IBM 1800 computer where it will be immediately processed. The resulting information will be displayed for attending physicians in surgery. Selected information can be stored in the computer's memory for subsequent recall. A team of physicians, engineers and computer programers from IBM's Advanced Systems Development Division is developing the monitoring system at the Mohansic Systems Laboratory in Yorktown Height, N.Y. and at the Presbyterian Medical Center in San Francisco.

Reconotron Keeps Mariner Properly Oriented

Jet Propulsion Laboratory engineers kept Mariner IV properly oriented on its precise course to Mars (only a small percentage of available mid-course correction was needed) by causing a small vacuum device to fix on the star *Canopus.* The device, called a "Reconotron", was developed by CBS Laboratories at Stamford, Conn. *Canopus* was selected because of its brightness, and lack of other bright stars in its vicinity. This made it a suitable reference to point cameras toward Mars and antenna toward Earth in the July encounter. The special tube is only 6 in. long and 1.5 in. diam.

Speeding Access to Stored Information

Stromberg-Carlson Corp. is expanding its product line in the business data handling field with the introduction of the S-C 1100 inquiry display system, obtained by acquisition of the Information Products Corp.'s assets from Renwell Industries earlier this year. Stromberg-Carlson will manufacture and market the items from its Data Products facilities in San Diego. The main element of the S-C 1100 system is a desk-top interrogator which looks like a compact adding machine with a small TV screen. Its primary purpose is to provide high-speed electronic inquiry and display of computer-stored information. It can also provide a method for entering new data into a computer's memory. In a typical

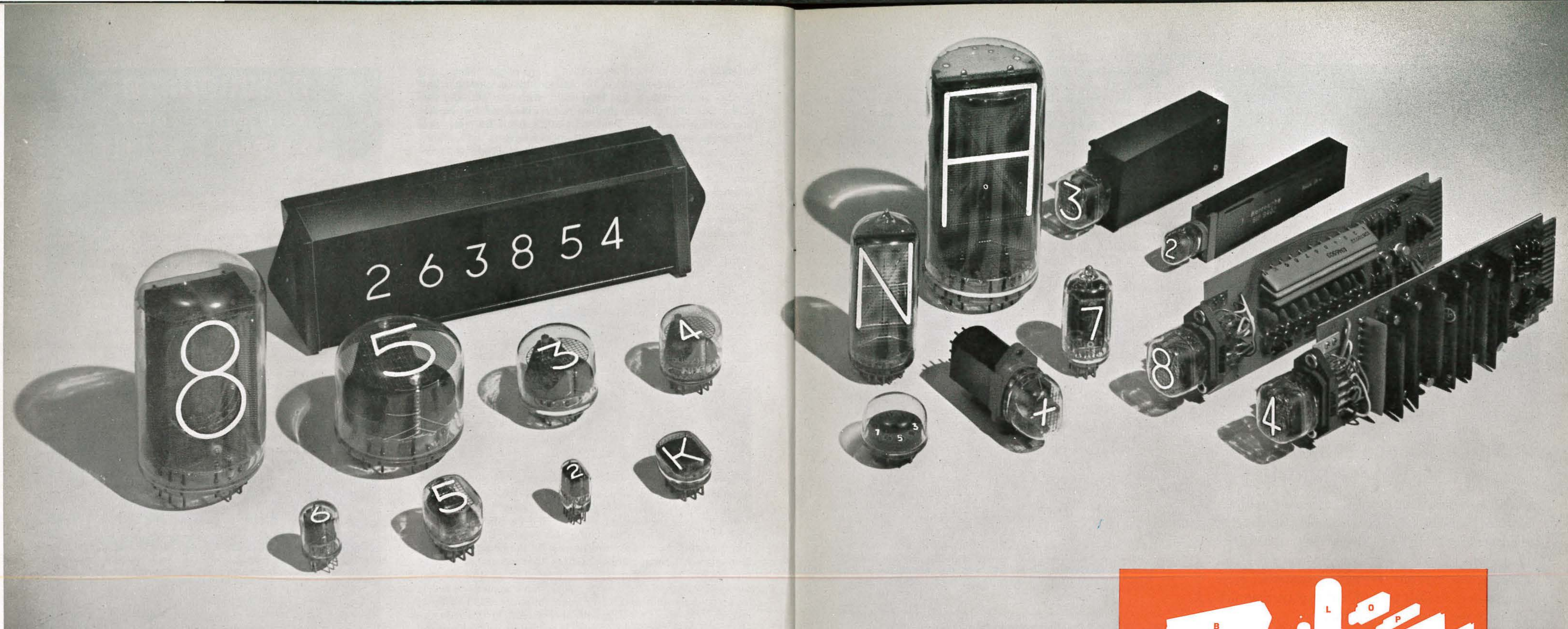
system, the operator receives an inquiry concerning an account or other record by phone. The clerk uses the keyboard to enter the account number. She visually verifies her entry on the cathode ray tube screen and by depressing the "transmit" bar, sends the request to the computer which immediately returns data related to the account or inquiry for display on the interrogator screen. With this system, the clerk or other company personnel have immediate access to up-to-date information. In some applications, entries to records may also be made with the system. In this case the clerk enters the record number, the data to be entered and the function code which tells the computer the type of entry to be initiated. When transmitted by the operator, the new information is added to the stored record automatically. Two versions of the S-C 1100 are available. One is capable of presenting 100 characters of information at a time on the tube face while the other model displays up to 500 characters. The desk-top display and entry unit provides complete message composition, communication and display facilities. The equipment can be operated by anyone after only a few minutes of instruction. The S-C 1100 has its own memory so the data will remain on the display screen until erased. The system can also be used in conjunction with a printer so an operator can obtain a permanent paper record of displayed data. Also included in the new line of Stromberg-Carlson products is a control unit which provides all the necessary controls to multiplex up to 24 interrogators.

Photography in Information Storage & Retrieval

The Society of Photographic Scientists and Engineers has chosen "Photography in Information Storage and Retrieval" for the theme of its 1965 Symposium Oct. 21-23 at Marriott Twin Bridges Motor Hotel, Washington, D.C. Each session chairman will be invited, and will present a state-of-the-art review in his field. The Symposium will conclude with an open panel session on various aspects of information storage and retrieval, including optics, recording materials, coding, read-in, storage, read-out, and over-all systems considerations, as well as the comparison and assessment of photographic systems with non-photographing systems. Tentative program topics include: *Information Properties* – Bit density, signal/noise, spatial frequencies, enhancement techniques; *Read-In* – Digitizing techniques, electro-optical devices, CRT and light matrix devices; *Storage* – Permanent and reversible materials, memory form, electro and photosensitive media, transport systems; *Read-Out* – Parallel and serial access, search techniques, photoelectric recognition, display, rapid printout; *Optical Computers* – Digital, analog, Coherent systems. Information may be obtained from William S. Dempsey, SPSE Publicity Chairman, Houston Fearless Corp., 1413 K St. NW, Washington, D.C. 20005.

Computer Handles 9 Programs Simultaneously

Honeywell's Electronic Data Processing Div. has moved further into the third generation with the introduction of a new large-scale computer using advanced microcircuitry throughout. Termed the Honeywell 8200, it combines key features of the firm's two top computer lines, enabling it to process nine separate programs at the same time. It is designed for mixed business, scientific and realtime data processing, and can operate on both word- and character-oriented programs. Memory and input/output protection features, plus extensive interrupt capabilities, make the H-8200 extremely attractive for time-sharing applications, the announcement said. The H-8200 can share memory among the equivalent of 10 central processor groups (multi-processing); run nine programs at once (parallel processing); and have more than one "live" program controlled by a single processor group (multi-programming). More than 3,000 stations can share time simultaneously. The H-8200 contains three major subsystems: *Processor, memory* and *input/output*. The *processor* has within it 10 programming groups – nine running active programs and a tenth – called the master control group – monitoring the entire computer. Eight of the active programming groups handle data and instructions in the form of fixed-length words. The ninth active programming group handles data and instructions in the form of discrete variable-length characters. The master control group provides intercommunication among all active programming groups. The processor also includes console, display and manual control facilities. The *memory subsystem* has one to eight memory modules and a memory multiplexor (MM). Each module holds 131,072 characters (16,384 words) for a total maximum core storage capacity of 1,048,576 characters (113,072 words). Memory cycle time is 750 nanoseconds per eight-character word. This speed and capacity, in addition to a high computational rate, makes possible a basic data transfer rate to peripheral devices of 1.33 million characters a second. The MM, to provide maximum memory utilization, can access up to three memory modules during each cycle. It handles and routes multiple requests for access to memory, assigns priorities, resolves conflicting requests and provides memory barricade control so that one active program will not disturb operation of another. The *input/output subsystem* comprises an input/output multiplexor (I/OM) and up to 32 read/write channels. Up to 48 peripheral control units, and their associated devices, can be connected to the subsystem, enabling the H-8200 to operate up to 32 peripheral devices simultaneously. The I/OM continuously scans all peripheral control units connected to the system and requests time from memory whenever a data transfer is to take place. In a time-sharing or data communications application, for example, each control unit can be linked to a 64-line communications device for a total of 3,072 remote connections. Access to the H-8200 will, in effect, be instantaneous from the standpoint of the remote communications devices. The I/OM contains hardware which enables the program-assignable read/write channels to "float" among the peripheral devices connected to the system. Any peripheral device is available for either word- or character-oriented programs.



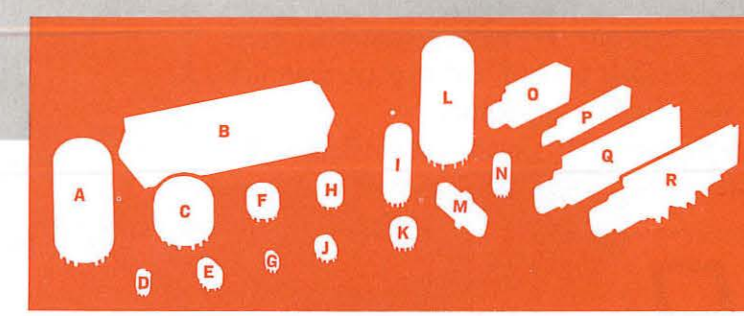
There's a **Burroughs NIXIE® tube display** to fit your application your specification your budget your equipment

We're applications oriented . . . that's why NIXIE tubes come in more sizes, shapes and types than any other readout available. There's a NIXIE tube to suit requirements ranging all the way from numerical readout of navigational data for "inch-conscious" aircraft instrument panels to alphanumeric display of stock-market transactions for viewers up to 100-150 feet away.

We're budget conscious too. The per-digit cost of a NIXIE tube display is less than that of any comparable electronic display technique, especially when you consider the cost of associated drive circuitry and power supplies. Add to this the extreme reliability and a two-year warranty, items which can't be bought in any other readout at any price, and you've got an unbeatable deal.

And we're equipment conscious . . . which means that we've designed display modules to match almost any input requirement. Using hybrid circuits with face-bonded single-sided semiconductors, we've come up with extremely flexible units which give custom performance at costs rivaling high-production items. Now you can buy NIXIE tube drivers, decoders, counters, with or without memory tailored to meet your specifications.

So let's hear from you. Your application, specification, budget, equipment are important to us. We're in business to meet your display requirements. Remember—you get much more than a readout when you buy a NIXIE tube display.



