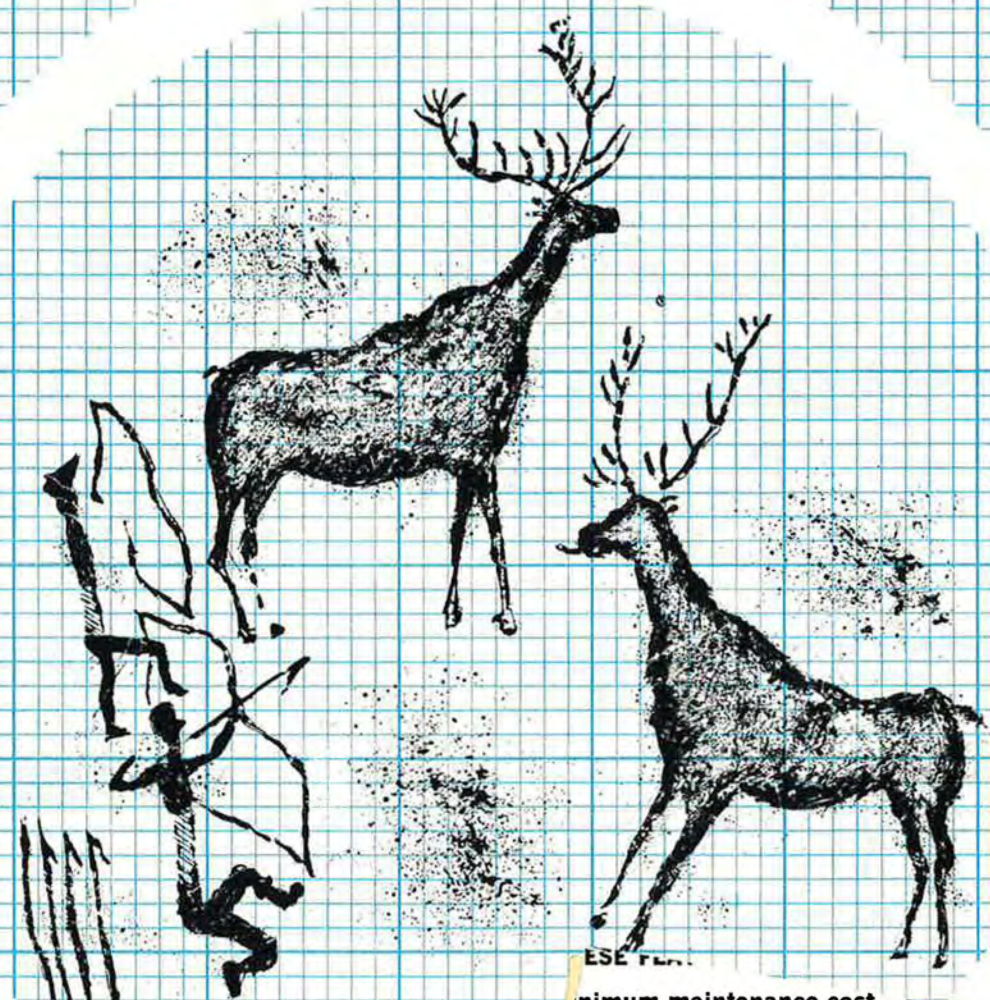
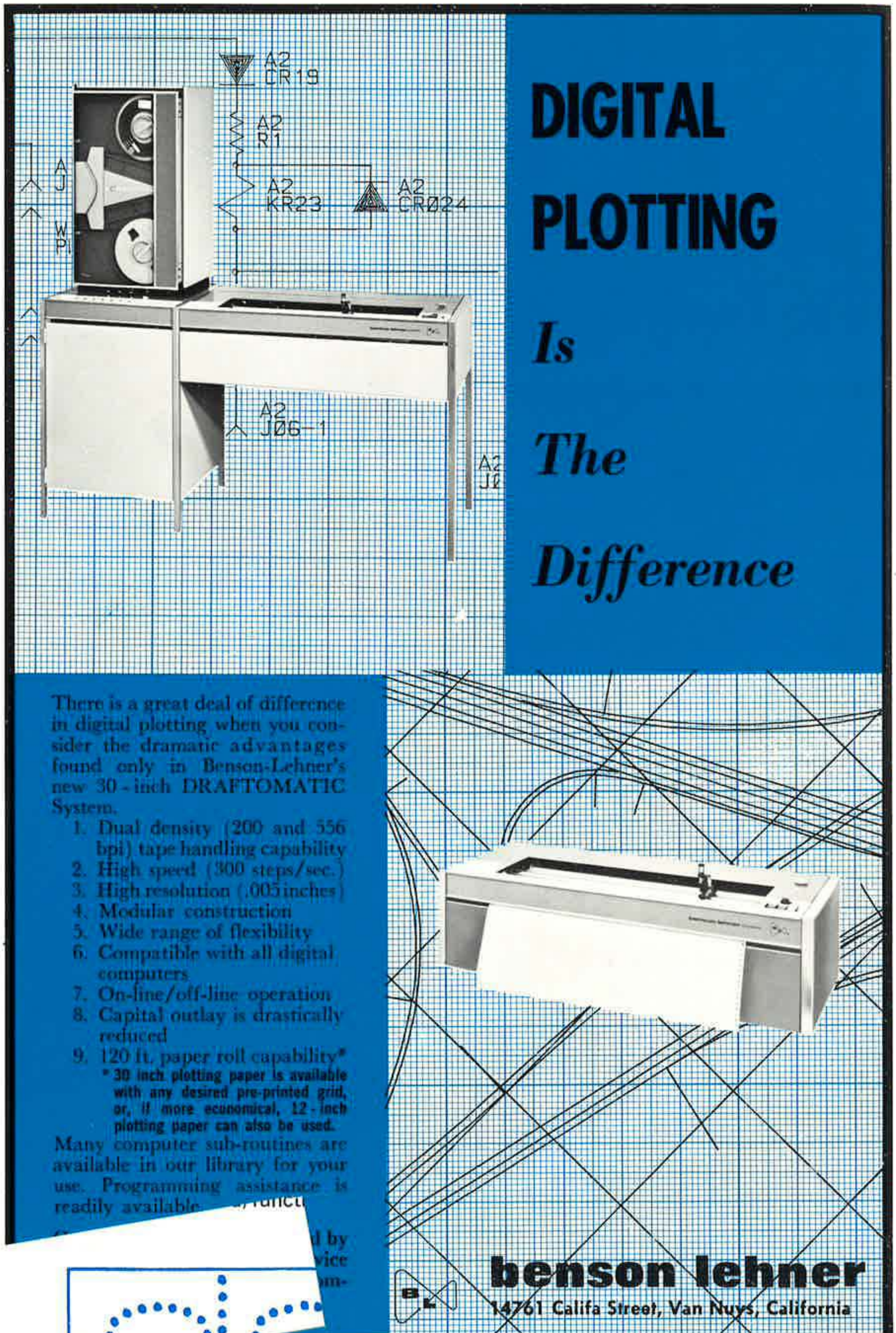
Volume 2 • Number 2 • March/April, 1965

Information Display

Journal of the Society for Information Display

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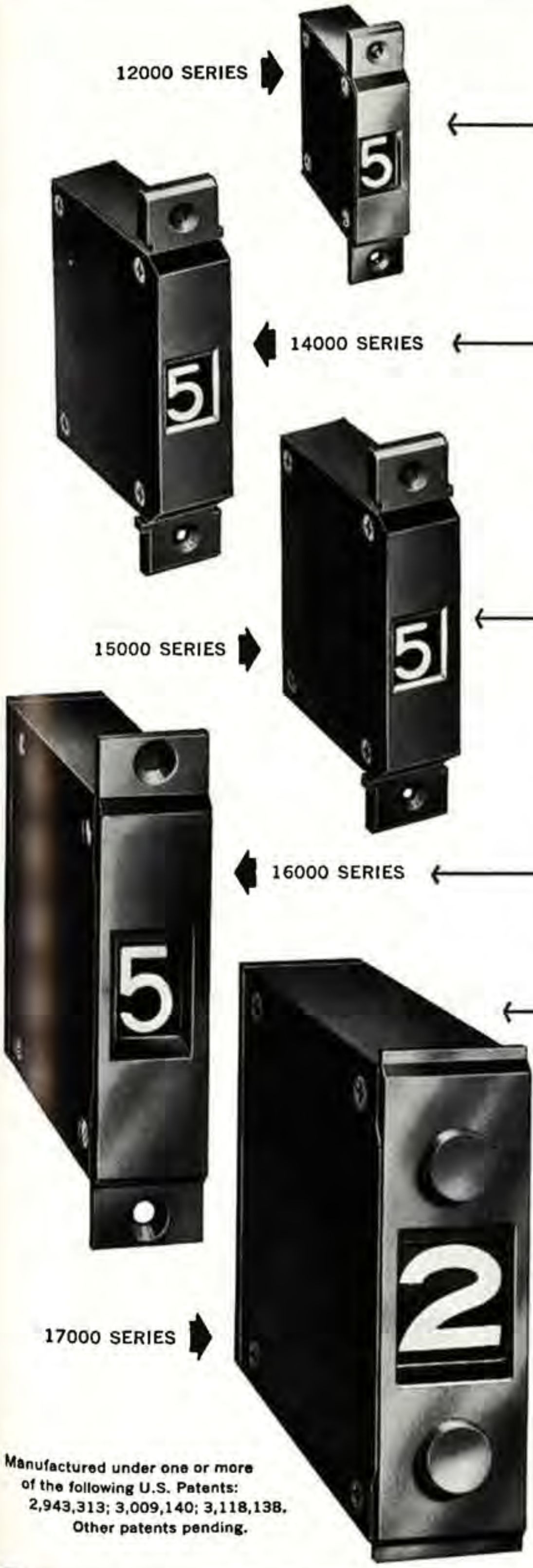

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EDITORS & PUBLISHERS................ Hal Spector
Martin H. Waldman
FEATURE EDITOR........................ Robert Mount
NEWS EDITOR................................ Lew Darling
ART DIRECTOR .... John Sandlin
PRODUCTION MANAGER.............. Betty Kunin
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Information Display

Journal of the Society for Information Display

ARTICLES

Part I of a three part article on scan conversion. Theory underlying the two types of electronic scan converter tubes, single and dual gun, and an analysis of characteristics and application techniques pertaining to specific tubes currently available.

Feasibility of using a crystalline element which exhibits the "Electro-optic Effect" as the control layer of a light valve projection display system, the results of a study conducted at Rome Air Development Center.

FEATURES

Here the earliest form of graphic display, a 10,000-year-old pictograph from the Cueva de la Vieja (Cave of Antiquity), Spain, is superimposed within symbolic CRT circle on graph-paper background by *Information Display* artist Howard Goldstein, depicting ancient-to-modern displays.

IN YOUR OPINION, HOW WELL DOES THIS CHECK LIST FOR SELECTING READOUTS STACK UP?

☐ **A READOUT MUST BE READABLE.** No ifs or buts about it. Legible presentation of the message is a readout's only mission.

☐ **IT MUST PROVIDE DISPLAY VERSATILITY.** You should be able to select the message medium best suited to your needs: letters, numbers, words, colors, symbols, or a combination of any of these.

☐ **WIDE VIEWING ANGLES.** The operator can't be chained to his post. A good readout should be readable from fairly wide angles to permit freedom of movement.