A. **B7037**—Side-viewing Jumbo Tube • Character size—2" Viewing distance—100'

B. **Readout Assembly**—6-digit bezel assembly containing 8422 NIXIE tubes

C. **B8091**—Large Tube • Character size—1.4" Viewing distance—65'

D. **7977**—Miniature Tube • Character size—0.3" Viewing distance—14'

E. **8422/B5991**—Standard Rectangular Tube • Character size—0.6" Viewing distance—30'

F. **8423/B6091**—Super Tube • Character size—0.8" Viewing distance—38'

G. **B4998**—Miniature Rectangular Tube • Character size—0.3" Viewing distance—14'

H. **8421/B5092**—Standard Tube • Character size—0.6" Viewing distance—30'

I. **B-8971**—Large Alphanumeric Tube • Character size—1.5" Viewing distance—65'

J. **B5971**—Standard Alphanumeric Tube • Character size—0.6" Viewing distance—30'

K. **B9012**—PIXIE® Position Indicator Tube • Character size—0.125" Viewing distance—8'

L. **B7971**—Jumbo Alphanumeric Tube • Character size—2.5" Viewing distance—100'

M. **BIP-8200 Series**—Binary-coded-decimal to decimal decoders; drives 8422 standard rectangular and B5992 plus-minus rectangular NIXIE tubes.

N. **B5030; B5025**—Long Life Biquinary Tube; Non-Mercury Biquinary Tube • Character size—0.6" Viewing distance—30'

O. **BIP-9451; BIP-9501; BIP-9502**—Decoder/Driver Modules with memory to operate 8422 standard rectangular tube from BCD or decimal inputs or B5971 alphanumeric tube from 13-line input.

P. **BIP-9402**—Miniature Decoder Module with memory to operate B4998 miniature rectangular tube.

Q. **BIP-8055**—150KC decade counter; decimal output is available for preset/reset operation and carry output is provided for cascaded multi-decade applications. Preset/reset module available to reset up to six decades.

R. **BIP-8054**—110KC bi-directional decade counter; decimal output is available for preset/reset operation, and carry output is provided for cascaded multi-decade applications. Building-block support modules are also available to provide accumulator function.

Only Burroughs manufactures NIXIE Tubes.

Burroughs Corporation / ELECTRONIC COMPONENTS DIVISION
PLAINFIELD NEW JERSEY

Circle Reader Service Card No. 33

New Air Line Arrival/Departure Display

Ozark Air Lines has unveiled a new electronic display system that provides the flying public with up-to-the-second information on the arrival and depature of all Ozark flights at O'Hare International Airport. The information is displayed in glowing green characters on cathode ray screens at ticket counters and departure gates in the Ozark Terminal. The system was supplied by the Bunker-Ramo Corp. The departure screens show up to twelve different flights, giving the flight number, destination, time of departure, and gate number. Arrival screens show flight numbers, points of origin, arrival times and gate numbers. Each flight carries remarks such as "boarding," "on time," "extra section," etc. The flight information data is entered through a special input/output device at Ozark's Flight Control Center in Chicago. The characters appear on a small screen in front of the operator for verification. Then at the touch of a button the information is transmitted to the 23 in. cathode ray screens for public viewing.

New TV Hard Copy Printer

A television printer which produces high quality hard copy prints of video information displayed on a TV cathode ray picture tube, has been developed by GPL Div., General Precision, Inc. The printer provides photographic-quality 8½ in. x 11 in. prints of any image viewed on a control monitor, in only 30 seconds, and at a cost of only 7¢ per print, according to the manufatурer. The new GPL TV printer consists of three major assemblies: CRT and Electronics; Optics; and Rapid Processor. Front panel controls include On-Off, Exposure Timing, and PRINT pushbutton. The completed semi-dry print is ejected through a slot in the lower front section of the unit. Operation can be remote, automatic and unattended with either 525- or 675-line horizontal-scan-rate accepted. Other features include: Adjustable aperture correction, electronically regulated power supplies, and switchable picture polarity. The unit weighs 140 lbs., and measures 32 in. high x 18 in. wide x 36 in. deep.

Near Real-Time Aerial Recon Information

Philco's Aeronutronic Div., Surveillance Radar Dept., Blue Bell, Pa., has developed an aerial reconnaissance photograph scanning and reconstruction system to provide near real-time information for field commanders. Called Project See Fast by the Air Force, for whom it was developed, the system is currently under evaluation. It is designed to provide improved close air support for ground troops. The system scans sensor imagery and reconstructs it at a remote receiver station. It utilizes an airborne single-line flying spot scanner to transform information from 70-mm film to video form for transmission via data link to a relay aircraft, thence to a ground station where a CRT film recorder converts video data to a photo image on 5-in. film. Also in use is a Lockheed C-130, converted by LTV, as an Airborne Battlefield Command and Control Center for alternate use. Philco reports the system is capable of scanning 50 feet of aerial photographs of 70mm film at a rate of 1 in./sec. and reproducing them at two times size on 5-in. film at a rate of 2 in./sec. The over-all resolution is 20 optical lines/mm with 10 shades of gray ranging from neutral density 0.2 to neutral density 2.0. A line traced formed by a 1.2 mil (half brightness) spot on the scanner's 5-in. CRT light source is imaged 1 to 0.5 on the continuously-moving 70mm photographic images. The intensity of the spot is modulated by the density of the emulsion in the photograph and its light is collected by a photomultiplier which yields the video signal for transmission. The system operates in the near ultraviolet spectral region with a P-16 phosphor CRT, special color corrected optics and an S-11 response photomultiplier.


DUAL BEAM OSCILLOSCOPE
SWEEP GENERATOR
CALIBRATOR
AMPLITUDE

Sixth SID Symposium Features Four Top Display Experts

20 Technical Papers in 4 Sessions Include six "5-Minute" Offerings; A Ladies' Program Is Introduced

New York City, Sept. 29-30, 1965

Brig. Gen. A. T. Culbertson, USAF, Commander, Rome Air Development Center, New York, will deliver the keynote address Wednesday morning, Sept. 29, prior to the start of technical sessions of the Sixth National SID Symposium.

Other speakers at the 2-day meeting include:

John Sullivan, Dean of the School of Business Administration, Florida Atlantic University, a new school designed around the use of Information Display as an integral part of the educational program. He will address the Wednesday luncheon after an introduction by MC .Ford Brown, Symposium General Chairman.

E. J. Stockwell, of NASA's Office of Tracking and Data Acquisition, will speak at the annual banquet, Wednesday evening. He will be introduced by Bob Klein, Chairman of the host Mid-Atlantic Chapter.

Hal G. Davis, North American Aviation/Space & Information Systems Division, Downey, Calif., will address the Thursday luncheon. He will be introduced by Carl Machover, Program Co-Chairman.

Site of the two-day meeting is the 2000-room Hotel Commodore on New York's 42nd Street between Park and Lexington Avenues (adjacent to Grand Central Station).

New York's Commodore Hotel, 42nd St. at Grand Central Station, is the scene for the Sixth National Symposium of SID

Technical Sessions

The technical sessions on Wednesday and Thursday morning and afternoon will all be related to displays but will cover broad areas, including systems, display-computer-user interface, as well as physics, electronics, optics, photochemistry, physiology and psychology as they are applied to information display.

Some of the papers submitted cover applications of photochromic materials both inside a cathode ray tube as well as ultraviolet excitation in air.

Laser display applications will be covered, as well as a variety of electroluminescent display techniques.

There will be papers describing the use of color in large screen and other displays, as well as storage systems for color.

Electronic and computer systems, together with alpha-numeric character generating systems, will be discussed as they are applied to graphic arts.

Applications of information displays in business, management, automatic checkout, as well as space vehicle control systems will be covered.

There will be descriptions of work on a number of display system components, including special cathode ray tubes, circuitry and switching systems.

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.

Symposium Committee

Ford Brown, President of Photomechanisms, Inc., is the overall Convention Chairman, and he has chosen a well-qualified, hard-working group of chairmen responsible for specific activities. Sol Sherr of Sperry Gyroscope is Vice Chairman.

Edmund Kennedy, of Rome Air Development Center, is the Papers Chairman. Program Co-Chairmen are William Bethke of RADC and Carl Machover of Information Displays, Inc. The Exhibits and Equipment Show are being coordinated by Sherman Blumenthal of Touche, Ross, Bailey and Smart. Frank Masters of Trade Associates, Inc. is the Exposition Manager.

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

Publicity and Publications Chairman is Gordon Burroughs, of Gordon Burroughs Engineering.

Advance registration forms and a preliminary program have been mailed out, but additional advance registration forms can be obtained from Burton Price, Philco Corporation, 3900 Welsh Road, Willow Grove, Pennsylvania 19090 (Telephone (215) OL 9-7700). Any other information can be obtained from Ford Brown, Photomechanisms, Inc., 15 Stepar Place, Huntington Station, L.I., New York (Telephone (516) HA 3-4411).

Abstracts of Addresses

Gen. Culbertson's command includes the responsibility for R&D of display devices across a very broad area, for Air Force use. An abstract of his keynote address follows:

"We seem to have reached a leveling-off period in technology. We have in the past three or four decades been applications oriented. Little basic research has been done within recent time.

"It is evolution in science which breeds what seems like technological revolution to the lay men. Individual investigators, each working in his narrow area of specialty, laboriously pile stone upon stone of scientific knowledge. Finally, an investigator with an inventive turn of mind sees the form of the structure developing, adds a few deft touches, and the completed pyramid takes shape. The average person sees the completed pyramid as the scientific revolution; he does not consider the piling up of the individual stones. Thus, to build a pyramid representing a technological break-through, we need both the stone masons to pile stone upon stone and the architects to realize that enough stones are available to assemble the completed structure.

"Perhaps, it is time to turn, or divert more of our efforts from 'application' to 'theory and experiment'. Through the adoption of this approach, we, in the display area, may progress beyond evolutionary advances and realize a truly revolutionary breakthrough."

Dean Sullivan will discuss the need for and advantages of utilizing the most forward technology available in education today. An abstract of his luncheon address follows:

"With the increasing number of students entering college and the lack of a corresponding increase in the number of adequately trained teachers for college, new teaching methods must be uncovered and exploited. The use of information displays for higher education becomes obvious. Florida Atlantic University is pioneering in this area. Programs in Business Administration, such as, Management Planning, Computer Instructions, etc. are prepared on video tape. Limited use of this technique for foreign language instruction has been attempted. The results of this program will be presented."

Mr. Stockwell, presently a Staff Scientist with the NASA Office of Tracking and Data Acquisition, is head of Manned Space Network Operations. An abstract of his banquet address follows:

"*The Count is now T-30 and Holding*. To the average citizen who has just been informed on TV or radio of this situation, it is just words and numbers. At this stage in our Aerospace Program, they are educated enough to know that it is going to be 30 more minutes until launch; that is, they think it will be 30 minutes because the countdown clock, unlike the ordinary alarm clock, can stop and go without precedent. (Obviously invented by a showman and with a sole purpose of building up tension and interest.)

"These sets of numbers and an unemotional voice team up in the strange ritual of counting backwards until at last the clock strikes zero and the countdown is ended in a fiery spectacle as the launch vehicle slowly lifts off the stand and then picking up speed, rapidly moves out of sight into the heavens. And that is all there is to it – to the layman.

"Very few laymen know the real purpose of the countdown or just how the countdown is carried out. My talk will attempt to demonstrate that the countdown is a carefully developed procedure of preparation for launch and because of its tremendous importance to the success of the launch program, the countdown should be better understood."

Mr. Davis is currently Manager of Data Systems Analysis in the Information Systems Div. of NAA/S&ISD, with responsibilities in many current and future areas of display. An abstract of his luncheon address, "A Display System for Management", follows:

"In recent years the Space and Information Systems Division of North American Aviation, Inc. has attained a highly developed skill in the application of closed-circuit television to management communications. Program production teams have utilized the fully-equipped, commercial television standard obile vans, studios, mobile receivers and transmitters to serve projects and facilities over a dispersed complex covering 50 miles and 280 outlets. Indicative of the usefulness of North American Aviation's CCTV, more live programming has been transmitted over the 500 miles of cabling and microwave links than has occurred on any network broadcasting in the past year.

"Stressed in the presentation will be: (1) Management communiaction in large organizations; (2) Effect of displays in management communications; (3) Novel applications at NAA that contributed to CCTV's success in management communications; and (4) Summary of proven uses, possible uses and implied boundaries for use."

Invitation to Symposium

Please accept my personal invitation to participate in the Sixth National Symposium of the Society for Information Display. My first attendance at the Society stemmed from such a personal invitation, and I think it only fitting to pass it on to you. I am sure that your participation at this Symposium, whether it be a repeat attendance or one for the first time, will have a most satisfying and professionally enriching effect on your life.

The international situation of today tends to foreshadow such activities as these. However, none of us should forget that the display industry we represent is a vital tool for national defense and preparedness. There is not one major defense system or defense installation in this country or abroad that does not depend in one way or another on information display. I think it is our responsibility to continue to expedite the long term advancement of the information display industry if for no other reason than to contribute to the preparedness stature of the United States. I will be looking forward to seeing you at the Symposium.

Jim Redman
NATIONAL PRESIDENT

Technical Program

Four technical sessions are planned, two each day, at which a total of 20 papers are to be offered.

SESSION I is composed of a series of six 5-minute "Quickie" papers (an innovation) to be presented in just 90 minutes. They cover a variety of subjects. Chairman is Thomas T. Goldsmith, Fairchild Camera & Instrument Corp., Clifton, N.J.

SESSION II will cover the so-called "hard sciences", physics, chemistry and their myriad subdivisions and combinations, such as electronics, optics and photochemistry. Chairman is George B. Collins, IBM, Kingston, N.Y.

SESSION III will feature the "soft sciences", psychology and physiology, including psychophysics, information transfer and personnel hazards. Chairman is Carl Silver, Franklin Institute, Phila., Penna.

SESSION IV will deal with systems science and art, including display/computer/user interface, programming, and specific applications. Chairman is Edith Bairdain, Data and Information Systems Division of ITT, Paramus, N.J.

Papers to be presented at the various sessions include:

Welcome

The Mid-Atlantic Chapter is looking forward to the opportunity of welcoming all SID members to New York for the Sixth National Symposium of the Society for Information Display.

This meeting comes at a time when public awareness of the need for information management and display are appearing, not only in technical publications, but in daily newspapers. Sunday supplements discuss electronic computers and their effect on everyday life. Banks, businesses and universities, as well as the military, are employing computers in ever increasing rates, and with them, the man-machine interface devices which constitute display components and systems. Every day presents new challenges to our technology.

In this environment of growth, new applications and new ideas, the forthcoming SID symposium represents a wonderful opportunity for all of us to get together again to compare concepts, exchange views aid explore the future. We are looking forward to sharing it with you.

Robert C. Klein
Chairman
MID-ATLANTIC (HOST) CHAPTER

Session I

Suggestion for an On-Line Braille Display, by Theodor H. Nelson, Vassar College, Poughkepsie, N.Y.

ABSTRACT: A simple and inexpensive Braille output device is described. It would use pins in a drum, and require little power. A feedback device informs the computer of the reader's progress, and display is modified accordingly. The display would hold about half a line of type, though this could be varied. Using standard teletype code and phone lines, it could be hooked to a remote data-set far from the computer; multiple units could be easily time-shared from a single computer. Essentially the device would substitute quick response for large display area.

Because the actual displayed area would be small, unusual software is required, by which the computer may continually modify the display on the basis of the reader's movements. The program must use reader feedback to control back-spacing, line and page forward stepping, and skips. Other software must facilitate browsing, and provide indexes, modality shift (to summaries or footnotes), and information customarily carried by such cues as page position.

Such a device might reduce the need for Braille hard copy, and put the blind within immediate reach of all the books that have been digitally recorded. •

Electroluminescent Pictorial Status Displays, by John S. Frost, specialist, research, Autonetics Division, North American Aviation Inc., Anaheim, Cal.

ABSTRACT: Status displays are a requirement in vehicular operations to indicate the functioning of complex subsystems. Current status displays usually consist of a cluster of gages, supplemented by advisory information, utilizing the technique of illuminated areas and accompanied by appropriate English language or numeric identification. Observer response to this type of presentation requires several stages, including scan, synthesis, perception and action.

Many status displays can be shown in pictorial form with the object of enhancing the observer's recognition of and response to the ensuing situation. Several types of pictorial status displays have been constructed showing stylized versions of real world situations. Electroluminescence has been utilized in these displays. By selective electrode deposition, complex shapes may be generated by simple on-off selections, thus affording unlimited flexibility in selection of the output display format. Dynamic information (including illusory motion) can be presented by straightforward switching techniques.

Initial evaluation has shown the Pictorial Status Display affords a significant reduction in the electrical complexity of the computer/display interface. Further testing is required to determine the relationship between representative pictorial status displays and observer-operator efficiency. •

Footlamberts, Film and P-11 Phosphors Don't Mix, by H. P. Field and R. H. Akin, Gamma Scientific Inc., San Diego.

ABSTRACT: The P-11 phosphor is the most widely used phosphor for CRT film recording because it has the highest photographic efficiency. Many men in this field are faced with the problem of how to measure the light output from a P-11 phosphor. Traditionally this has been done in terms of footlamberts with a photometer that has a special response matching the standard human eye curve. This is an erroneous technique and should be abandoned. For instance, when more than one photometer is used, disagreement is the rule.

The reason for disagreement is a basic one; all of the P-11 energy is located at a low and sloping portion of the blue skirt of the eye's response. Apparently minor variations in the photometer's response in this region can cause major differences in readings of P-11 sources. In addition to the instrument-to-instrument variations causing lack of correlation, a more serious consideration is the fact that while the P-11 is at a low point (about 5%) of the eye's peak response, it is at a maximum for most films. Hence, we are using the wrong tool for making the measurement. We should use a photometer whose spectral response matches the film.

It is argued that footlamberts should no longer be used as the basis of P-11 light output measurements. Instead, calibrated P-11 sources and photometers that match the film's spectral response should be used to solve this problem facing the instrumentation engineer in measuring P-11 light output meaningfully as it relates to photographic film. ●

The Faster the Better?, by Carl Silver, Franklin Institute, Phila., Penna., and Lt.-Col. Ralph Cruikshank, U.S. Army.

ABSTRACT: In developing a display sub-system to support information retrieval and processing in military command and control systems, there is a great temptation to base systems specifications upon the current state-of-the-art rather than upon objectively identified requirements. This is especially true with regard to speed of display creation and presentation. It is understandable that this temptation exists because it is ordinarily a matter of some difficulty to identify display users' requirements in terms of permissible delay. Such analyses often lead only to the conclusion "The Faster the Better." In considering such a conclusion, it is useful to distinguish between tactical systems and strategic systems.

In tactical systems the requirement for speed in display creation and presentation ordinarily depends on the speed with which significant related events are occurring.

In strategic systems on the other hand, the permissible delay is not ordinarily related to the time sequence of events in the field. ●

Batch Fabricated Computers: The Challenge to the Display Field, by L. C. Hobbs, Hobbs Associates, Corona Del Mar, California.

ABSTRACT: The course of technological history has proven the importance of related technologies advancing roughly equivalently. Inevitably, lack of progress in a particular technology tends to hold back the effective utilization of related technologies. Alternatives will be found and the offending technology will fall by the way side. Batch-fabricated electronics and the new computer applications they will permit offer such a threat, and hence challenge, to the display field.

Developments presently underway in integrated circuits and batch-fabricated memories are creating a revolution in computer technology.

The future of the display field will belong to those who realize the dramatic changes underway in electronic and computer technologies and concentrate their efforts on the development of compatible display technologies. ●

High Contrast Dark Field EL Panel Development, by Martin C. Rader, E. J. Soxman, and G. N. Steele, Sigmatron Inc., Goleta, California.

ABSTRACT: None available. ●

Session II

Photochromic Glass—A New Tool for the Display System Designers, by Ben Justice, Corning Glass Works, Corning, N.Y.

ABSTRACT: The announcement of a reversible photochromic glass in January of 1964 by Corning Glass Works, generated a great deal of interest in many areas of application. In the area of display applications, photochromic glass is unique. Corning's silver halide compositions are non-fatiguing, light sensitive, erasable, durable, predictable, reversible, exhibit high resolution, and formable by most conventional glass working or finishing processes. Applications have been requested involving darkening and fading rates that range from microseconds, to several hours. Needs for optical density after exposure range from 0.3 to 4.

For many applications there are two methods for influencing the "natural" behavior of photochromic glasses – the control of temperature and the use of optical "bleaching" radiation.

It is possible to impress information on photochromic glass. This information can then be read, projected, stored, or written and erased thousands of times. This paper will describe this unique system and relate its important properties to display applications, including a demonstration. ●

The Laser Display: A Large-Screen, Real-Time Display Technique, by Charles E. Baker, Texas Instruments, and Anthony D. Rugari, Rome Air Development Center.

ABSTRACT: Development of the laser as a practical, continuous, coherent light source has opened the way for a novel and promising new approach to a large-screen, high-brightness, high-resolution, real-time, projection display technique. A feasibility model has been constructed which operates from commercial television broadcasting and uses a high power neon-helium gas laser. A 40-inch-wide 525-line raster is projected onto a directional reflective screen to give a display having between 5 and 10 footlamberts highlight brightness.

Considerably higher resolutions are possible and the availability of visible continuous lasers in the red, blue and green portions of the spectrum now make it possible to design a full color display. It is concluded that this technique deserves serious consideration for some of today's most pressing display problems. ●

Visual Write-Erase-Nonstore and Electrical Readout Accurate Tracking Display Storage Tube, by Phillip P. Damon and John Kolostyak, Vacuum Tube Products Div., Hughes Aircraft Company.

ABSTRACT: A display storage tube has been demonstrated which has high tracking accuracy between the four functions of visual write-erase-nonstore and electrical readout. A "light pen" may also be employed to enter or read out information. This new approach may be utilized with any diameter display storage tube. Features are simplified economical construction, additional operational capabilities not now available in existing halftone display storage tubes, improved performance characteristics and simplification of system requirements. ●

Thin Film Electroluminescent Display Panels, by E. J. Soxman, G. N. Steele, and M. C. Rader, Sigmatron, Inc., Goleta, California.

Chairmen's Message

We have made a sincere effort to make this Sixth National Symposium of the Society for Information Display the best ever. We hope your attendance will be as rewarding to you as we have tried to make it. We will welcome your comments or suggestions on any aspect of this symposium.

FORD BROWN
Photomechanisms Inc.
Symposium General Chairman

SOL SHERR
Sperry Gyroscope
General Vice Chairman

EDMUND KENNEDY
RADC
Papers Chairman

WILLIAM BETHKE
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Philco Corporation
Registration Chairman

HENRY OPPENHEIMER
CBS Laboratories
Financial Chairman

GORDON BURROUGHS
Gordon Burroughs Engrg.
Publicity & Publications Chairman

ABSTRACT: This paper presents a review of past and current research efforts on the development of thin film electroluminescent x-y matrix display panels. Initial development of a 28x28 line matrix with a resolution of 33 lines per inch is described, with emphasis on performance variations which result from changes in phosphor film thickness and composition. Variations of intensity of emission as a function of a variety of drive conditions is discussed. Suppression ratio measurements of the order of 10^6 are presented. Design criteria established for a matrix of 258x258 electrodes is discussed, and the performance of such panels is described. Final panel configuration provides an active surface area of more than 90 square inches on a single substrate.