☐ **PROPER BRIGHTNESS / CONTRAST RATIO.** The two should work together to assure crisp, legible display under varying ambient light conditions, without eye fatigue.

☐ **DISPLAY CHARACTERS MUST BE FAIL-SAFE.** A readout using shared character segments can give a wrong reading if one of the segments fails. It's much safer when the readout indicates trouble by showing no message at all.

☐ **VARIETY OF CHARACTER SIZES.** Why marry your designs to one or two sizes? The readout you select should provide the height character you require, from 5/16" to 3⅜"

☐ ______________________
(You add one)

☐ ______________________
(One more)

If this seems like a reasonable list of reasons to specify just about any readout, you'll be interested in an equally reasonable list of reasons to specify IEE readouts.

HERE ARE AT LEAST TEN GOOD REASONS TO SPECIFY IEE REAR-PROJECTION READOUTS. TAKE YOUR PICK.

GOOD REASON 1: SINGLE-PLANE PRESENTATION

IEE rear-projection readouts display the required messages, one at a time, on a non-glare viewing screen. Only the message that's "on" is visible for visual crispness and easy readability.

GOOD REASON 2: INFINITE DISPLAY VERSATILITY

You name it, we'll display it. Because IEE readouts are miniature projectors using lights, lenses, film, and a screen, they can display literally anything that can be put on film. And, *each* readout has 12 message positions which may be used singly or in any combination to display letters, words, numbers, colors, symbols.

GOOD REASON 3: MOST READABLE CHARACTERS

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GOOD REASON 4: BALANCED RATIO OF BRIGHTNESS TO CONTRAST

It's not enough to display bright characters! Excessive brightness in itself leads to eye strain. On the other hand, a character of comfortable brightness displayed against a dark, glare-free screen is actually more readable than a glaring filament against an illuminated background.

GOOD REASON 5: WIDE-ANGLE READABILITY

The combination of single-plane projection, flat viewing screen, proper ratio of brightness to contrast and big, bold characters offers wide-angle readability and longer viewing distances.

GOOD REASON 6: CLARITY IN HIGH AMBIENT LIGHT

IEE readouts remain readable in brightly lighted surroundings, with no filters, screens, or shades required. Equally important, our readouts may be dimmed in dark areas for greater eye comfort.

GOOD REASON 7: FAIL-SAFE CHARACTERS

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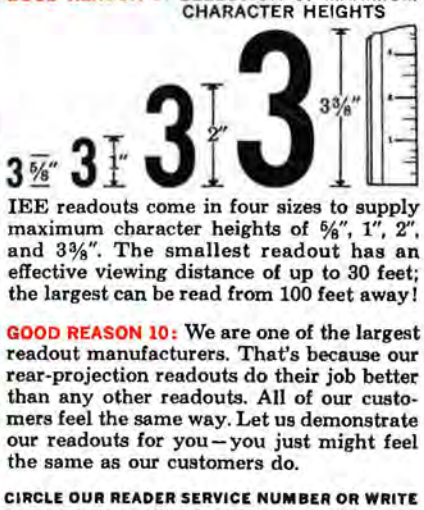
GOOD REASON 8: EASY TO OPERATE

IEE readouts are available with voltage requirements from 6 to 28 volts, depending on lamps specified. Operate from straight decimal input or driver/decoders with low current levels are available to accept conventional binary codes. Additional internal translation is not required.

GOOD REASON 9: SELECTION OF MAXIMUM CHARACTER HEIGHTS



IEE readouts come in four sizes to supply maximum character heights of ⅝", 1", 2", and 3⅜". The smallest readout has an effective viewing distance of up to 30 feet; the largest can be read from 100 feet away!

GOOD REASON 10: We are one of the largest readout manufacturers. That's because our rear-projection readouts do their job better than any other readouts. All of our customers feel the same way. Let us demonstrate our readouts for you—you just might feel the same as our customers do.

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The Hidden Objective

As I wandered through the halls of the beautiful Miramar Hotel and chatted with old friends and acquaintances during the Fifth National Symposium of the *Society for Information Display,* an idea began to germinate in my head. As I studied the extremely interesting exhibits and listened to the very professional papers given in the technical sessions, the idea took form and I realized that:

SID is waging war against paper.

The stated objectives of *SID* include the encouragement of understanding, use and application of information displays. There is little question that the field is recognized on its own merits, and that it is growing rapidly. I don't think, however, that it is recognized that along with the stated objective of encouragement of information display comes the hidden objective to wage war against paper.

Why do we want to fight paper? There is too much of it around and it is growing too rapidly. This editorial, alone, will generate and consume many pounds of paper in notes, drafts, carbon copies, proofs, masters and finally a page in this Journal. For what purpose? To present to you, the reader, information in a form which you can easily read and understand. This is but a trifling example of the millions of pieces of paper used but for one purpose: to display intelligible information to the observer. It is this kind of paper against which *SID* is waging war.

Historically, the human voice was the first and for a while, the only method of presenting (displaying) information to the listener (observer). Later, primitive pictures were drawn on cave walls and were used to tell a story, notably upgrading the information transfer process. Simple, then increasingly complex symbols were developed to speed up and improve the display of information to the observer. Finally, whole families of symbols and characters were put together in alphabets and used to form complete written languages. Other than handwriting, the printing of these language forms has been about the only way known to present information clearly, quickly and with a minimum of mechanical and interpretive errors. This has been sufficient in the past. But today, the modern data processing system handles vast amounts of data in the blink of an eye. Computers can calculate, compare, correlate, store, retrieve, make decisions and provide volumes of data orders of magnitude faster than we can use them. So we have put the old trustworthy printer to work to "unload" the computer, and to prepare data in readable form on documents which we can somehow locate later.

As a result, the largest single computer output medium is still the printed page. The rapid increase in the printing load has created massive problems which have no real solutions in themselves. These include: 1) The printer oriented data processing system user must continue buying expendable materials as long as he uses the printing equipment. As his load goes up so does the cost. 2) He must provide a storage system. He may use filing cabinets, binders, notebooks, logs, books and reports. But he must store his output. In many cases, the space needed for storage of records is greater than that necessary for the job or item to which the records pertain. 3) Retrieval techniques must be employed to get at the required data. There are a raft of fancy filing systems in use and some attempts have been made to automate document retrieval systems, but by and large the systems in use today are manual and as such are slow and costly. 4) The information is obsolete. In this modern world of rapidly changing data, a document is often out of date by the time it is printed.

Now, however, with the help of *SID*, more and more attention is being paid to the replacement of printed documents with volatile data presentation systems, i.e., information displays. A variety of techniques exist to present these displays, and thanks to the development of mass random storage devices, they can be effectively computer operated.

These developments make it possible to begin the war against paper and the associated problems of paper handling: 1) A data system user who emphasizes electronic storage and retrieval techniques with information displays can count on decreasing expendable costs. 2) His electronic data processing system can provide automatic storage. As time progresses, these storage devices will shrink in both size and cost which is just the opposite of the paper storage trend. 3) His retrieval problems will nearly disappear. Properly programmed, his computer can provide the data he needs, when he needs it, in the form he needs it, and without extraneous information. 4) He will obtain real-time up to date information. Since his computer is controlling the storage system, any new data coming into the computer is immediately available to the display.

These arguments are not meant to be anti-printing or anti-recording. In all seriousness, they are meant to bring to the forefront for discussion a growing problem which faces all of us, the rapidly increasing use and storage of paper. An extrapolation of the present trend will show a "paper explosion" which may compete with the more familiar "population explosion". As all the information in the universe expands and as data processing equipment is developed which can handle more data faster, the problems associated with the printed record will increase accordingly unless the volatile information display concept catches up and overtakes it.

It will be many years before you check your bank statement, read the daily newspaper or send "for-the-record" inter-office memos on cathode ray tubes or their equivalent. But that day is coming. Even today, techniques are available for automatic metering of your gas, power and water consumption, the amount of gasoline used in your car, even the selection and use of groceries. The next step will be automatic debiting of your bank account to pay for these things. Even these bank procedures are being carried out today experimentally without paper, thanks to information displays. Many other companies which operate with very large data bases including insurance companies, utilities, even publishing companies are exploring ways of using information displays to improve their products. Some day we may all have inquiry/display sets on our desks and in our homes.

Properly used, the information display can provide a great benefit to mankind by making more data more readily available, expediting all forms of human transaction and reducing unnecessary volume and costs of data presentation and storage. It is my personal contention that the encouragement of information display carries with it the implicit but hidden objective of war against paper.

JAMES H. REDMAN
President, SID

James H. Redman is the newly elected President of the Society for Information Display. He has been active in the Society since its formation and was the charter President of the San Diego Chapter.

Mr. Redman is currently Manager of Marketing for the Stromberg-Carlson Corporation/Data Products, San Diego, California. Prior to his present assignment, Mr. Redman was manager of Government Requirements for General Dynamics/Electronics in San Diego.

He has held both engineering and marketing positions in the display field since 1953, and was directly associated with display development activities for the SAGE Program, one of the earlier large scale computer information display systems.

Prior to beginning his display career, he worked for the California Research & Development Company in Livermore, California, a contractor for the Atomic Energy Commission.

Mr. Redman received his BS Degree from the San Jose State College, San Jose, in 1952.

Scan Converter Tubes and their Applications

Part I of a three part article

by G. T. Nagy

Summary

The scan converter tube described in this paper is a special Cathode Ray Tube used for the bright display conversion of air traffic control displays. In recent years, this device was further developed for several other display systems, for storage, scan conversion and signal integration. The tubes developed by several manufacturers are designed with different target systems and, therefore, different operation principles. The theory of the target systems and operation principles, storage capabilities and properties are discussed. The two major types of tubes, the single and dual gun tube construction and their applications, are described in a form which shows the usefulness and further potential for the future of this device.

Introduction

In recent years, the complexity of both airborne and ground-based systems has increased considerably. This increased complexity, together with the resultant increase in display requirements, has placed a premium upon display panel space. Therefore, it has been necessary to develop means by which several related functions may be combined into a single or common display. One of the most useful and versatile forms of display for this purpose is the Cathode Ray Tube (CRT). By means of a CRT, data such as radar and/or contour map information may be combined with alphanumerics and symbology to form a comprehensive and meaningful display.

However, since a CRT display is nothing more than a sophisticated TV monitor, all of the dynamic data presented (i.e., radar scan, symbology, etc.) must be converted to a TV raster scan format. To accomplish this conversion to a common format, two basic forms of scan conversion are used: (1) electronic scan conversion, and (2) optical scan conversion. Of the two, electronic scan conversion offers the highest degree of efficiency and versatility. Unfortunately, the full capabilities of this technique have yet to be utilized. This is due primarily to the lack of published information regarding scan converter tubes and the resultant unfamiliarity with its capabilities.

With this in mind, this paper is intended to enlighten those interested in this form of scan conversion. The first four sections set forth the theory behind the two types of electronic scan converter tubes. The balance of the paper discusses the specific tubes available and present their various characteristics, together with various means by which these tubes may be applied.

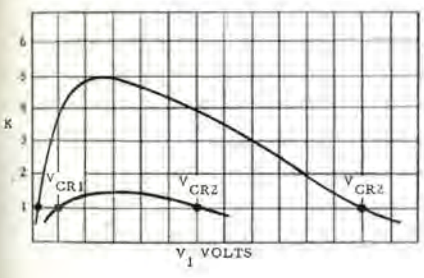


Figure 1. Secondary Emission Curves.