Finally, data is presented which indicates that the drive conditions required for the emission of light in the 20-100 foot-Lambert range can be adjusted over a wide voltage range by proper selection of fabrication techniques. This can be accomplished without loss of suppression. Latest results of current life tests will be presented, with a discussion of most recent data available.

The work reported was sponsored, in part, by the Joint Army Navy Aircraft Instrumentation Research Committee under Contract Nonr 4509(00) and the Naval Air Development Center under Contract N62269-2540. ●

Limitations on High-Energy Cathode Ray Tube Beams with Regard to Phosphor Life, by W. R. Elliott, The Boeing Co., Seattle.

ABSTRACT: The extremely high energy of the electron beam in the cathode ray tube, when the tube is employed as a source of ultraviolet energy for exposing Kalvar dry processed film, presents a problem in preserving the prosphor. In a conventional oscilloscope tube, leaving the spot on one location will eventually cause deterioration of the phosphor. With the beam powers contemplated in this application, allowing the spot to dwell for a fraction of a second will cause not only deterioration but total destruction of the phosphor at that location. The possibility that the dwell time required to obtain sufficient light energy to expose the Kalvar film may be greater than the maximum permissible time thus becomes a major problem.

It is assumed that phosphor damage in a cathode ray tube is a result of the temperature rise of the phosphor. Since most phosphors are quite inefficient, most of the kinetic energy of the electrons in the beam is converted into heat. The temperature rise is determined analytically assuming that the heat is dissipated by conduction in the glass face. ●

Session III

Methodology for the Definition of a Space Vehicle System, by N. J. Arntz, The Boeing Co., Seattle.

ABSTRACT: Not available.

The Perception of Flicker in Cathode Ray Tube Displays, by Rodger Elmo Turnage Jr., Stromberg Carlson Corp., San Diego, a Division of General Dynamics Corp.

ABSTRACT: The critical fusion frequency (cff) of flicker in CRT displays was experimentally measured under the conditions prevalent in information display systems. Much published data is not applicable because CRTs were not used and the humans were adapted to scotopic vision, wide angle flickering fields, or low contrast targets. Apparatus was constructed consisting of interchangeable CRTs with seven different phosphors and electronic equipment to modulate the CRT beam current with sinusoidal and rectangular pulse signals of variable frequency.

Results show that the cff of a phosphor-human system is reduced substantially below the cff of a human visual system by phosphor persistence. The relative ability of phosphors to reduce flicker can be predicted from their persistence characteristics, but quantitative predictions of cff cannot be made by combining an exponential phosphor hypothesis with published human cff data taken under different conditions. The phosphors ranked in order of their reduction of cff are: P12 (greatest reduction), P7 yellow component, P1, P28, P4, P31, and P20. The P28 phosphor tested exhibited neither the expected reduction of cff nor its published persistence. No significant differences in flicker perception were found among the three observers used in the pulse modulated experiments. The apparatus and techniques were found capable of repeating cff data within 2 cps.

Visual Display Techniques in Vehicle Stabilization and Control, by William Kingston, Video Systems Engineering Branch, Norden Div., United Aircraft Corporation.

ABSTRACT: The integration of vehicle status information into a single pictorial display has become an accepted idea in the field of instrumentation. Independent efforts in the human sciences have sought to determine man's behavior and performance for a variety of control tasks, and have shown the types of tasks for which his performance approaches the optimum.

The research described in this paper encompasses both the human sciences and instrumentation. Analytical methods are presented which establish the information requirements for optimum flight control. These requirements form the basis for development of an integrated control and status information display. The behavior of the status and control information symbols under various flight situations is discussed.

The work reported was conducted under funding by the Joint Army-Navy Aircraft Instrumentation Research (JANAIR) Program.

Seven: A Stroke of Luck?, by Paul R. Fuller, Lear Siegler Inc., Grand Rapids, Mich.

ABSTRACT: One of the difficult problems in the development of practical electroluminescent (EL) displays is that of switching. In the development of numeric EL displays, cost, weight and complexity of switching could be minimized as the number of display elements would be minimized. For example, if all digits could be generated by use of seven elements, three horizontal and four vertical, without serious degradation of reading time or accuracy, this would be preferable from an engineering standpoint to the use of a large number of elements. However, there is evidence that the seven stroke format is not so easily read as is the more standard ones, such as those called out in MIL STD 803. An empirical test series was undertaken to measure the time and accuracy of response to a seven stroke EL display and a comparable light-emitting display which used the standard form for Arabic numerals.

Accuracy in reading both types was high. There were slightly more errors initially with the EL numbers. (No statistical significance) The total accuracy in reading EL numerals was 99.533%. If the first five trials were considered learning and familiarization trials and were dropped from analysis, the accuracy of reading became 99.933%. This was comparable to reading the regular numerals with which subjects had had many years experience.

Session IV

Mobile Computer-Generated Display Systems, by Paul Horowitz, Nortronics Division, Northrop Corp.

ABSTRACT: The purpose of this report is to discuss several computer-generated display concepts that appear to be suitable for use in tactical operations centers. The report does not present a survey or review of data display "state-of-the-art", but rather it attempts to set forth the human and subsystem requirements of tactical centers in general, as well as some that may be unique to a particular system. The display subsystem design described in the report is within the current state-of-the-art and hence could be available without an extensive research and development program.

The techniques and devices needed to readily implement the mobile display subsystem are not available in large variety. This may be attributed to present "state-of-the-art", availability within the time period under consideration, and the diverse environmental and operational requirements demanded. There are many characteristics which directly influence the choice of components and subsystems. The display subsystems must be meticulously selected, designed, and tested prior to field us.

A conceptual design readily implemented from "off the shelf" components meeting many of the postulated requirements concludes the paper. •

Alpha-Numeric Generator Operation, by William Dunn, NAFEC, Atlantic City, N.J.

ABSTRACT: Not Available. •

A Stored Program Display Console: The Bunker-Ramo Model 90, by R. A. Koster, The Bunker-Ramo Corp., Canoga Park, California.

ABSTRACT: The Model 90 Visual Analysis Console is the newest in a family of Bunker-Ramo control-and-display devices that enable users in widely differing fields to communicate directly and extemporaneously with a computer. Like most of its predecessors, the Model 90 makes use of keyboard buttons labeled in natural, problem-related terms. The two most significant *new* features of this console are: Stored program logic; and combined electronic and photographic displays, through a fully corrected, rear-ported CRT. This paper will discuss the stored program logic concept.

The advantages of the stored program feature are flexibility and simplification of hardware. Most of the characteristics of the console and the functions of its controls are determined by the program. Functions of the console can be changed in the field without downtime by reading a different program. Since there is less hardware than in a comparable wired logic console, it is less expensive to reproduce and logistically support and has higher reliability. Less special logic simplifies maintenance training and maintenance time. •

Computer Graphics in Architecture, by Allen Benholtz, School of Architecture, University of Toronto, Toronto, Canada.

ABSTRACT: This paper deals with the use of computer graphic displays as an aid in the synthesis of architectural form. One of the major drawbacks in the historical process of designing an environment is that there is no way of pre-testing the effect of a form on those who will experience it. There is, therefore, no way of "correcting errors" in form synthesis, until the structure is actually built, and not readily susceptible to correction except at great expense.

Now, using computer-generated perspectives and other three-dimensional views, we can simulate the visual experience of a projected environment under various conditions. By generating multiple views of a form, from different positions, or successive views with varied viewing distances, and then producing standard or animated motion pictures of these views, we can simulate the visual experience of walking through the environment. Moreover, by generating stereo pairs of views, an illusion of real depth-of-space can be created.

To test the effect of computer graphic simulation, various people can view the film produced while wearing a "head camera." This device records the actual film and at the same time superimposes on it a small spot of light bounced off the retina of one of the viewer's eyes, giving simultaneously, a record of his visual reaction and the object viewed. By combining this computer-assisted simulation of form with a computer-aided analysis of the design problem, environmental forms of consistent functional and aesthetic merit can, we believe, be produced by the creative designer. •

Problems of Management Display in Advanced Business Systems, by Sherman C. Blumenthal, Advanced Business Systems, Touche, Ross, Bailey & Smart, New York City.

ABSTRACT: In traditional computer-based information systems, if management needed a new or changed type of report, a set of requirements had to be developed and submitted to the programming staff. Thereupon ensued a delay while the requirement was programmed, debugged, computer time scheduled for processing the necessary tapes, and the output finally printed, decollated, bound and distributed. Management has found several shortcomings in this state of affairs. It would then appear to be a major goal of an advanced, computer-based, information system to provide management with the ability to communicate with it in an easily, timely, and readily understandable way.

The paper describes the overall requirements to be met on the part of display manufacturers and display users, if commercial success in their further application is to be achieved. These requirements include types of equipment needed, flexibility, reliability and maintainability, cost guidelines, human interaction considerations such as ease of use, and lastly generalized software systems to make their implementation less costly and time consuming. Requirements considered from the user's point of view cover information base, functional integration, communications, training, organization, and related procedures. •

Ladies' Program

On behalf of the Ladies Program Committee and the members of the Society for Information Display, I wish to extend to you a most cordial invitation to join us at the Fall Convention on September 29th and 30th. This is the first time we have planned a special program for the wives of SID members attending the New York Symposium. We hope that you can attend so that we may continue such programs at future symposia.

The Ladies Committee has planned a variety of activities so that your visit to New York may be an interesting and memorable occasion. Among these will be a visit to the United Nations on Wednesday with lunch in the Delegates Dining Room and the Banquet in the evening. On Thursday there will be a tour of Radio City, brunch at La Fonda del Sol and a show at the Radio City Music Hall. To round out your week in New York, we have made arrangements for several special events at the World's Fair on Saturday, such as lunch at the Top of the Fair and reserved admission tickets for the Ford and General Motors shows. If you wish information about the stores, shows or planning your own sightseeing, professional advisors will be present to assist you at any time Wednesday and Thursday.

We are looking forward to having you with us and hope we can make your visit a most pleasant one.

Barbara Brown
(MRS. FORD M. BROWN)

ID Authors

Leo Beiser

Leo Beiser is Staff Physicist, Intelligence Systems Dept., C B S Laboratories. He is engaged in research, analysis, and new development in image technology. He received his BS and ME (Physics) from Hofstra University, and was an honor student in additional graduate work. He has engaged in consulting or directed research with NASA/JPL (information transfer), Raytheon/Autometric, Radio Receptor Corp. (ATC "bright" display), and Loral Electronics. His patents and disclosures relate to optics, electronics, mechanics, MCW tuning, character generation and unique display processes.

Rudolph L. Kuehn

Rudolph L. Kuehn is Manager of Design Engineering, Control Nucleonics Div., Giannini Controls Corp. and Chairman of *SID* Publications. His biography appeared in Vol. 1 No. 2 of *Information Display*, Nov./Dec. 1964.

Dr. Herman Graff

Dr. Herman Graff is Director, Applied Research Dept., Research & Systems Center, Librascope Group, General Precision Inc. He received his BS (1947) and MS Inorganic Chemistry (1950) from the University of Chicago, and his PhD Inorganic & Physical Chemistry (1954) from USC. Earlier he was a research chemist with Aerojet-General. Current work includes performance and direction of studies in chemistry and physics of thin film solid state materials. Projects include development of image-retentive display panels and computer application; preparation of high-bit density arrays of selenide and sulfide photosensitors by chemical deposition techniques, measurement of the sensitivity detectors, their use in tracking systems and analytical instruments; and others.

Frederick N. Ingham

Frederick N. Ingham has been an Associate Engineer in storage tube development at Electronic Tube Div., Westinghouse Electric Corp., since 1963. He is responsible for development of new display storage tube types to meet customer specifications. He is presently a candidate for the MEE from Cornell University; he received his AB-Physics from Northeastern and worked as an engineering aide (1959-63) with Raytheon in receiving tube design and storage tube development under Northeastern's cooperative work program. WEC projects have included the WX-5444 and WX-30138 tubes.

Richard A. Martel

Richard A. Martel is Senior Chemist, Research and Systems Center, Librascope Group, General Precision Inc. He has been engaged in the study of materials having nonlinear characteristics in the electro-optical areas and in the development of techniques for the application of these materials to display devices. He holds the BA Chemistry (1951) from St. Anselm's College, and engaged in advanced studies in Nuclear Chemistry and Nuclear Physics at Northeastern University. He has engaged in research work with Hetherington Co., and Hughes Aircraft Co., as well as at Librascope, mainly in the area of electroluminescence. He holds two patents and has six pending in specialized display devices and allied areas, nearly all involving electroluminescence.

(Continued from page 40)

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Photorecording Technology

1. SPSE Symposium on Photography of Electronic Display (co-sponsored by N.B.S.) October, 1962, in particular,
   a. A. J. Derr, "Energy-Sensitivity Relationships in the Photographic Recording of Electronic Displays"
   b. R. W. Tyler, "Photography and Photometry of Cathode-Ray Tube Displays"
   c. R. C. Eisen, T. G. Veal, R. W. Tyler, "Photography of Cathode-Ray Tube Oscilloscope Traces"
   d. F. R. Hays, "Evaluation of Fiber Optic Cathode-Ray Tube Faceplates"
2. Kodak Publication No. P-37, "Kodak Films for Cathode-Ray Tube Recording," 1962.
3. A. J. Derr, "Characteristics of a Photographic Film as a Recording Medium," (Ansco Div., General Aniline & Film Corp.). Cathode Ray Tube Recording Symposium, Aerial Recon. Lab., Dayton, Ohio, 1959.
4. R. J. Hercock, "The Photographic Recording of CRT Traces," Ilford, Ltd.
5. L. Levi, "Photographic Emulsions as Computer Storage Media – Especially with CRT Readout," Applied Optics, Vol. 2, No. 4, pp. 421-424, April, 1963.
6. M. Sadowsky, "Cathode-Ray Tube and Photographic-Film Characteristics Related to Film Recording for Television," J. SMPTE, Vol. 70, pp. 81-84, February, 1961.
7. R. W. Tyler and F. C. Eisen, "Emulsion Sensitivity for the Photography of Cathode Ray Tubes," Journal of the SMPTE, Vol. No. 4, pp. 222-225, April, 1959.
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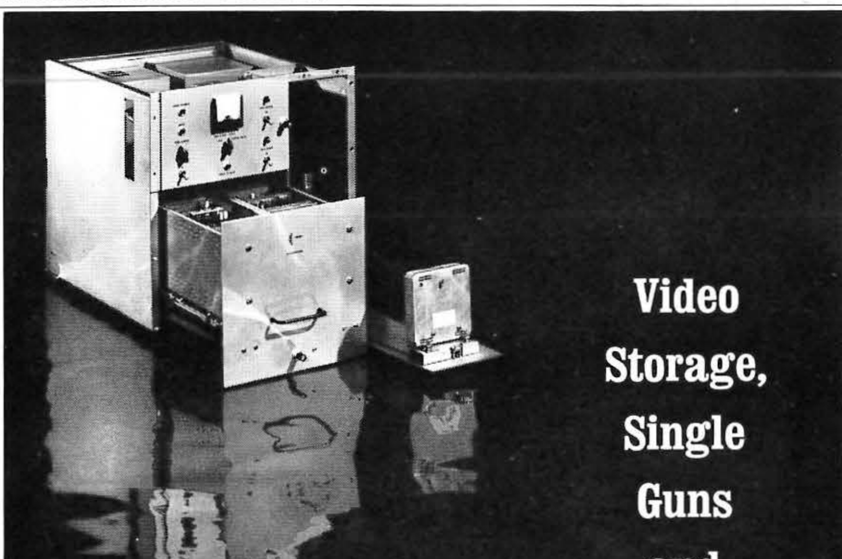
9. W. E. Zunke, "CRT Parameters," Cathode Ray Tube Recording Symposium, 1959, Dayton, Ohio, (Strike & Recording Camera Section, Aerial Recon. Lab., WADC).

This paper was selected by ID's Editorial Advisory Board from those presented at the Second National Symposium on Information Display held in New York City, Oct. 3-4, 1963. Limited quantities of bound volumes of all technical session proceedings for this and other National Symposia are available, free to members, $10 a volume to others. Write: *Information Display*, 160 S. Robertson Blvd., Beverly Hills, Calif.



ID Correspondence

Displays categorized

Editor
Information Display
Dear Sir:

A preliminary effort at categorization and classification of displays is presented in the following material. It is hoped that so modest a beginning will serve to stimulate constructive criticism and thus lead to a more formal and comprehensive treatment.

As a first step in limiting the area of inquiry, it is suggested that information display devices should exclude "emotion evoking" types such as those of the arts and advertising. Also to be excluded are the quasi-emotional types such as newspapers and magazine articles. Thus, attention is here directed towards displays characterized largely by the (visual) presentation of selected information which the viewer(s) must study prior to making some logical decision or other consequent action.

In the following sections, information displays are considered with regard to the following aspects:

Usages (level at which consequent action occurs)
Manner in which display content is controlled
Source of information (i.e., level of data processing before viewing)
Display format
Physical principles (finally a look at hardware)
Physical characteristics (performance parameters)

Usages

1. *Monitoring* — No immediate action expected of the observers.

   Example: United Givers Fund contribution status report.

2. *Decision Making* — Action may be taken immediately through some implementation not tied into the display.

   Example: "Clock watcher" near quitting time.

3. *Control* — A feedback loop or interaction exists between the observers and the results to be displayed.

   Example: Helmsman's compass or automobile speedometer.

Controlled Display

1. *Viewer Controlled* — Normally the number of viewers is limited to one or at most a few.

   Example: Automobile speedometer or weapon control display.

2. *Non-Viewer Controlled* — A monitoring or decision-making device of two basic types:

   a. Briefing officer provides control.
   b. Wired logic or computer programming provides control.

Data Source

1. *Direct* — Transducer, radar receiver, etc.

   Example: Early radar displays operated on "raw" video direct from receiver.

2. *Filtered*—Noise or other extraneous information removed by some sort of filtering process.

   Example: Radar set with Moving Target Indication (MTI) feature.

3. *Mathematical Manipulation*—"Raw" signal is first processed to generate additional information for display.

   Example: Automobile speedometer takes a first derivative as speed. Video processor takes first derivative of radar returns to provide track course and speed.

Format

1. *Tabular* — A display format having alpha-numeric or symbolic content in some regular and unchanging order (normally in rows or columns).

2. *Reference* — Such information is relatively static.

   Example: Map grid lines, geographic outlines.

3. *Graphic* — Analog or digital data, either raw or processed, is displayed in such a manner that a variable (e.g., position, velocity vector, signal strength, etc.) can be inferred as a result of spatial, luminance, or chrominance discrimination.

4. *Categorization* — The more sophisticated display systems include a vast quantity of processed information stored according to some categorization scheme, with only a limited amount of information being selected by category for display at any one time.

5. *Coding* — Displayed information can be coded in many ways: Spatial, luminance, and chrominance discrimination used to present graphical information, with blinking being a form of luminance discrimination.

Letters, numbers, and arbitrary symbols, with further coding in terms of size and orientation, as well as blinking and color variations.

Physical Principles
(A look at the hardware)

1. *Cathode Ray Tube* — CRT phosphor surface is directly viewed by eye.
2. *Projection* — Front and rear projection screens; light source may be CRT, film, lantern slide, etc.
3. *Panel* — Light source is essentially a plane surface.

Examples: Electroluminescent panel, panel of light vanes, light amplifier panel.

4. *True 3-B* – "Crystal Ball" display.
   a. Rotating panel
   b. Oscillating plan
   c. Illuminated interstices
   d. Projecting rods

Physical Characteristics
(Performance parameters)

1. *Size Limitations* – Size of CRT or projection screen, etc.
2. *Brightness* – (More properly known as luminance)
3. *Ambient Limitations* – Darkened room, polarized lighting, broad band blue, etc.
4. *Response Time* – This could mean writing speed, frame time, target updating time.
5. *Resolution* – Ability to distinguish two separate targets is measured in many ways.
6. *Updating Capability*
7. *Hard Copy Capability*
8. *Symbol Limitations*
9. *Color and Halftone Capability*
10. *Storage*

Conclusions

While the foregoing attempt at display categorization and classification is admittedly incomplete, it does serve to shift emphasis from the usual designer's viewpoint to one which regards a display as a black box performing certain functions. Once the desired functions have been determined and performance parameters specified, then one can begin to select suitable hardware. Please note that this material represents the views of the author only, and in releasing it for publication the U.S. Naval Research Laboratory does not necessarily endorse the contents.

H. G. Talmadge, *Head*
Display Techniques Section
U.S. Naval Research Lab.
Washington, D.C.

Whitham statement challenged

In reading the article *The Determination of Display Screen Size and Resolution Perceptual Limitations* by Mr. (Glenn E.) Whitham, *(ID, Vol. 2. No. 4, July/Aug. '65)* he makes the statement, "The equivalent number of line pairs is, of course, one-half the number of elements or raster lines." This statement holds true for a chart or device which actually has line pairs spaced exactly upon the raster. However, if other information than this rather limited item is displayed, resolution is somewhat less than what you might expect. A figure often used is 1.4. I trust that Author Whitham will be a little more specific as to his intentions in the future.

John Shaver, *PE.*
The Bunker-Ramo Corp.
Sierra Vista, Ariz.

Mr. Whitham submitted the following reply, in response to ID's request for his answer to Mr. Shaver's letter.—Ed.

Mr. Shaver is indeed correct in pointing out that the resolution of a line raster along the axis normal to the lines is degraded for arbitrary display subject material to a value less than indicated by consideration only of the line structure. This resolution loss factor has been found by various experimental[1, 2, 4] and theoretical[3] studies to lie in the range of 0.53 to 0.85, with 0.7 a good nominal figure. For obtaining a given value of display resolution the number of lines required is 1/0.7 or 1.4 times the number of desired resolution elements along the axis normal to the lines. This correction factor is commonly known as the Kell factor. Further discussion of this subject was included on page 10 of the paper by Dr. Luxenberg, *Quantitative Measures of Display Characteristics* which just preceeded my paper in the July/August 1965 issue of *Information Display*.

GLENN E. WHITHAM
Staff Engineer
Raytheon Company
Wayland, Mass.

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P.S. The second sentence of the last paragraph on page 17 of my paper should read, "Situation type data displays usually require a resolution of about 1000 to 2000 elements for adequate symbol resolution and differential position discriminability."

Information requested

We have been doing a considerable amount of work in the field of electroluminescent displays, and in the course of this work several product ideas have evolved in the area of moving pointer and moving scale panel indicators.

In order to determine the direction our product development work should take we are trying to collect as much information as possible on desirable characteristics of panel indicators, user preferences and requirements and the potential value of electroluminescent displays in providing a useful product improvement.

Any information that you could supply which would be helpful in this investigation would be greatly appreciated, including suggestions of other possible sources of information.

C. H. WARSHAW
Industrial Products Manager
Huyck Systems Co.
Huntington Station
Long Island, N.Y.

We are presently engaged in a study of the graphic recording field for process control and laboratory usage, and are interested in future trends in this area. Therefore, I would appreciate information that you feel may be helpful to us.