Secondary Emission of Materials

Storage By Secondary Emission

A charge image can be formed on a dielectric surface with the process of secondary emission.

The first such storage process was utilized by pickup tubes as image iconoscopes. These tubes use sensitive continuous photo surfaces which emit photoelectrons in direct proportion to the light at each point. Since storage cannot be achieved directly on such surfaces, these electrons are accelerated toward a storage element by an electrical field. This storage element consists of a dielectric surface, which emits secondary electrons when bombarded by primary electrons. The secondary emission/primary emission ratio minus one is equal to the sensitivity gain. For example, if one primary electron incident releases three secondaries, the net change of charge is a loss of two electrons, or an effective signal gain of two.

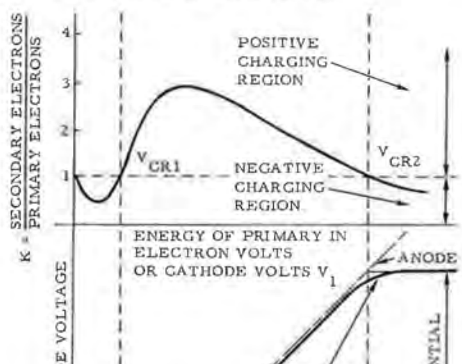
Secondary Emission of Target Materials

Materials, metals or insulators, exhibit secondary electron emission if bombarded with an electron beam. Secondary emission occurs from most surfaces whenever the energy of the incident electrons is much in excess of the work function of the surface. In many practical cases, however, it does not become appreciable until the energy of the incident electrons is of the order of 20 electron volts. The velocity V_1 of the electron beam and the target material will determine the secondary electron emission factor "K," where

$$K = \frac{\text{secondary electrons}}{\text{primary electrons}}$$

Figure 1 illustrates "K" emission ratio curves. This is the ratio of secondary

Figure 2. Secondary Emission Ratio K as a Function of the Beam Energy.



Work performed by author while with the Autonetics Division of North American Aviation, Inc.

and primary electrons versus acceleration voltage for metal and insulator.

Low velocity primary electrons in the electron beam yield only a few secondary electrons. The curves in Figure 1 show an increase of factor K with increasing V_1. Factor K has a maximum at some value of V_1 and finally decreases by further increase of V_1.

The behavior of metals, semiconductors, and insulators concerning the secondary emission differs in maximum value. Metals have a curve with value of K from somewhat less than 1, to about 3. Insulators and semiconductors, however, range from less than one to a maximum of 10. Figure 2 shows a typical secondary emission curve for a dielectric storage surface.

The system shown in Figure 3 consisting of an insulated target, an electron beam with acceleration voltage (cathode voltage) V_1, and a ring electrode-anode, is called a collector. The target is insulated from the ground but is initially at ground potential. The electron beam from an electron gun bombards the target.

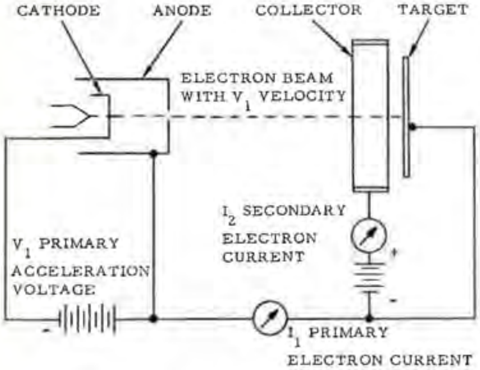


Figure 3. Schematic of a Secondary Emission Target System.

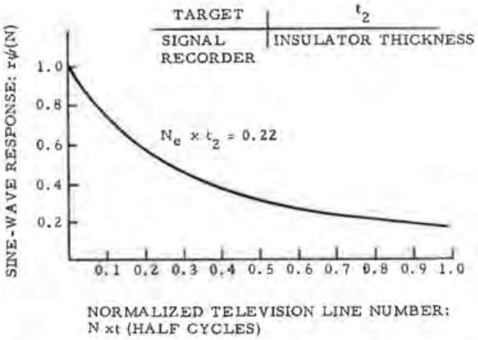


Figure 4. Sine Wave Response of an Electrostatic Target.

The cathode is a negative, and the ring collector is at positive potential with respect to the ground. The ring collector collects the secondary electrons emited from the target surface. Because of initial ground potential of the target surface, the primary electron beam energy V_1 is equivalent with the negative cathode voltage. The curves of Figures 1 and 2 shows two crossover voltages V_{cr1} and V_{cr2} at the K = 1 line. If velocity V is less than V_{cr1}, the target surface is in the negative charging region. The target loses less than one secondary electron for each arriving primary electron and $K < 1$. The target surface becomes increasingly negative as it starts to collect negative charge carriers, and after a while it will be at such a negative potential that no further primary electron can be received.

Beyond the second crossing point V_{cr2}, the target surface similarly starts to collect negative electrons. However, here an equilibrium will be established; when the target potential comes to some negative value with respect to the ground. The velocity of the primary electrons will be reduced to the Value of V_{cr2} and stay at this point regardless of the target to the cathode potential, called the "sticking potential," is a characteristic of the target material.

The third portion of the curve is that from V_{cr1} to V_{cr2}, where each primary primary electron should produce more than one secondary electron. The factor $K > 1$, the number of leaving secondary electrons is higher than the arriving primary electrons. This loss in electrons results in a positive charge of the target. This positive-target, surface potential increases until either (1) the primary electron beam reaches the target

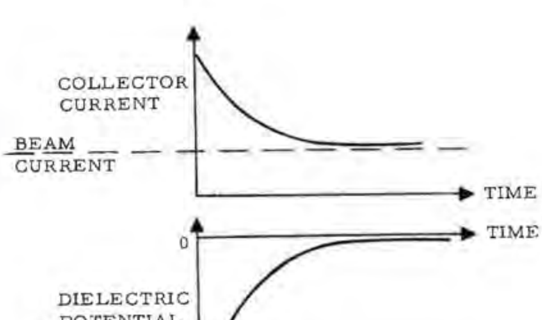


Figure 5. Writing Process with Negative Charged Dielectric.

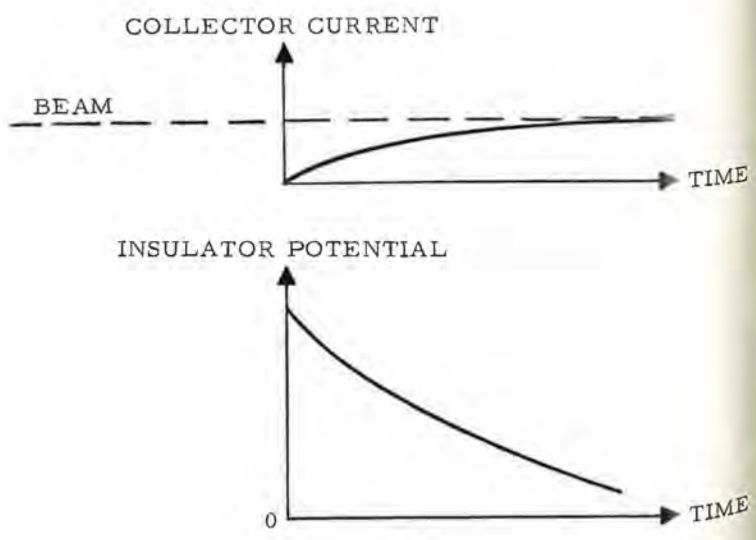


Figure 6. Writing Process with Positive Charged Dielectric.

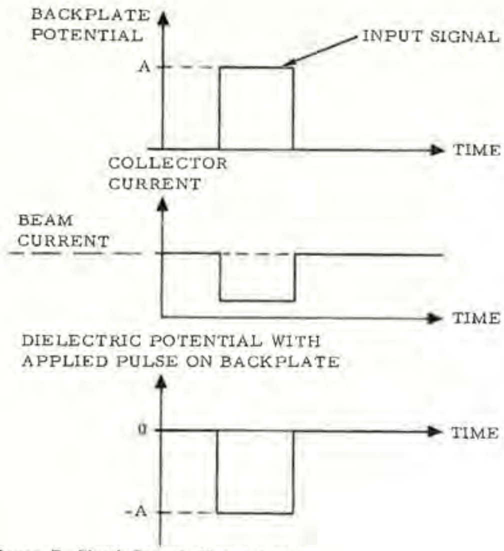


Figure 7. Fixed Target Signal Inputs.

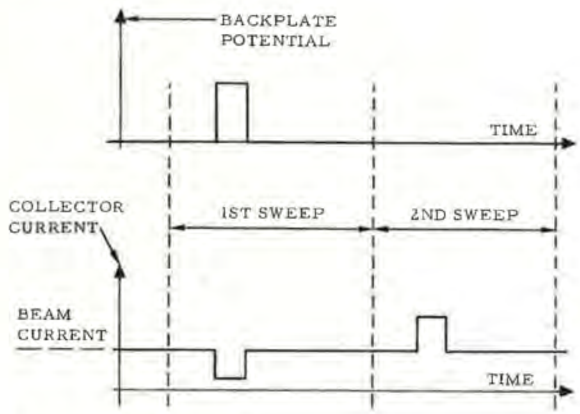


Figure 8. Moving Target Signal Inputs.

with a potential of V_{cr2}, or (2) the target potential rises to an equilibrium with the collector voltage. As a result of secondary electron velocity, the target surface potential becomes slightly positive with respect to the anode of the gun. The final result will be determined by one of the two limits, whichever will be reached first. The target surface potential will never exceed the collector potential, and will not increase above a potential which causes the primary velocity to rise above V_{cr2}.

Storage systems for scan-converter storage tubes are as follows:

1. Barrier grid
2. Transimssion grid modulation using dielectric material deposited or placed on a metal mesh target
3. Electron Bombardment Induced Conductivity (EBIC) uses a continuous semiconductor target
4. MTI-R tube, a continuous dielectric target
5. Fiber-optics photon target with photoconductor and fiber optics between write and read side.

Resolution of Recording Storage Tubes

The resolution of electrostatic storage targets can be specified with the number of information bits stored on its surface. The unsatisfactory value of this parameter could significantly limit the performance of a storage tube. To investigate and analyze this problem, an evaluation is necessary first of the tube parameters and second of the circuit parameters.

Tube Parameters

In order to investigate the whole target area behavior affecting the resolution, one particular point of the storage surface has to be analyzed affecting this important parameter.

The following parameters affect the resolution at one particular point of the target storage surface:

1. Electron gun voltages, writing and reading beam.
2. Electron beam currents (write and read).
3. Linear speed of the scanning beams over the one particular point of the target. This can also be expressed as charge per unit length of scan.
4. Scan repetition frequency of write and read beams.
5. The relative scan direction between the write and read beam, regarding the one particular point of the target surface.

The electron gun voltages, as cathode voltages, focus electrodes and eventually other electrode voltages will effect primarily the beam spot size on the target.

In any form of writing, such as secondary emission or EBIC principles, the writing beam is focused on the storage surface and will determine one element of the written pattern. The writing beam spot size, therefore, is very important. This spot size is formed by the electron-gun electrode voltages, and the beam current will consequent this voltage. The scanning electron beam speed, particularly the writing beam linear speed, will effect the charge written in one point. If "dq" electrons striking the target in "dt" time scanned at "dl" linear length, the writing beam charge per unit length of scan is specified. If this speed is too high regarding the equivalent rectangular pass band of the point image, the spot will be "smeared" on the storage surface. Another function of the writing beam can cause this "smearing" of the point charge. This is the saturated writing case when several writings happen before reading, and this writing repetition frequency is too high.

Reading the written charge pattern with either a fast electron reading beam such as destructive readout or a slow electron beam such as nondestructive readout, the reading beam spot size affects the resolution.

Finally, in this qualitative analysis, besides the magnitude of the two electron beams scanning speed, their relative direction will affect the resolution of one point. The resolution can have a factor of $\sqrt{2}$ larger if the writing beam scan is perpendicular to the reading beam scan. This was proven by several experiments.

Aperture Theory

The aperture or point image theory deals with the transformation of a charge pattern into a potential pattern on the surface of the storage dielectric. This storage target is the aperture. This electrostatic storage tube resolution can be expressed with the electric field of the storage target. The properties and combination of point images or apertures can be described in the space domain by transmittance functions and in the frequency domain by their Fourier spectra or sine wave response. It can be proven that the sine wave response of such an electrostatic target as aperture and its equivalent pass band is determined solely by the insulator thickness "t."

Under transient conditions as single frame operation, electrostatic field effects the storage surface. The sine wave response of an aperture is actually a Fourier transform of its line transmittance. If "N" is the TV line number as the number of half cycles in unit length, then

$$N = \frac{\omega}{\pi}$$

With the aperture process and Fourier transform, the theoretical sine wave response is

$$r\psi(N) = \frac{1 - e^{-2\pi Nt}}{2\pi Nt}$$

where "r" is the transmittance of the aperture, and "t" is the dielectric thickness.

Figure 4 shows the sine wave response curve of an electrostatic target. The equivalent rectangular pass band of the aperture is:

$$Ne = \frac{\ln(2)}{\pi t} = \frac{0.22}{t}$$

Total Resolution of a Storage Tube

The conditions of optimum resolution at one point was discussed before. The well focused spot size, however, moving across the storage surface could vary even if the corresponding values of focus parameters are kept constant. In case of fast beams, the cause of such variations could be:

1. Spherical aberration, where the round spot size becomes larger.
2. Astigmatism caused by deflection plates, and the spot becomes oval instead of round.

In case of slow beams, the different length of beam path during scan, where collimation is used, defocuses the beam on the edge of the target. This last mentioned defocusing can be corrected with dynamic focusing, where a dynamic waveform is superimposed on the focus d-c bias. A variation of the beam current could cause defocusing also. The total resolution definition, therefore, has to be established for specific focusing conditions. Either optimized focus at the center of storage surface or corrected dynamic focusing.

A variable speed of scan causes a degradation of resolution. If the relative scanning direction between the two scanning beams varies, a degradation occurs in resolution. This is the case with PPI to TV raster conversion, where in one direction the read and write beam scan parallel, and in the other direction they scan perpendicular to each other. The total resolution of the storage tube is effected therefore by:

1. Focusing conditions
2. Variation of beam current
3. Variaition of scanning speed
4. Variation of relative scanning angle

Circuit Parameters

The parameters of the electronic circuits operating with the storage tube affect the resolution. Video signal to the input or writing side and from the output collector should be amplified, and particularly the output signal amplifier should not distort the signal. This

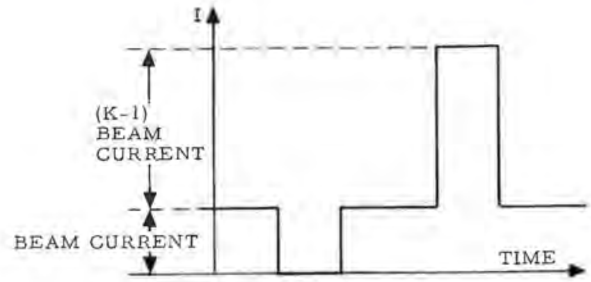


Figure 9. Output Asymmetry.

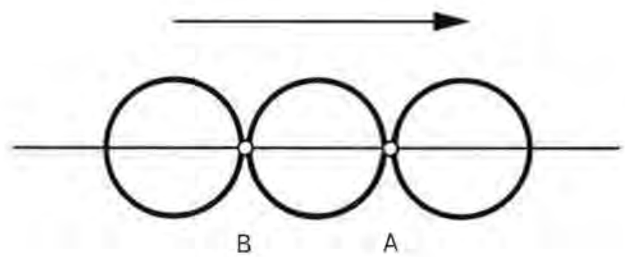


Figure 10. Moving Beam Spot.

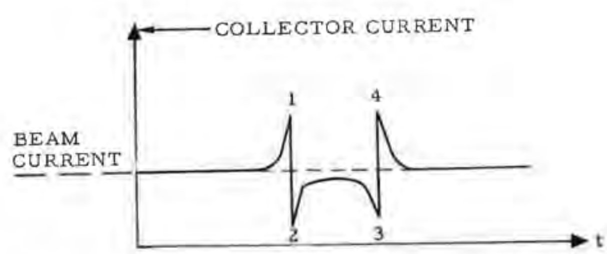


Figure 11. Overshots on Leading and Trailing Edge.

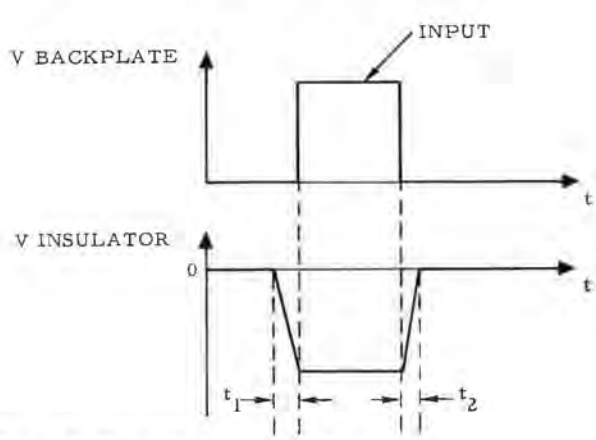


Figure 12. Charge Outlines on Dielectrics.

requires bandwidth response of the amplifier which corresponds to the video bandwidth required for the horizontal line resolution.

The video bandwidth required for 1000 lines horizontal resolution, based on 1199 scan line system, 1:1 aspect ratio and a standard frame rate of 30 cps, can be determined as follows:

Total time per line:

$$= \frac{1}{\text{frame rate x no. of lines}}$$

$$= \frac{1}{30 \times 1199} = 27.8\ \mu\ \text{sec}$$

Active line time

= total line time minus retrace blanking time

$= 27.8 - 6\ \mu\text{sec (approx)}$

$= 21.8\ \mu\text{sec.}$

1000 TV line resolution

= 500 cycles

Bandwidth

$$= \frac{\text{Resolution (cycles)}}{\text{active line time}}$$

$$= \frac{500}{21.8 \times 10^{-6}} = 22.9\ \text{mc}$$

Note that it is standard practice to express resolution (in TV lines) as a given number of TV lines based on the picture height. In the event a 4:3 aspect ratio is used, 4/3 times as many picture elements must be scanned in the same active line time. Therefore, the required bandwidth will be 4/3 that required for a 1:1 aspect ratio. In the above case, the result would be 30.6 mc. Furthermore, since noise is directly related to bandwidth, it follows that a 1:1 aspect ratio, for given resolution, will permit a lower bandwidth and consequently lower noise (higher signal-to-noise ratio). Since minimum noise is desired in this application, it is highly recommended that a 1:1 aspect ratio be used.

Radar Fixed Target Signal Cancellation

The principle of the secondary emission of electrons of a target material by bombardment with a primary electron beam was discussed earlier. Depending on the primary beam energy, the secondary emission ratio curve shows two crossing points. By lower energy before the first cross point, the secondary emission ratio $K < 1$ at the crossing point $K = 1$, further increases the beam energy $K > 1$ until the second crossing point, where again $K = 1$ and finally the value of K drops below one.

Storage Process

For reading moving target indicator (MTI) displays, single-gun processing storage tubes could be used. Such tubes are presently produced by several manufacturers with different target systems but with similar cancellation techniques of fixed target echos.

The writing with the primary beam on a target takes place with a ratio $K > 1$. The target, therefore, loses electrons and becomes positive charged. The collector current with the secondary electrons is first larger than the beam current. This decreases until equilibrium state is reached. The dielectric surface, however, at the same time gradually becomes less negative (Figure 5).

Actually, the read value of K is larger than one, even if the apparent value $K = 1$.

Assumed that the tube is barrier grid type and the dielectric is initially positive when the priming beam scans the target, the result is that the primary beam current approaches the collector current; and the dielectric potential decreases toward the grid potential (Figure 6). In either case, the primary beam tends to bring the dielectric potential toward zero, which is, in this example, the barrier grid potential.

Fixed Target Input

The principle of operation of single-gun recording storage tubes for MTI displays is that the radar return signal is applied to the backplate, assuming the dielectric charged full positive and is at the equilibrium. The fixed-target return pulse applied to the metal backplate is positive going. The insulator surface follows this potential increase. The beam spot, however, scanning during the pulse duration tends to bring back this area of the storage surface to zero volt. The positive pulse on the backplate and the negative potential with the sweeping beam on the storage surface reduces the collector current on this spot with respect to the rest of the dielectric surface. The beam energy has to reach the -A amplitude. (Figure 7)

If the return signal came from a fixed target, the positive pulses from the first, second and following echos will have the same amplitude, same duration and same location on the sweep. The second and following pulses on the backplate during the pulse duration raises the dielectric potential to A. The beam spot, however, hits the dielectric surface section during the pulse duration with a potential A, and the surface section potential rises during this time to zero potential. The result is that as soon as the second return pulse signal is received and applied to the backplate, during those pulse durations, the scanning spot moves on points of the dielectric surface which are all on equilibrium potential. During that scan period, no change in collector current occurs, no output signal comes from the coupline capacitor and, therefore, the fixed target signal is cancelled.

Moving Target Input

The purpose of a moving target indicator is to extract from the received radar echos those which come from the moving target only. As described before, the signals from fixed targets are cancelled already and do not appear on the display. The return signals, however, should appear on the screen. As the curves in Figure 8 show, the first return signal pulse causes a change in the collector current similar to that of the fixed target. In the following PRF, however, the pulses received from the same moving target show a variation in amplitude and therefore a change in collector current. This change, as an a-c signal, results in an output from the collector and a moving target indication on the display screen.

Figure 8 shows that while a moving or fixed-target return pulse charges one point of the dielectric surface to a potential different from equilibrium, the electron beam spot, passing over this point on the surface, discharges it if no pulse is present at this time. It brings it back to equilibrium potential. This is a change in collector current before opposite polarity is caused in the presence of the return pulse. This output, in case of moving target, and the following pulse returns caused outputs to indicate the trace of the target on the display screen.

Limitations and Other Effects

Noise

The noise appears in the collector current as a high-frequency modulation, generated internally due to the target imperfections. The grid type tubes generate this noise while the electron beam scans through the grid. It responds to the surface irregularities and also generates secondary electrons from the grid itself. The tubes without grid, having continuous dielectric surface, have a noise from the surface irregularities also and further the spread of the spot and charge on the surface. All these effects result in a high-frequency type variation of the secondary emission and the collector current.

Cancellation Ratio

Assumed previously, an ideal condition is that the scanning beam energy is adequate to charge completely the area which was swept during the pulse being applied from the return signal. There are, however, physical limitations which make it obvious that in real operation this doesn't happen. First, the spot is focused on the dielectric surface, and the focusing process limits the beam energy reaching the target. Therefore, the number of electrons reaching the target is only a fraction of the ideal beam energy. In practice, therefore, one scan is not able to cancel completely the fixed target return. The number of sweeps required for complete cancellation is a function of the sweep speed, pulse length, and the dielectric recovery time.