L. P. LANE
Arthur D. Little, Inc.
Cambridge, Mass.

I am very interested in an area of the field in which I find no reference contained in recent issues of your magazine. This is in the requirements, theory and/or construction of display and status boards posted manually from the rear. I have seen several in operation in military installations but have never had the forethought to look into the manufacturing stage.

Could I impose upon your good offices to look among your advertisers and contributors and to furnish me some contacts with technical competence in this particular area. I will be very appreciative of any assistance you can render in this search.

HENRY D. BATEY
Chief, Graphics
United Aircraft Corp. Systems Center
Farmington, Conn.

ID readers who can contribute desired information are urged to communicate directly with the above correspondants — Ed.

SID and Journal helpful

Both the activities of the *Society for Information Display* and the articles in *Information Display* are of great interest to me. Material presented in the Journal has contributed significantly to my knowledge and understanding of data display technology.

It is my responsibility to design and implement the "Total Information System", culminating in display design in the following categories:

1. Large Area Display
2. Small Area Display
3. Desk Top Display

The project in which I am engaged is designed to provide the company with a system in the 1970's that will be suitable to the environment at that time.

JOHN P. THOMPSON
Director of Data Processing
Hoffmann-La Roche, Inc.
Nutley, N.J.

on the move



KELLER GORDON BAILEY

Litton Industries Data Systems Div. has announced appointment of **Ralph Neal** as a director of product support and advanced operations programs, and **Capt. H. Stanwood Foote Jr.**, USN-Ret., has been appointed director of advanced Navy programs for the Div.

Roland Fribourghouse has joined the staff at Ling Electronics Div. of LTV Ling Altec, Anaheim, Calif., in the newly-created position of marketing planning manager.

Librascope Group of General Precision Inc., Glendale, Calif., has appointed **George Bradley** general manager of its Components Division, responsible for the division's engineering, marketing and administrative activities.

Walter W. Smock has been appointed manager of Army programs, Defense System Div., The Bunker-Ramo Corp., Canoga Park, Calif. Smock will be located in the Washington, D.C., office.

R. Joseph Keller has joined the Servo Corporation of America as marketing manager for the firm's Infrared and Electro-Optics Div.

J. Paul Walsh has been named Chairman of the Board, The Matrix Corp., Arlington, Va., to succeed **Harry J. Older,** who will continue to serve the firm as a consultant in scientific and technical areas.

Robert M. Gordon has been appointed manager of applications programming for Raytheon Computer at Santa Ana, Calif., responsible for software specifications, operation of Raytheon Computer's programming library, application and system analysis, liaison with Raytheon Users' Group, and education and training company and customer personnel. Raytheon has also named **Ralph A. Martin** assistant general manager of its Submarine Signal Div., in Rhode Island.

William E. Martin has been appointed to the newly-created post of marketing manager, Electroglas Inc., Menlo Park, Calif. He will assume responsibility for the firm's Electroglas sales network and marketing program.

Robert A. Bailey has been appointed director of marketing of The Scionics Corp., Northridge, Calif.; he was formerly President of Binary Electronics.

Eugene L. Rogers has joined Memorex Corp., Santa Clara, Calif., as director of corporate planning, a new management post responsible for market research, long-term plans, annual operating plans, public relations, product advertising, and legal matters.

Marshall Industries has announced the appointment of **Charles G. Smith** as VP/marketing, for its Electron Products Div.

Appointment of **Robert A. Hall** as VP/Pricing and Information Systems, The Douglas Aircraft Co., has been announced; he is responsible for computer requirements and applications, company management programs, and creating company pricing policy and monitoring cost reduction programs.

Willis J. Nolan has been named general auditor of Electronic Communications Inc., St. Petersburg, Fla., succeeding **Gerald W. Heidisch,** now comptroller for Benson Manufacturing Co., an ECI subsidiary in Kansas City, Mo.

Applied Technology Inc., Palo Alto, Calif., recently named **David B. Leeson** as head of its Solid-State Techniques Section.

Richard P. Castanias has been appointed Director/Houston Operations, for Informatics, Inc., a Sherman Oaks, Calif., firm.

Henry F. Brockschmidt has been named general manager of the newly-formed Astro-Optical Div. of the Perkin-Elmer Corp., based at Costa Mesa, Calif., and responsible also for activities of the recently-acquired Boller & Chivens Inc., in South Pasadena.

Victor A. Babits has been appointed VP/research for Marshall Laboratories, a subsidiary of Marshall Industries.

John R. Hollahan has recently joined the staff of Tracerlab/West, a division of Laboratory for Electronics Inc., Richmond, Calif., as chief scientist in the R&D Dept.

Alan R. Gruber has joined Electro-Optical Systems Inc. as manager of corporate planning; he will be responsible for integration of EOS planning functions with those of Xerox, the parent firm.

D. C. Arnold has been elected Executive VP of Hoffman Electronics Corp., El Monte, Calif., responsible for all operations except Consumer Products Div. and Hoffman Products Corp.

William T. Welsh and **Mike W. Fossier** have been elected VPs of Raytheon Co. **W. Martin Lyford** has been named ntl. sls. mgr. for Raytheon Computer, Santa Ana, Calif., and **Bryant A. Campbell** has joined the engineering staff to manage data equipment engrg.

Paul J. Teich has been named to the newly-created position of mgr. of program support for GE's Heavy Military Electronics Dept. at Syracuse, N.Y.

J. R. Kerry, FM phototube inventor, has joined Sylvania Electric Products Inc. as an advanced development engr. to conduct comparison studies of laser communications techniques.

Charles L. Benesh has been appointed to the new post of special programs mgr., Itek Corp. Government Systems Group.

Systems Engineering Laboratories Inc. has announced the appointment of **Samuel F. Sears** as Florida Area mgr.

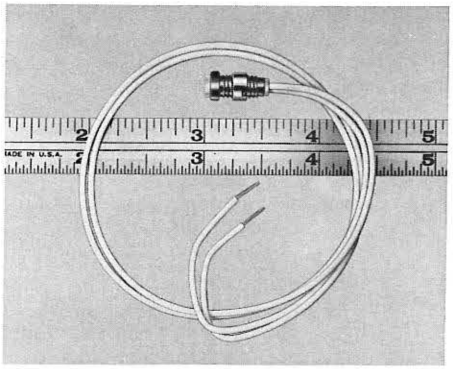
Graham Tyson has been named VP/Operations, for Delta Products Corp.

The Clary Corp. has appointed **Philip C. Davy** mktg. dir. of its Computer Div.

Arthur Carr has been promoted to dir., prod. planning, Computer Control Co. Inc.

ID Products

Subminiature Display Lite



A new SDL Series subminiature display lite with incandescent lamp for use where panel and back panel space is limited or where indications are intentionally small, is now available from Transistor Electronics Corporation, Minneapolis, Minn. This extremely small indicator light mounts on ¾ in. centers horizontally and vertically, and is reportedly ideal for installation above and below toggle switches and to verify settings of relays, solenoids, etc.

The SDL Series uses the extremely rugged T-1 type incandescent lamp with a design life as high as 100,000 hours. The miniature size, full range of lens colors, choice of wire lead or connector hook-up and low heat dissipation makes this compact lite ideal for small information display panels and displays requiring many indicators. Terminals for SDL-A Series are two 0.018 in. diameter gold-plated pins for insertion in female connector supplied with the indicator. SDL-B Series is provided with 6 in. long nylon coated leads stripped 3/16 in.

Circle Reader Service Card No. 56

Pushbutton Switch

International Electro Exchange, Minneapolis, Minn., has announced a new D-series pushbutton switch featuring individual slider units accessible from the front panel, with the slider, pushbutton, return spring, and contacts removable as a unit for cleaning or replacement. Contacts are completely enclosed.

The switches are available with momentary, push-push, latching, or intermixed action mechanisms with from 1 to 10 stations, using round, rectangular, or decorated knobs. Prices depend upon style and quantity.

Circle Reader Service Card No. 57

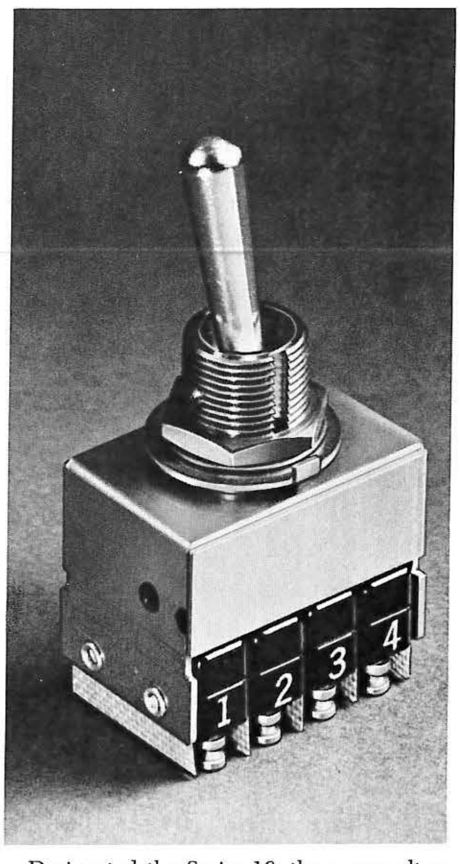
Integrated Logic Decade

The new model BCD8A, by United Computer Co. Inc., Phoenix, Ariz., is an improved logic module complete with in-plane display. It can be used as a decade counter, shift register, and BCD to decimal display. It contains only 13 integrated circuits and 7 silicon controlled rectifiers. Display is ¾ in. high, uses 100,000-hour lamps, and is readable to ever 25 ft. Counting speed is in excess of 3 million counts/second. Other specs include: Size, 1 in. width x 3 in. height x 4 7/8 in. depth; voltage +3.3v @120 ma for logic, 5v ac @300 ma for lamps; weight, 4 ounces.

Circle Reader Service Card No. 58

New Toggle Switch

New toggle switch assemblies featuring a switching mechanism, reputedly so precise that contacts of all switches within a unit are transferred with a 1° segment of the toggle lever 34° travel arc to effect near simultaneous switching of up to four switch modules are now available from Master Specialties Company, Gardena, Calif.



Designated the Series 16, these new alternate action, maintained-maintained switches also feature a detent force requirement that precludes accidental switching, and a positive full-travel lever action that prohibits "tease" action or operation. Once the lever has been started on its travel arc, the switch mechanism carries it through to the opposite position with a positive, irreversible force. Switches are available in 2PDT or 4PDT types.

Circle Reader Service Card No. 59

Flat-Faced CRT

A new 12-in. flat-faced cathode-ray tube, which has two rear-viewing windows for symbol presentation, photographic recording, or image projection, is now available from the Westinghouse Electronic Tube Div. The tube, designated as the WX-30211, uses optical-quality rear windows which are flat and parallel to the faceplate. These permit the simultaneous performance of three functions: Normal cathode-ray-tube display, optical projection of information on the screen from the rear, and photographic recording of the composite display from the rear. Both CRT display and optical projection are visible to the operator from the front of the tube.

In addition to the primary 36-degree magnetic deflection, the tube is equipped with auxiliary electrostatic deflection plates which enable the operator to add symbols to the display. The WX-30211 has a screen diameter of 10¾ in. and operates at an anode voltage of 12,000 volts. It can be supplied in most of the standard JEDEC phosphors.

Circle Reader Service Card No. 60

Digital Plotter

Discon Corp., Ft. Lauderdale, Fla., is marketing what it describes as a truly digital plotter. The Discon product features absolute position sensing by means of photoelectric readers scanning 19-track linear precision engraved binary coded scales on each axis.

The system reputedly eliminates sources of error common to incremental plotters. It accepts manual, tape, and card inputs. Life time accuracy is within .002 inches, and repeatability within .001 inches. It has an eight-character ten-symbol print head.