The following assumptions can be used to analyze this problem:

1. The pulse amplitude or voltage applied to the backplate is large compared to the dielectric potential change between two scans.

2. One scan would bring the surface potential to equilibrium.

3. The load resistance is small to the dielectric layer resistance.

With this assumption "D," the cancellation ratio is

$D = \triangle i_m / \triangle i_f = \triangle q_m / \triangle q_f$

where

$\triangle i_m$ = current change by moving target

$\triangle i_f$ = current change by fixed target

$\triangle q_m$ = deposited charge increment at moving target

$\triangle q_f$ = deposited charge increment at fixed target

The "q" is the deposited charge during a single scan and on the areas where the spots are during the pulse duration.

If "c" is the capacitance, "r" the resistance of a single element and $\triangle V_k$ is the voltage increment caused by a $\triangle q$ deposited charge, then "T" is the time between two scans, V_b the pulse voltage on the backplate.

$\triangle q_m = c \triangle V_k$

$\triangle q_f = [T(V_b + \triangle V_k)/r] - [TV_b/r] = T\triangle_k/r$

The cancellation ratio is

$D = c\triangle V_k \sim T\triangle V_k/r = r\,c/T = R\,C/T$

when "R" is the resistance and "C" is the capacitance of the whole scanned dielectric layer.

Asymmetry in Output

The variations in secondary emission current and primary beam current ratio can be determined with three states:

1. The state of an extreme positive pulse on the backplate which causes a collector-current maximum modulation equal with beam current.

2. Collector current which is equal with the beam current in the equilibrium state.

3. An extreme negative pulse on the backplate, where the secondary emission is maximum, the maximum collector modulation in positive direction is $(K-1)$ times the beam current and where K is the secondary emission ratio. (Figure 9)

An asymmetry is apparent at the output because the secondary emission ratio is not equal by positive and negative pulses. Also, a negative pulse applied to the backplate, charges the point of the dielectric faster than a positive pulse.

Leading and Trailing Edge Overshots

In Figure 10 the three circles represent three adjacent positions of the electron beam spot.

Suppose a beam spot the size of 0.1 mm. Points "A" and "B" on the storage surface are in a distance equal with the spot size. The radar return pulse applied to the backplate occurs when the spot arrives to point "A." Suppose a positive going pulse, which causes the deposit of negative, charges between points "A" and "B". In this moment the full beam energy hits the points in point "A", and a part of the energy hits only the points between "A" and "B". The same occurs at the end of the pulse at point "B". The shape of the charge pattern at the point of the storage surface is shown in Figure 11.

Figure 11 also shows the spikes at the two edges of the pulse pattern at fixed-target radar returns. The charge outlines of the dielectric versus backplate pulse is shown in Figure 12. In this figure t_1 and t_2 represent the time of a spot diameter length scan.

The second and following sweeps find, between points "A" and "B", a negative potential just before the pulse starts and brings it to equilibrium potential. This causes a sudden increase of the collector current and spike No. 1. While the spot between points "A" and "B", the pulse starts on the backplate. This results in a sudden decrease of the collector current and spike No. 2. Both overshots occur at pulse trailing side also. Fortunately, the radar receiver has bandwidth limitations and rounds up the sharp edges which practically erase the spikes. (Figure 13 shows typical curves of MTI.)

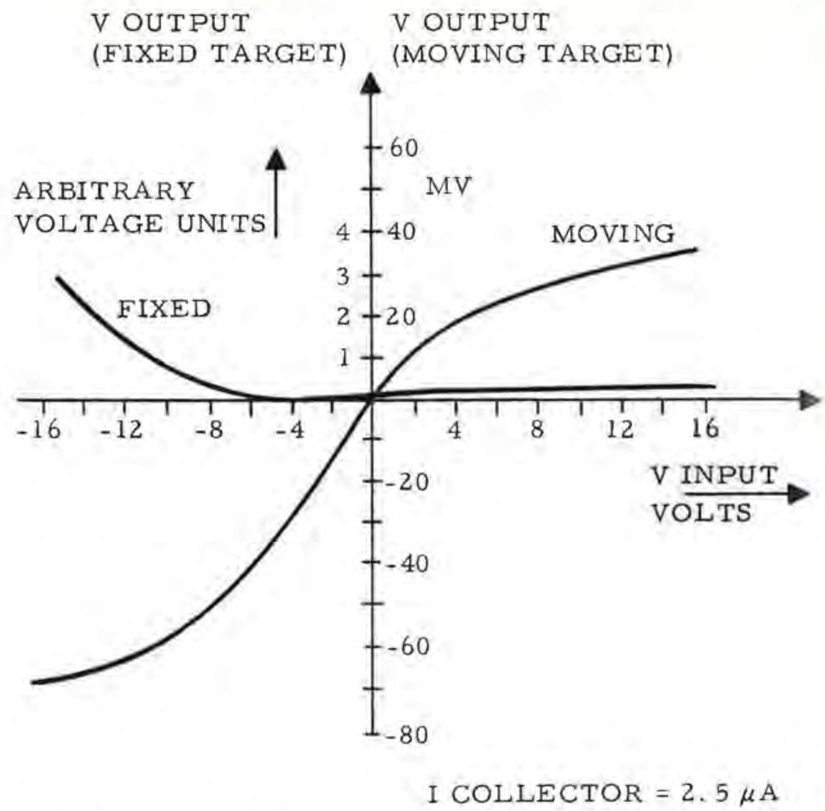


Figure 13. Typical Curves of MTI.

Electron Bombardment Induced Conductivity

The secondary emission of a metal or dielectric material by impinging primary electrons with an electron beam is the operating principle. Storage devices such as storage tubes, some with and some without visible image, store only electrical information. Some storage tubes, such as scan converter tubes, with electrical inputs or writing and electrical outputs such as reading, have a storage/write/read system called EBIC. The EBIC target system is built with a storage material, dielectric or semiconductor in contact with a conductive material, a thin metal backplate. The storage and read-out process takes place on the dielectric or semiconductor surface while scanning with two electron beams, one on the dielectric surface and another on the conductive-metal backplate side.

The scanning electron beam on the dielectric surface causes a secondary electron emission as discussed earlier. This emission of electrons from the material, in case of secondary emission ratio $K > 1$, causes a loss of electrons in the dielectric surface leaving a positive charge or holes. This build-up of a positive charge continues if primary electron beams hit the surface until the positive potential of the storage surface equals to the collector potential. This is true regardless of the metal backplate potential. Therefore, the potential drop across the thickness of the dielectric material from backplate to storage surface could be adjusted to the potential difference of the target material to collector.

The target dielectric can be regarded as a condenser. On one side is the metal backplate, and on the other side the electron beam. The uniform charge over the whole condenser area could be determined as starting an equilibrium condition. In fact, the insulating storage material does not conduct transversely; therefore, the discharge of any part or point of the condenser can be achieved discretely without affecting adjacent points, even by any random pattern.

The discharge of such a condenser or storage target in this summer could be done with the EBIC. This discharging process of dielectrics, or recently semiconductors, can be achieved by conducting materials thin enough to be penetrated with an electron beam. The bombardment with an electron beam causes a current to flow through the thin film, and this current can be much larger than the electron beam current itself. This penetrating current creates a conduction in the insulating material contracting the thin metal film material. The insulation recovers immediately if the bombarding electron beam should be removed.

The electron beam penetration or induced conductivity increase with the square of the acceleration voltage. If the charging or reading beam operates with 1 kv acceleration voltage, the discharge or writing beam should operate with 10 kv. This writing beam can be deflected and modulated in any random pattern and information.

As stated earlier, the electron beam from the reading gun charges the storage element, such as a capacitor in positive direction to equilibrium with the positive collector electrode. The writing electron beam, however, penetrating the metal backplate supplies electrons through the bombardment induced conductivity to the storage element and charges it in the negative direction to equilibrium with the negative or grounded backplate potential. The written signal which leaves the storage surface discharged or charged according to the modulation will be stored for some length of time on the target with or without reading. The storage time can be analyzed quantitatively regarding the target, which can be replaced in the theory as a group of elemental condensers. It is assumed that the size of the capacitor elements is equal to that of the focused spot size of the reading beam. This is equivalent to a standard TV picture element. The metal backplate is common for all the capacitors as one electrode, the other electrode is formed by the electron beam spot. The writing beam penetrating one element size of the backplate discharges one element of the storage surface completely. The reading beam, however, will charge up in the positive direction the same element to the collector voltage.

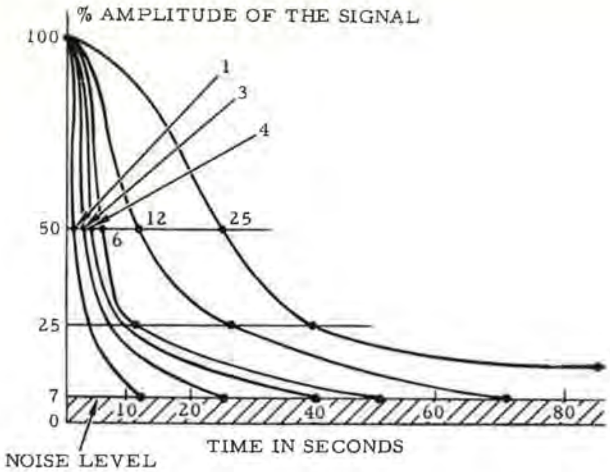


Figure 14. Output Signal Decay Curves.

The charge "Q" of a one-element capacitor with "E" collector voltage and c capacity of one element

$Q = E \cdot c$

With constant beam current and saturated secondary electron current is the average charging current I_c in the element capacitor in time T, then,

$E \cdot c = I_c \cdot T$

The secondary emission current is K.I or the secondary emission ratio times the beam current. The difference between the secondary emission current and the beam current charges the capacitor element. The charge current is therefore:

$I_c = K \cdot I - I = (K - 1)\ I$

I is the average beam current per capacitor element.

From the above equations:

$E \cdot c = (K - 1)\ I \cdot T$

The number of target elements is "x".

The scanning beam distributed to each element is only 1/x fraction of the total I beam current.

$$E \cdot c = (K-1)\frac{I}{x}\,T \text{ and } T = \frac{E \cdot c \cdot x}{(K-1)\ I}$$

The total capacity of the scanned target surface area is:

$C = x \cdot c$

and

$$T = \frac{E \cdot C}{(K-1)\ I}$$

A parallel plate condenser capacity with "Σ" dielectric comst. "F" condenser are and "d" thickness of dielectric is:

$$C_p = 0.0885 \cdot 10^{-12}\ \frac{\Sigma \cdot F}{d} \text{ Farads}$$

The charging or storage time therefore is:

$$T = 0.0885 \cdot 10^{-12}\ \frac{\Sigma \cdot F \cdot E}{d\ (K-1)\ I} \text{sec}$$

During this T time, the storage element with the reading beam produces a detectable output signal. Actually, the storage time is longer than T when no reading beam scanning is used. This storage time is determined by the leakage current through the dielectric. The expression of T time contains the whole capacitor area only and not the number of elements. This charging or storage time expression assumes that I current is uniform over the whole area only and not the number of elements. The charging time is also proportional to the target area which can mean a function of the target size or tube diameter. In the recent developments, however, the doped semiconductor storage materials and the proper combination of storage and viewing time could give longer T time as calculated by the above expression.