Circle Reader Service Card No. 61

RF Shields

Controls Co. of America, Melrose Park, Ill., has developed a special indicator light and switch shields to prevent radio frequency interference leaks in pushbutton switches and indicator lights. The front-of-panel cutouts required for mounting switches, indicator lights, and other components to the panel is the source of much of the RFI leakage problem. Even after such components are attached to the panel, mechanical and electrical discontinuities still exist and allow RFI to pass through, thus producing undesirable stray signals in surrounding equipment.

To eliminate these leaks, CCA designed a metal mesh shield inside the plastic indicator lens, as a means of blocking RFI signals. In sealed indicator light models, this shield is bonded to the indicator case, and in removable-lens models, the shield is connected to the case by a special conductive gasket. The cadmium-plated brass case completes the path to ground.

Circle Reader Service Card No. 62

Readout with Decimal

NL-809, a new rectangular readout tube with decimal point, is being introduced by National Electronics Inc., Geneva, Ill. It is a long-life neon-glow tube displaying 0.6 in.-high characters 0-9 and a decimal point.

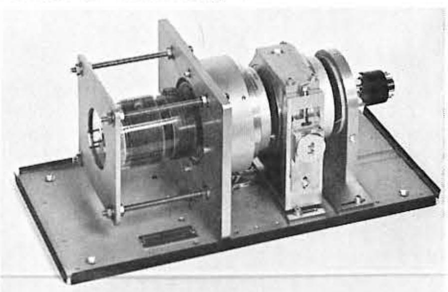
The decimal point is an integral part of the tube. Rectangular shape and decimal point permit close spacing of characters with the decimal point correctly located with respect to the numerals. Use of two or more NL-809 tubes permits switching the decimal point without wide spacing of numerals.

NL-809 has an ionization of 170v dc; requiring a minimum supply voltage of 170v dc. Higher anode voltage may be used with proper resistor. Anode current ranges from 1.5 to 3.0 ma dc, with a typical value of 2.5.

Circle Reader Service Card No. 63

Standard Tube Mounts

Beta Instrument Corp., Newton Upper Falls, Mass., announces the availability of a variety of versatile coil and tube mounts. Several types are designed for use with CRT systems. Others are intended to achieve optimum performance with the complex recording storage tube, an "electrical-in, electrical-out" device often used in scan-conversion applications.



These flexible assemblies permit precise variation of position and arrangement of deflection and focus coils used with CRT and storage tubes, Beta claims. A typical result of the mounts' flexible design is that beam alignment and "read" and "write" registration accuracy are maximized and tube shading minimized. All assemblies are constructed in the form of an optical bench. The various components rest on a machine-channeled tracking base. A number of coil mounts can be placed in-line.

Circle Reader Service Card No. 64

Incandescent Indicators

Dialight Corp., Brooklyn, N.Y., has available a new catalog of its one-terminal subminiature incandescent indicator lights. This catalog present a complete line of one-terminal lights for use on grounded circuits — that meet or exceed the environmental and operational requirements of MIL-L-7806 and MIL-L-3661.

Complete specifications and data are given for assemblies that: Accommodate a T-1-¾ Incandescent bulb with midget flange base in a range of voltages from 1.35 to 28V; mount in a 13/32 in. or 15/32 in. clearance hole; offer a wide choice of lens cap shapes, finishes and colors; and provide for use of hot-stamped or engraved legends. It contains lamp data, illustrations, drawings and catalog number charts to facilitate selection of the required indicator lights.

Circle Reader Service Card No. 65

Sawtooth Signal Generator

CELCO, Mahawah, N.J., has announced immediate availability of their new SG1 sawtooth signal generator for CRT displays. Features are small size, 0.22 cu. ft. and 5.0 lb.; overlapping ranges from 20 μsec to 100 msec; linear ramps with retrace less than 10% of sweep period; internal or external sync; any TV raster may be produced by two generators; with off-the-shelf delivery.

Circle Reader Service Card No. 66

Silicon Rectifier

General Electric has announced automation of the manufacture of a solid-state component called a silicon controlled rectifier (SCR), with attendant cost reduction. In large quantities, the units will sell in the 35- to 50-cent range to manufacturers of consumer and other products. When G.E. first introduced the SCR eight years ago, it sold for about $300. The price for the new consumer unit is about one-half that of the lowest-cost SCR now available.

Solid-state control of electrical equipment enables the user to dial speed, light and heat in the same way he has always dialed the exact level of sound he desired on his radio or TV set. G.E. believes the new SCR will open the doors to a host of consumer products that previously were impractical because of the high cost of semiconductors.

Circle Reader Service Card No. 67

Digital Clock

Parabam Inc., Hawthorne, Calif., has introduced a new all-silicon logic, solid-state digital clock which the firm claims presents a price breakthrough in the digital field. Especially designed for on-line use in data logging, process control and computer systems, it provides time-of-day, elapsed time, or countdown time in the form of digital logic and/or digital display.

The new Series D clock is a precision time source which features front-panel access, all-silicon logic, plug-in logic cards, BCD or decimal coded logic output for use with recording devices. Options include BCD, Nixie or projection-type digital displays.

Circle Reader Service Card No. 68

Polarization Rotator

Spectra-Physics, Mountain View, Calif., is offering a new polarization rotator for gas lasers, which provides control of the polarization vector of the output of helium-neon gas lasers operating at 6328 Å. The rotator attaches directly to Spectra-Physics lasers and may be adapted to other helium-neon lasers, or to optical benches, through use of a special mounting plate.

The device allows the plane of polarization of the laser output to be rotated through an accurately calibrated angle with respect to a predetermined reference. It consists of a half-wave retardation plate and a compensating plate mounted to a graduated circle which is indexed against a vernier scale. Extinction ratio is better than 1 part in 10,000. Aperture is 1 cm. Angular difference between axes of input and output beams is less than 0.2 milliradiam. Accuracy of rotation is ± 0.2°.

Circle Reader Service Card No. 69

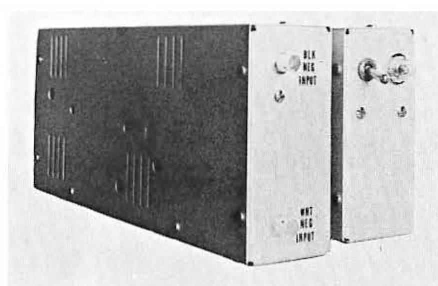
5-Display 17-In. CRT

Telonic Industries Inc., Beech Grove, Ind., is offering an eight-page brochure on its new Skan-A-Scope display unit. This unit represents a state-of-the-art advance, according to the manufacturer, because of its ability to simultaneously show five displays on a 17-in. CRT, in a unit containing its own power supply.

The illustrated brochure takes the reader through a step-by-step discussion of the test set-up and analysis of a simple bandpass filter. To show the versatility of the Telonic Skan-A-Scope, the catalog also describes how the unit is used in the test and alignment of TV tuners, alignment of concentric tuned circuits, concentric techniques in production alignment, as a multi-channel monitor, and the test and alignment of a parametric amplifier. Electrical specifications and dimension are also given.

Circle Reader Service Card No. 70

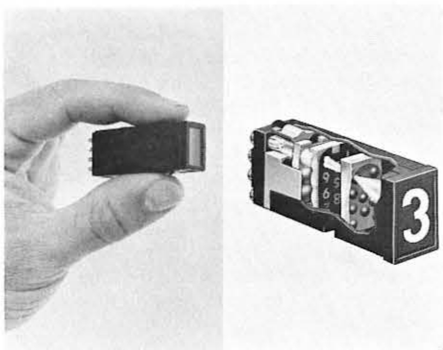
75-V Video Amplifier



The new ITI Electronics' video amplifier, Model IT-284A, provides a 50% increase in output voltage over the original design, the Model IT-284. The preceding device has already been widely accepted for high resolution video applications. The response of the Model IT-284A is a maximum 3 db down at 14 mc/s providing 1100-line resolution capability. A peak-to-peak input of 0.25 volts will provide the 75-volt output. The predecessor unit, Model IT-284, will continue to be available for those applications where its 1600-line capability is required. Both devices, the Model IT-284 and the Model IT284A, are all solid state. Both are available from stock subject to prior sale or thirty days ARO.

Circle Reader Service Card No. 71

Rear-Projection Readout



Industrial Electronic Engineers Inc., Van Nuys, Calif., has introduced its new Series 340 microminiature rear-projection readout – reputedly the smallest rear-projection readout in the world. This miniaturized projection theatre is only ¾ in. high x ½ in. wide x 2 in. deep. Although it is microminiature in size, it is capable of projecting a display character of ⅜ in. high with a viewing distance of 20 feet.

The unit is made up of 11 incandescent lamps, two 11-lens honeycombs, and 11-message film, another honeycomb lens and a viewing screen. The 11-message displays may be rear-projected onto the viewing screen individually or in combination by lighting the corresponding lamp or lamps. Since the messages are on film, the unit can be set up to display anything that is photographically reproducible, such as numbers, letters, words, multi-words, symbols, special characters, colors and even half-tone pictures.

Circle Reader Service Card No. 72

Temperature Stickers

William Wahl Corp., Los Angeles, is offering a Temp-Plate (Reg.) line of direct-reading temperature indicating decals. The decals have a temperature reaction time of less than 1 sec. with $\pm 1\%$ accuracy. Maximum thickness for all models is 0.006 in. Model shown is one of many available in stock, others can be designed as needed.

Temp-Plates contain heat-sensitive elements which are hermetically sealed in laminated, high-temperature-resistant plastic. They have excellent adhesive quality for positive, easy mounting to almost any clean, dry surface. No activator is required for the adhesive, and the plates resist exposure to solvents, fuels, grease, oil, water, steam and reducing atmospheres. They can be immersed in hot liquids and will not crack, tear, wrinkle or lose indicating sensitivity. Stated temps are indicated by an irreversible change from pastel to solid black. The Temp-Plates are useful wherever temperature is an important consideration.

Circle Reader Service Card No. 73

Optical Bench

The Netek lens test system measures modulation transfer functions of optics through a carefully selected combination of light source, sign wave pattern generator, collimator, test bench, and recorder. The unit is completely automatic, being internally programmed to produce a continuous sequence of spatial frequencies and to measure and plot the MTF Curve. It is produced by TRAID Corp., Glendale, Calif.

The instrument produces lens modulation transfer function accurate to 2% over a range of resolution from 2.5 to 200 lines per millimeter, and from any point in the field of a lens from 0 degrees to 45 degrees. Focal lengths from 0.5 to 20 inches with apertures from F/1 to F/100 may be measured. The unit can also be readily adapted to record MTF at spatial frequencies much higher than 200 lines per millimeter.

Circle Reader Service Card No. 74

Digital Display

The DIDS-400, a table model digital information display system for rapid retrieval, editing, and composing of computer stored informtaion has been introduced by Raytheon Company's Equipment Div. The new system eliminates card punching, batch totaling and other intermediate steps by providing a direct interface between computer and operator.

Through the use of an alphanumeric keyboard, information in a random access memory can be recalled almost instantaneously for flicker-free presentation on a 6 x 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. 75

Message Annunciator

Advanced Research Products, Glendale, Calif., produces miniature transistorized message annunciators, called Bloc-Lite, designed for use in digital systems employing either P or N logic of any level. They measure 0.5 by 0.75 by 0.725 in. Blank lenses are available for laboratory use.

Features include ½ by ¾ in. message area, 20 microamp control current requirement guaranteeing high sensitivity, a memory mode, voltage-sensitive triggered mode, lamp life rated in excess of 100,000 hours, a variety of colors, 500,000 ohms input resistance, a light weight of only 3.5 grams, and 12 v standard (6 v available) lamp supply.