This continuous, doped semiconductor material of the storage layer at recent developments added many improvements to the EBIC system. It increased the induced conductivity ratio, which is the number of electrons and holes produced in the storage material over the number of writing electrons penetrating through the backplate into the storage layer. The doped semiconductor requires less energy to higher conductivity ratio. The doped material also controls the decay time with a process inside the EBIC layer. It produces traps which are filled during bombardment with the electron beam, but in variable times they empty themselves. This time depends on the electric field, also around the EBIC layer. The electric charges leaving the traps are flowing toward the storage surface and then to the collector. Figure 14 shows those decay curves of output signals versus time.

This concludes Part I of a three-part article. Parts II and III will appear in the next two issues of this Journal. The author's Acknowledgment and References will appear at the conclusion of Part III.

Three independent judges, Petro Vlahos, A. C. Stocker, and Warren Milroy met for the first time at the SID Fifth National Symposium on Information Display and selected "Solid State Light Valve Study" by Edward J. Calucci as the best paper presented. In the opinion of the judges Mr. Calucci's technical discussion, development of subject, delivery, and use of visual aids entitled him to receive the award of a \$100 U. S. Savings Bond. A number of other papers were also considered to be outstanding and may appear in these pages in the coming months. The entire Convention Committee as well as the judges wish to thank all the speakers and Session Chairman for their efforts in producing a noteworthy Symposium.

Solid State Light Valve Study

by Edward J. Calucci

Abstract

This paper reviews the results of an in-the-house investigation in the area of projection displays conducted at Rome Air Development Center. The objective of this study was to determine the feasibility of using a crystalline element which exhibits the Electro-optic Effect, as the control layer of a light valve projection display system.

The scope of this investigation included a study of the Electro-optic Effect, and the types of crystals which exhibit this effect. An experimental model consisting of a specially designed demountable cathode ray tube, electro-optic crystal, associated optical components and electrical drive circuitry was assembled to demonstrate the technique and to determine the limitations of the various display parameters. A typical display system application was envisioned and realizable problems of efficiency, highlight brightness, contrast, aperture size and resolution were investigated based upon the performed experiments.

The results of the study indicated that the technique is definitely feasible and appears quite promising although presently limited in optical resolution. The KD_2P crystal was best suited for the application since it possesses a lower half-wave retardation voltage (3500 volts) and an inherent charge storage which makes the optical image appear brighter. The TV images that were generated by the experimental model indicated the technique has great potential for real-time displays.

Introduction

Within the miliary there exist requirements for large scale, full-color display devices which are highly reliable and possess dynamic, real-time capabilities. Since command decisions depend ultimately on visual presentations, the following additional display requirements are also imposed: high brightness, high information rates, multiple input flexibilities and versatility.

The present display technology relies mainly upon photographic films and cathode ray tubes for military display applications. The cathode ray tube can provide most of the aforementioned requirements for a small scale display but is considered inadequate in size for group displays and an image brightness for large scale optical projection. Films, likewise, provide good display characteristics but due to the processing time, are limited in presenting dynamic, real-time information. To circumvent these problems, the light valve techniques were envisioned as posible solutions. The liquid light valve has been demonstrated as a feasible display device; however, further refinements in reliability, maintainability and input flexibility are definitely required.

The crystalline light valve which utilizes the Electro-optic Effect represents a versatile approach within light valve technology and, therefore, the Projection Techniques Section at Rome Air Development Center (RADC), has undertaken a program to investigate and develop a solid state light valve using this principle. Conceptually, the solid state approach offers the following advantages:

(1) No mechanically moving components
(2) Sealed-off capability
(3) Direct electro-optical readout
(4) Random or raster write modes
(5) Storage capability within the control layer

The technique of using Electro-optic Effect for light modulation is not unique; in fact a number of reports are available on this subject. Work was reported as early as 1934 on this approach and since that time various organizations have performed exploratory research in an attempt to reduce this technique to practice.

In 1961, Rome Air Development Center started an in-the-house investigation to exploit this technique for possible display applications. As a result of this internal study a contract was awarded to the Motorola Corporation to determine the feasibility of this technique for projection display applications. Later in 1964 another contract was awarded to Autonetics for further research and development of a solid state light valve. A continued in-the-house effort led to the decision to build a working model for feasibility studies and experiments.

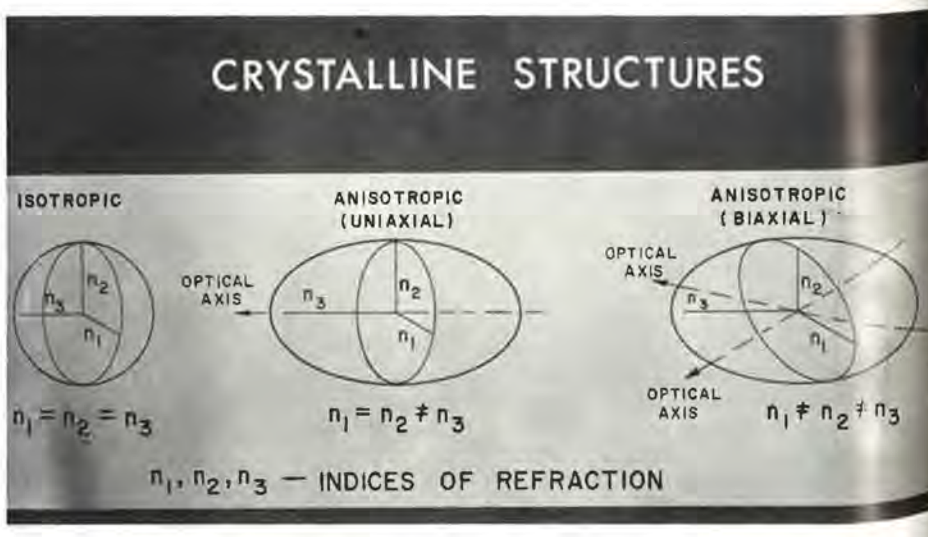


Figure 1.

General Properties of KDP, KD_2P, ADP

PROPERTIES	KDP (KH_2PO_4)	KD_2P (KD_2PO_4)	ADP ($NH_4H_2PO_4$)
A. Optical			
1. Half-wave retardation (KV)	7.8	3.4	9.6
2. Electro-optic constant $\tau 63$ (m/V)	10.7×10^{-12}	26.4×10^{-12}	8.2×10^{-12}
3. Indices of refraction ($\lambda = 5893°$)	Mo=1.5095 Mc=1.4684	— —	1.52418 1.47869
4. Transmission	~80%	~80%	~80%
B. Electrical			
1. Volume Resistivity (ohms/square)	$\sim 10^{12}$	$\sim 10^{12}$	$\sim 10^{-12}$
2. Surface Resistivity (ohms/square)	$\sim 10^{12}$	$\sim 10^{12}$	$\sim 10^{-12}$
Field $\perp$ optical axis	44.5		56.4
3. Relative dielectric constant Field 11 optical axis	21.4		16.4
4. Loss Tangent $\perp$	.0098		.0400
11	.017		.2400
5. Voltage Breakdown	>50,000 volts/mm		
6. Curie Temperature	—160°C		—100°C
C. Physical			
Melting Point	—	—	190°C
Outgassing (Temperature)	120°C	215°C	100°C
Hardiness	~2.5 Mohs	~2.5 Mohs	~2.5 Mohs

Crystals are also hygroscopic and exhibit both piezoelectric and photo-elastic properties.

Figure 2.

Electro-optic Effect in Solid State Crystals

Solid state crystals are categorized in 32 classes based upon the symmetry of the crystal structure. Twelve (12) of these classes are centrosymmetrical and therefore exhibit no first order Electro-optic Effect. The remaining twenty (20) crystal classes to exhibit linear electro-optic properties. However, for light valve applications the electro-optic crystal must: (1) exhibit a fairly strong linear Electro-optic Effect, (2) be single crystalline, (3) be free of natural stresses, (4) have sufficient size for versatility, (5) have good electrical properties, (6) possess high optical clarity, and (7) not be optically active.

These restrictions have presently limited the types of crystals for this application to two crystal classes. The two crystal classes are: (1) Tetragonal classes $\bar{4}2m$(Vd) which includes potassium dihydrogen phosphate (KDP), ammonium dihydrogen phosphate (ADP), and (2) cubic class $\bar{4}3m$ (Td) which includes cuprous chloride (Cu_2Cl_2), and zinc sulphide (Z.S).

The Electro-optic Effect can be defind as the change of optical properties within a crystal in the presence of an electric field. This effect can be further classified into two categories which depend upon the orientation of the applied electric field with respect to the optic axis of the crystal. A "Transverse Effect" results when the applied electric field is orthogonal to the incident optical wave and a "Longitudinal Effect" results when the applied electric field is parallel to the incident optic wave. For light valve applications, only the longitudinal effect is of interest since the optical properties within the crystal must be changed on a point by point basis to achieve an optical image. It is interesting to note that the $\bar{4}2m$(Vd) crystals exhibit a longitudinal effect and the $\bar{4}2m$(Td) crystals can exhibit both the transverse and longitudinal effects. These conclusions are apparent by viewing the electro-optical matrices as described by Mason [1].

The optical interaction with crystals can best be described by considering the following crystallographic representation. The optical properties can be conveniently represented by the "indicatrix" which is single-surface figure ascribing the indices of refraction within a crystal. The surface is generated such that the length of each principle axis is equal to the indices of refraction n_1, n_2, n_3 of the crystal as illustrated in Figure 1.

In an optically isotropic crystal (cubic class) the indices of refraction are equal, namely $n_1 = n_2 \neq n_3$. Thus, the resulting indicatrix is a sphere and the optical axis would be represented by a diameter of the sphere. For an anisotropic crystal, in particular, the uniaxial (Tetragonal class), two of the indices of refraction are equal, namely $n_1 = n_2 \neq n_3$. The indicatrix ascribed by these properties is a "rotational ellipsoid". When an electric field is applied to this uniaxial crystal the indicatrix becomes altered in shape thereby causing the uniaxial crystal to become biaxial, thus $n_1 \neq n_2 \neq n_3$. An important point about using these uniaxial crystals is that the incident light must be oriented parallel to the optic axis or the crystal will cause double refraction without any applied electric field. Mathematical deviations of the electro-optic matrices associated with $\bar{4}3m$ (cubic class) and $\bar{4}2m$ (Tetragonal class) are described in detail by Peterson[2], and Billings[3], respectively.

It may also be noted that crystals within the $\bar{4}3m$ class are better suited for optical modulation since the optical axis is omnidirectional (diameter of sphere). At the present time crystals within the $\bar{4}3m$ crystal class have not been used extensively in light valve applications. Although the technology for $\bar{4}3m$ class crystal growth is improving, single crystals of sufficient size and optical quality are not presently available. For this same reason only selected crystals of the $\bar{4}2m$ class were considered for this technique. (KDP, ADP, and KD_2P).

General Properties of KDP, KD_2P and ADP

Crystals of KDP, KD_2P, and ADP are artificially grown and single crystalline boules having four inch square cross-sections have been reported. However, the useable area is usually much smaller due to inherent strains and cracks formed by temperature gradients.

Some of the general properties of KDP, KD_2P, and ADP are shown in Figure 2.