Circle Reader Service Card No. 76

Precision Microteleviser

A new precision Microteleviser with capability for remote viewing and continuous focus magnification of microfilm data has been developed by GPL Div., General Precision Inc. Using TV, microfilm may be viewed at distances of several feet or several miles, for use in both airborne and fixed station environments. The Microteleviser accepts any film image, magnifies it to the desired size, and (when coupled with an automatic microfilm retrieval system) allows a remote operator to select a microfilmed document and view any area at the magnification desired.

Typical applications include: detailed examination of aerial photos, photo interpretation, document enlargement, reconnaissance sensor data analysis, and examination of any data such as maps, charts and drawings. Features include: remote viewing of any film images, simple "joy stick" operation, rapid area positioning, sharp image, uniform brightness, multiple station viewing, integration with automatic data retrieval equipment. Viewing area is 3-in. x 2½-in. at low magnification. The unit measures approximately 21 in. deep by 10 in. long by 7 in. high and weighs 35 lbs. plus weight of the camera.

Circle Reader Service Card No. 77

Segmented Readout

MB Associates, Phila., Penna., has announced a new segmented-type digital readout (model NSDFS) which the firm states will not display false digits due to lamp failures. The fail-safe feature is provided by circuitry which causes the bottom and lower right segments to turn off in the event of a lamp failure in any segment. Without these two segments lit it is impossible for the segments remaining lit to be interpreted as a normal digit.

Integrally mounted decoder-drivers accept BCD signals and are available for either positive or negative logic levels. The decoder-drivers have diode coupled inputs and have low current requirements. The readout, designed for behind-the-panel mounting, requires no special hardware or bezels. Both the display and the decoder-drivers operate from full-wave rectified line voltage with no filtering or regulation required.

Circle Reader Service Card No. 78

Trace Recorder

A new 70mm strip film trace recording camera has been developed for use by the oil well logging industry. Its developers, General Atronics Corp., Phila., Penna., designers and manufacturers of trace recording cameras and field portable oscilloscopes, said the new camera is especially designed for ease and reliability in photo recording phenomena from "downhole," as displayed on a CRT.

The new camera, Model SM170-OL, features easily variable ratios of film transport to hole depth; external shaft for selsyn drive; and 100 foot film capacity with takeup and supply reels in one removable magazine. Compactly designed to conserve aisle space, the SM170-OL is available with mountings to fit both 3 in. and 5 in. CRT screens. Direct viewing of the displayed phenomena during the photographic process is achieved through use of a dichroic mirror in the camera.

Circle Reader Service Card No. 79

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

benson-lehner *corp.*
14761 CALIFA STREET
VAN NUYS, CALIFORNIA
781-7100

Demonstrations Now Being Conducted at Van Nuys

Versatile-Display Console

Tasker Instruments Corp. has announced the development of a versatile-display computer input/output communications console combining multiple input controls, visual display of entire messages before transmission, and compatibility with a broad range of data processing programs.

Designed to communicate with an IBM 7288, the Tasker Model 544 console can be easily programmed to communicate with other systems. Key factors in its multisystem compatibility include modular construction and the availability of proven circuit designs. Visual display capability ranges from data presentation before message transmission to display of data-generated by external equipment in the data processing system.

Circle Reader Service Card No. 80

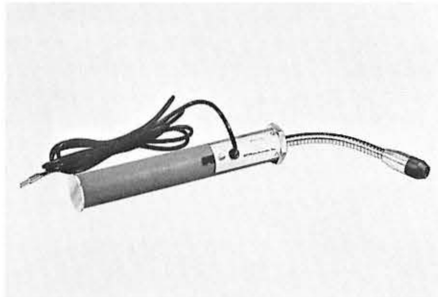
Synchronous Amplifier

A new synchronous amplifier, by Acton Laboratories Inc., Acton, Mass., chops output signals in phase with the input to provide especially high performance and high signal-to-noise ratios working from very low level signal sources. Model 510 is particularly applicable for amplifying interrupted information signals, such as from a chopped light or infrared source, Acton claims. Investigation of transmission and reflection characteristics of materials and spectrometry are cited as specific areas of usefulness.

Mechanically chopped radiation (typically from an incandescent source) is passed through or reflected from a material under study and is detected. The low level signal is then amplified, and is synchronously demodulated by a separately chopped reference source. Output is smoothed by adjustable time constant circuitry, over a 200-second range. The Model 510 synchronous amplifier is solid state throughout, and maintains accuracy and stability of better than 0.1%.

Circle Reader Service Card No. 81

Optical Tachometer



OPTOmechanisms Inc., Plainview, L.I., N.Y., is producing a new portable, transistorized optical tachometer which provides extremely accurate rotation and vibration measurements for all types of rotating equipment. The self-contained unit, equipped with a flexible gooseneck, operates on common flashlight D cells, and can be used in conjunction with the user's own oscilloscope, or with an optional OPTOmechanisms meter with a 7-range scale from 10 cps to 100 kc. Unlike conventional phototypes, only one readout instrument is required. Accuracy of ±2% of full scale is realized.

Circle Reader Service Card No. 82

EL Lenses

Staco Inc., Costa Mesa, Calif., has announced a series of electroluminescent lenses available on select lines of the firm's pushbutton switches. The new EL application was developed by Staco in conjunction with Sylvania Electric Products Inc., manufacturer of EL material. Staco lists the following advantages of the EL lenses over conventional lenses and incandescent lamps: even light distribution, lower power requirements, greatly increased life of EL lenses.

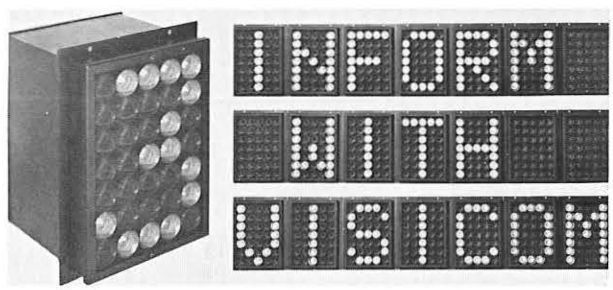
Power required for a Staco EL lens is only 0.0065 watt – less than 1/170 that of a T 1¾ lamp. In multiple switch installations, power supply size and cost can be significantly reduced through the use of EL lenses. Life expectancy of the new EL lens is over 6000 hours to half brightness. There is no surge current, and life is unaffected by cycling on and off. Operating temperature range is −100° to +160°F. Cost of the EL lenses is less than that of conventional lenses and incandescent lamps.

Circle Reader Service Card No. 83

Magnetic Shielding

Data sheet 179, just published, contains technical data and illustration of a new system of providing a low-level magnetic environment in any enclosed volume containing magnetically sensitive components and in laboratory or quality control work. It is available without cost from Magnetic Shield Div., Perfection Mica Co., 1322 No. Elston Ave., Chicago, Illinois 60622, phone (312) 384-2122. Direct inquiries to Glenn Powers, pres.

Circle Reader Service Card No. 84



Multiplier Phototubes

A completely new and revised 92-page catalog of Fairchild Du Mont multiplier phototubes has been printed and is available on request at a price of $1 per copy. It not only gives complete specifications and characteristics of the standard line of Du Mont photomultipliers, but in addition the catalog covers the theory of spectral emission, response curves, operational theory, dark current and signal-to-noise ratio, and selection guides.

The catalog deals with applications, nuclear radiation detection, flying spot scanner use, and the detection of light from miscellaneous sources.

Circle Reader Service Card No. 85

10-Station Keyboard

To meet current demands of the industry, Pendar recently has developed and is marketing now a new ten-station keyboard featuring three standard sizes of keyboard matrix: Petite, Lady-ette or Master. They are equipped with concave lenses, providing fingertip control.

The new Pendar product comes in one complete unit that can be mounted from the front without special tools. Installation is accomplished in one simple, fast, easy operation. They have been tested for millions of cycles, and meet all mil-spec requirements. Pendar, Inc., Coeur d'Alene, Ida., the manufacturers, are also supplying the keyboard or switch matrix to custom specifications.

Circle Reader Service Card No. 86

Motorized Computer /Trainer

A new, motorized Model 601 Computer-Trainer for teaching computer basics, programming, Boolean algebra, number theory and binary logic is now available from Arkay International Inc., Brooklyn. N.Y. The Model 601 is designed to enable the many industrial training courses and programs to better meet the requirement for trained personnel in design, programming and servicing of computers. It contains a decimal-to-binary encoder section for converting numbers into the binary system, and a five-address/four-digit scratch pad memory storage for containing and retaining binary-coded data or instruction, a binary add/subtract module for actual computation including multiplication and division by binary 2, a motorized one-step-at-a-time drum program section which brings each computer direction into a control panel read-out for manual operation, and an output section which converts the binary answer into a decimal number once more.

Featuring a grounded 3-prong line cord for maximum safety together with low-voltage operation and simple-to-follow-wiring, the student may operate the Computer-Trainer from the Control Panel while following his steps on the back-of-panel wiring. Each section is a complete, separate subunit and may be taught as a separate operation section in any given lesson.

Circle Reader Service Card No. 87

Display Design Notes

Photomechanisms Inc., Huntington Station, Long Island, N.Y., is producing a series of interesting, general technical design notes on data and display systems. The series is entitled *Hard Copy*. Latest in the series (No. 4) is entitled, "Design cf Photographic Data Systems", and covers the areas of high-volume data recording, rapid access at moderate recording rates, readout of data, PPI radar recording, command decision display, side-looking radar or facsimile, and computer output data recording.

Schematics are included for hard copy from computer output, side-looking radar, and command display or PPI radar. The firm specializes in solving data handling problems with non-conventional photographic processing.

Circle Reader Service Card No. 88

Glo-Dot Pilot Lights

Industrial Devices Inc., Edgewater, N.J., has released a new 4-pge. catalog which describes the firm's complete line of miniature "Glo-Dot" pilot lights. The neon pilot lights are available in seven lens shapes and four body sizes, to meet precise requirements. They can be speednut mounted in a 5/16-in. hole. The line incorporates insulated leads and built-in strain relief; lower cost bare thread models are also available. The new catalog describes all models and details all possible combinations of lens shapes, body sizes, lamps, and resistors.

Circle Reader Service Card No. 89

Vidicon Test Jig

Production of a new test jig (CTJ-1) for vidicon television cameras has been announced by Cohu Electronics Inc., Kin Tel Div., San Diego. Simplification of maintenance and setup is achieved by providing reliable, reproducible and standardized test conditions. The test jig is designed for rigidly mounting and properly positioning the TV camera in front of lighted test patterns.

An unusual feature of the CTJ-1 is that both the linearity and resolution test patterns are an integral part of the jig. These standard EIA-type glass patterns are mounted in frames hinged to each side of the light box and swing into position when in use. Although designed primarily as a universal jig for all Cohu television cameras, the CTJ-1 will accommodate most makes of closed-circuit vidicon cameras.

Circle Reader Service Card No. 90

Image Expander

Ednalite Research Corp., Peekskill, N.Y., has published a new data sheet describing the firm's stereoramic oscilloscope CRT image expander which adds valuable new functions to the 5-in. CRT image oscilloscope.

The technical data sheet illustrates how oscilloscope displays can be enhanced markedly using the Image Expander, an optically corrected accessory instrument which provides maximum visual amplification and resolution without distortion. Clamp-on mount and swivel mount models are pictured. Also shown is Ednalite's polarizing glare shield accessory, designed to eliminate extraneous light from the viewing area.

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Circle Reader Service Card No. 50

ID Advertisers

Index — Sept./Oct., 1965

Kollsman introduces datakrome™: the first simultaneous four-color data display projector

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