Light Valve Principle

The solid state light valve uses the principle that plane polarized light incident on a biased crystal (uniaxial) will experience a rotation of the polarization vector. This is illustrated in Figure 3.

The electro-optic crystal (Z - 0° cut, i.e. slab cut perpendicular to Z axis) is positioned such that its optic axis is oriented along the direction of light propagation (Z - direction) and the slides of the crystal are parallel to X and Y. The polarizer and analyzer are oriented at 45° and −45°, respectively to the referenced axes.

Initially with no voltage applied on the crystal, the transmitted light is blocked since the polarizer and analyzer are positioned orthogonally. By applying an electric potential by means of transparent electroding on the faces of the crystal, the crystal becomes biaxial and the incident polarized light resolves into two ray components: (1) ordinary ray, and (2) extraordinary ray. The ordinary ray is the component of light which vibrates normal to the optic axis and the extraordinary ray is the component of light vibrating parallel to the optic axis. Since the indices of refraction differ

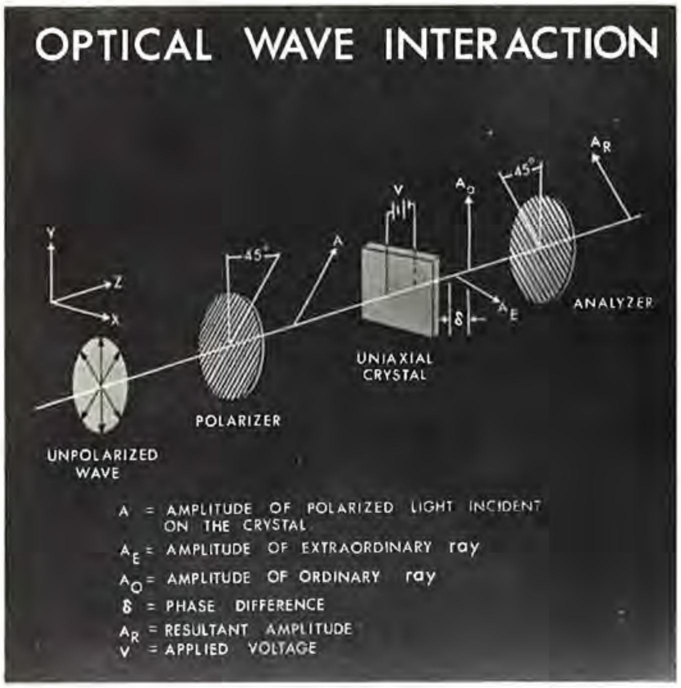


Figure 3.

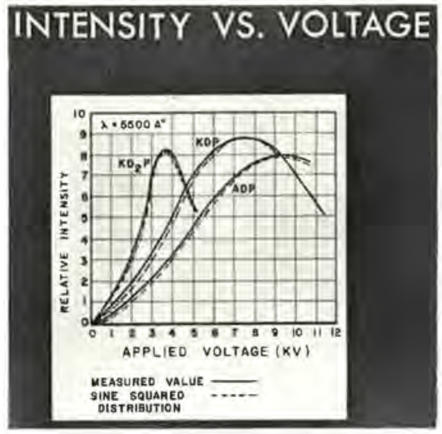


Figure 4.

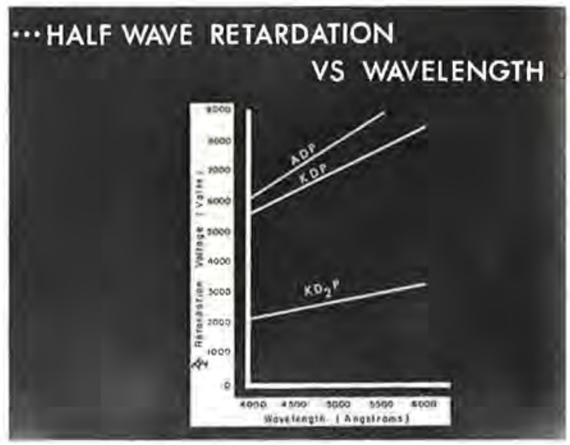


Figure 5.

along these paths, the combined resulting wave is transformed from a linear polarization to an elliptical polarization to pass, thus allows a linear polarized wave to be transmitted. It may be pointed out that the amount of light which is allowed to pass the analyzer is dependent upon the applied voltage. Maximum light is achieved when $\delta = \pi/_2$, and that voltage which causes $\delta = \pi/_2$ is normally referred to as the "half-wave" retardation voltage for the electro-optic material.

Graphs were plotted for ADP, KDP, and KD_2P and are shown in Figure 4. As indicated in graphs, the intensity of the light transmitted follows very closely a sine square relationship and can be expressed as:

$$I_o = K\sin^2 \left[\frac{\pi}{2} \frac{V}{V_{1/2\lambda}} \right] \text{ where}$$

I_o = relative transmitted light intensity

K = proportionality constant

V = applied voltage

$V_{1/2\lambda}$ = half wave retardation voltage

$V_{1/2\lambda}$ = half wave retardation voltage (voltage for maximum light intensity)

An additional graph was plotted illustrating the ½ wave retardation voltage as a function of wavelength and is shown in Figure 5. It is apparent from this plot that the transmissions are linear within the visible spectrum.

Solid State Light Valve Projector

A typical display projector envisioned utilizing the linear Electro-optic principles can be conceived as shown in Figure 6. Other such designs can be depicted which may possess certain advantages, for example, a reflective scheme requires less voltage to produce the same optical retardation as a transmissive design. Nevertheless, this illustrated concept was enacted since it represents a simple design for experimentation and the resulting data would be pertinent to most designs. The components are self explanatory. Its operation is similar to that which was described earlier in this report. To reiterate, the polarizer and analyzer are cross polarized, consequently any light incident upon the combination will not be permitted to pass the analyzer. When a voltage is applied by means of an electron beam, an optical anisotropy is produced within the crystal which results in a transmission of an optical spot. By modulating and deflecting the electron beam an optical image can be projected onto the screen.

Experimental Model

To investigate the feasibility of the solid state light valve as a display device and determine the various display parameters, an experimental light valve was assembled at RADC and is illustrated in Figure 7. This model consists of (1) 100 Watt Mercury Arc lamp and supply, (2) 3" collimating lens, (3) 2" plastic polarizer, (4) special designed cathode ray tube, electro-optic crystal, and associated drive circuitry, (5) Glan-Thompson prism analyzer, (6) Veeco two inch high vacuum station, (7) Sorensen high voltage power supply, and (8) conventional optical bench, screen, and projection lens.

The cathode ray tube which is shown in more detail in Figure 8 was purchased from Westinghouse, Baltimore, Md. It is a rather unique device and consists of specially designed stainless steel chamber which allows the flexibility of changing electro-optic crystals and electron guns. The gun which was supplied by Westinghouse is a high resolution gun with the capability of producing a .7 mil spot size. The control element was obtained from Autonetics, Anaheim, California, and consists of a 1" x 1" x .020" KD_2P crystal (with a deposited electrode) mounted on a glass substrate.[7]

Additional drive and interfacing equipment was assembled to provide simple images and closed-circuit TV (525 line standard) for image evaluation.

A block diagram of the video drive circuitry is shown in Figure 9. Because the metallic construction of the chamber was placed at ground potential and a negative voltage was applied to the cathode of the gun, the design introduced the problem of supplying low video

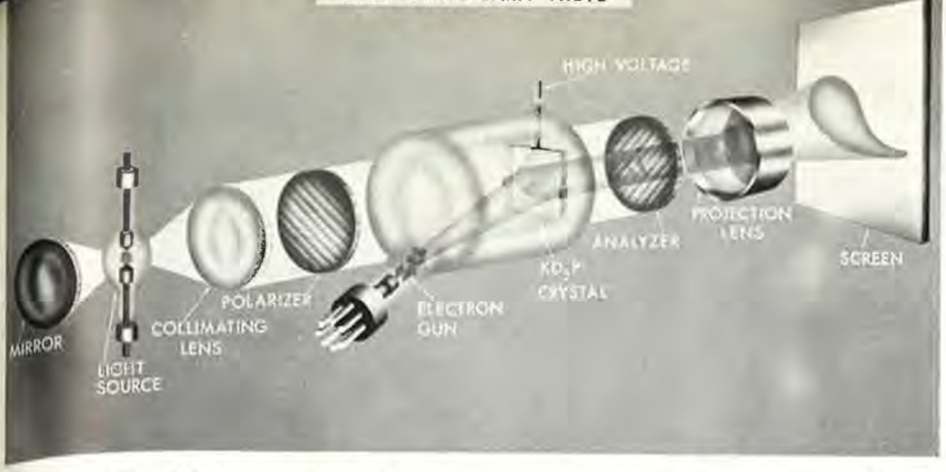


Figure 6.

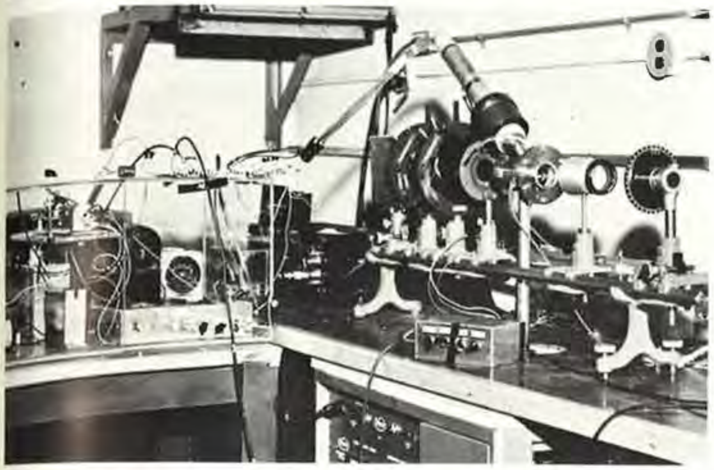


Figure 7.

voltages to the cathode which was a high negative potential. The 40 mc. carrier was modulated to couple the video signal through a high voltage capacitor which served as the D.C. isolator.

A TV resolution chart view of the closed circuit TV was projected using the predescribed solid state model and is shown in Figure 10. Operating conditions of electron gun were as follows: beam voltage of 19KV, focus voltage of 6.2KV, beam circuit ~ 2-10 μA. A resolution of about 250TV lines per inch was demonstrated, however, it was felt that the resolution was limited by the following factors: (1) the video coupler is limited in bandwidth (~ 2mc bandwidth), (2) the focus supply used is not properly regulated (a 5 volt change on a 5 kilowatt voltage is significant to defocus the electron beam spot), and (3) a thinner crystal of approximately 4 mil thickness should be used to provide maximum grey scale and resolution.

Contrast measurements indicated a contrast ratio in excess of 150:1. Measurements of optical efficiency from light source to screen approximated 5%.

Initial experiments with a DKP crystal with similar transparent electrode showed an image of reduced brightness. This appearance may have resulted from the differences in potentials (½ wave retardation voltage for KDP is 7200 volts), but further comparative tests indicated that KD_2P possessed a definite increase in optical sensitivity. ADP was also inserted in the chamber and the image produced was almost identical with that of KDP.

Some exploratory tests were run on this experimental light valve to become familiar with the equipment. Electron gun potentials, anode voltage, vacuum pressure, scan configuration and optical polarization were varied to achieve optimization of the image. Continued operation of the light valve indicated a slight discoloration and deterioration of the crystals. This was attributed to the high vapor pressure of the crystals and their instability under an electron beam. In view of this fact no experiments involving this problem were considered for further investigation since it was thought that coatings applied to the crystal surface would remedy this situation. The chamber was continuously pumped to prevent contamination of the electron gun.

As reported earlier in this report, Autonetics under the sponsorship of RADC is also investigating this technique for military application. They, too, have demonstrated a TV image and indicated a resolution capability of 250 optical lines per inch. They have developed techniques for sealing the crystal and incorporating a Vacion pump for a sealed-off device. A final report of this investigation should be available within a few months.

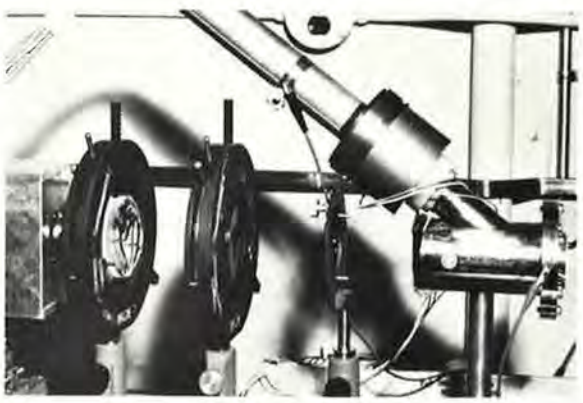


Figure 8.

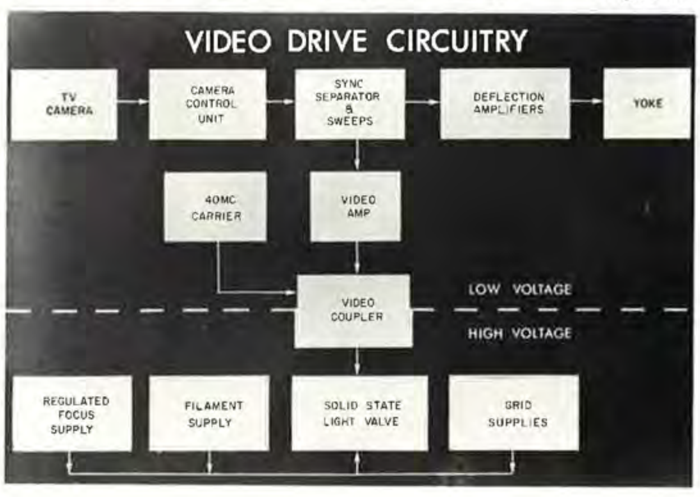


Figure 9.

Conclusions and Recommendations

It has been demonstrated that the solid state light valve which uses an electro-optic crystal as a modulating device is definitely feasible and appears quite promising for large screen display applications. Studies and experiments performed with presently available electro-optic crystals have indicated that the $\bar{4}2m$(Vd) Tetragonal class is best suited for this application; and particularly KD_2P, since it possesses lower half-wave retardation voltage and an inherent storage capability which makes the optical image appear brighter. The simple images and TV images that were generated by the experimental model indicated that the technique has great potential, particularly for real-time displays.

Figure 10.

The materials studies performed during this investigation point out a deficiency of available electro-optic crystals. For optical modulation applications which include the laser technology, electro-optic crystals must exhibit a strong electro-optical coefficient, single crystalline structure of sufficient size and must possess relatively good optical and electrical properties. These requirements have somewhat restricted the types of crystals to two crystal classes with limited crystal in each class.

A materials research program is required to develop new and improved electro-optic crystals. Such a program should include growing of new crystals, particularly the KDP isomorphs and measurements of optical and electrical properties. The crystals must be single crystal, strain free, uniform in resistance, free of aqueous inclusions and stable in a vacuum. As might be expected, this combination of requirements is generally difficult to meet in practice.

Continued studies both on contract and at RADC are anticipated and will be directed toward: (1) optimizing the resolution capabilities, (2) investigation of the effects of higher optical flux densities, (3) examination of the heating effects and methods of cooling the control elements, and (4) design of a solid state device for large scale display applications. Pending the results of these studies a system concept will be considered later to include full color capability and peripheral drive equipments. Hopefully, within a two year period this technique will be useful as a practical large screen projection device.

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ID Correspondence

Management Systems

I read with interest Mr. Raymond E. Bernberg's article, "A Look at Future Management Data Display Technology," in the January/February issue of your fine journal. Mr. Bernberg is quite right that management systems use seriously lags behind command and control type systems use particularly in government research and development activities. The lag, however, in my experience (13 years in Air Force research and development planning and programming) is *not* due nearly so much to technology deficiencies as to human limitations in the practice of the management arts. Managers are either unaware of the current potential for automation of management data and its display or they are unwilling to integrate fully into their regular operations an automation capability for many reasons. Many half-hearted attempts to "graft" onto their operations some data processing equipment has resulted only in complete failure because the users cannot rely on the products produced.

We in the Air Force Office of Scientific Research have a management data and scientific information handling system that has been in full operation since 1 July 1963. This system does work, and works well and enjoys the full confidence of the users because it was fully integrated into our operations. The system is now being extended by our parent organization, the Office of Aerospace Research, for use in its other three research centers, thus giving a command-wide capability.

DONALD R. CURRIER
Lt. Colonel, USAF
Assistant for Plans and Programs
Air Force Office Scientific Research

Corrections

Will you please advise your readers of two errors that were made in my article "Displays, Papers, and Lighting" in the Sept./Oct. issue of *Information Display*.

There was a displacement: Lines nine to fourteen, first column of page 26, should have been printed at the bottom of page 20.

And there was an omission: The Handbook of the Illuminating Engineering Society states that their recommendations are based on the more difficult office tasks, such as reading poor carbons. They appreciate the value of good contrast in reducing the required illumination, as is shown by the more detailed statements of their Committee on Recommendations (see reference five) where less than three footcandles is recommended for reading typed originals and print in common sizes.

A. C. STOCKER
RCA

* * *

What is OK with D.O.D.?

I have read Dr. Ruth M. Davis's article in the first issue of *Information Display*.

For the last two years I have been a Display Project Engineer on the AWCS 412-L Project for General Electric. Part of my duties have been concerned with the 412-L Light Valve and the problems we have faced. It is my feeling that although we have had our problems and more money was spent than originally planned, the 412-L Light Valve is doing the job. Can Dr. Davis state what Large Scale Displays (both Static and Dynamic) the Department of Defense deems operational and is the 412-L Light Valve considered operational?

When Dr. Davis said that "no color display has yet been used by the Command for what it was intended", I assume she meant for extended periods of time. The Air Force has stated that the Light Valve does provide the type of information necessary for evaluating the air situation on a real time basis and the display is more than adequate. The only question has been one of maintainability and relability.

I feel that one of the major problems in the design of a Large Scale Display is that many times the procuring agency does not know what the Using Command really needs and this leads to the Using Command being dissatisfied with the product they must use and maintain.

The contents of this letter reflect my own views and not those of my employer.

JOHN W. WALTERS
Display Engineering Unit, G.E.

* * *

Information requested

The following display devices are to be used in conjunction with the existing Apollo Data Processing Laboratory. This display will permit display and analysis of data in an area remotely located from the laboratory. The input data source to the displays will be either generated or called for from the laboratory and will be in a digital format.

1. Cathode Ray Tube Displays; Bar Charts, Monitor Scopes, Charactron Tube.
2. Microfilm Handling; recording, processing, projection, displaying, storage, retrieval, hard copy conversion.
3. Visual Readout; nixies, electroluminescent, meters.
4. Recorders; strip chart, event, oscillographic.
5. Plotters.
6. Color Displays.
7. Closed Circuit Television.
8. Projection System.
9. Information Storage and Retrieval System.
10. Data Expansions contractions, overlays annotation.

The undersigned is requesting literature and brochures from various suppliers on these data display devices and techniques. An information which you can have sent or send in this regard will be appreciated. On any literature sent please reference the number MO8604.

R. D. SCOTT, *Buyer*
Divisional Purchasing
Test Equipment Section
NAA Space and Information Systems Division

* * *

Higher resolution

We feel there are two misstatements of fact appearing in the article "Display Requirements of the Integrated Management Information System 1968-1970" appearing in the November/December 1964 issue of the Journal.

The authors state that the Eidophor is currently available with resolution of 525 lines and will be extended to 1000 lines by 1968. Theatre Network Television, Inc., the exclusive distributor of the Eidophor in the U.S., has had standard high resolution models of the Eidophor available for some time giving resolution in excess of 1000 lines. Numbers of these high resolution Eidophors have been delivered and are currently giving satisfactory performance. Some of these high resolution equipments were delivered well over a year ago.

Since the authors make no differentiation between scanning standards and resolution, I feel it is important that your readers be aware that the Eidophor is available with both more than 1000 raster lines and more than 1000 lines of resolution.

As distributors of the Eidophor, we are mystified at the low figure for MTBF quoted by the authors as this figure can nowhere be borne out by fact. Further, the system price stated by the authors for class 1V which includes the Eidophor at the low end of the range shown is much too high for the most complex Eidophor system conceivable, and is many times the cost of the average Eidophor system.

ERWIN BERNSTEIN
Director of Marketing
TNT Electronics

* * *

Display Glossary

In our work at the American University relating to electronic information display systems, we have been faced constantly with a need for a Display Glossary suitable for managerial personnel. Not being able to find any display glossary at all, I have compiled one myself. In preparing it reference was made to various books of others. Therefore, credit is given to the following individuals for definitions taken wholly or in part from their writings or statements:

Bill Bethke
Frances Darne
Ruth Davis
Rudy Kuehn
Dick Loewe
Ray Sabeh
Harvey Talmadge

In addition, some definitions are directly taken from the Bureau of the Budget's "Automatic Data Processing Glossary," dated December, 1962, and available from the Government Printing Office, and others are from a working paper prepared by a committe of Working Group VI.

Perhaps some of the readers of *Information Display* will be interested in this Glossary of Selected Terms, a copy of which is enclosed.

JAMES H. HOWARD
Center for Technology & Administration
The American University
Washington, D. C.

See next page →

DISPLAY GLOSSARY

[To our knowledge, the glossary presented on these pages represents the first compendium of ID terminology ever assembled. Reader Howard (see letter on preceding page) is to be commended for his valuable efforts—Ed.]

ACCESS TIME, DISPLAY – Time lapse between a user's request and the display of requested information.

ACUITY (VISUAL) – The ability of the human mechanism to distinguish small spatial separations or intervals between portions of the visual field; ability to distinguish closely spaced, small objects, or to detect individual small elements. It varies with contrast, luminance, and the nature of the target.

ALPHANUMERICS – Alphabetic and numeric characters.

CELL, MATRIX – The assembly in a regular pattern (matrix) of a discrete number of individually excitable light-producing, or absorbing elements (cells).

CHARACTER GENERATION – The generation electronically, of an identifying over-lay on a conventional display, or on a display surface in the absence of another display. In one form of character generator, the device consists of X and Y Integrators which convert digital instructions from character matrices into analog wave forms. These wave forms trace out the character on a CRT.

CODE – A set of symbols employed to convert a given set of data or items into a quantitative or qualitative series.

CODING – Visible markings on a two-dimensional display surface may be by color, size, shape, orientation, blinking, etc.

COLOR – The characteristics of light other than spatial and temporal in homogeneities. Color sensations are caused by a combination of luminance, wave length, and purity.

COMMAND (MILITARY)—Those decisions and actions which establish military objectives, strategies, policy and direction of action consistent with available resources, the political climate and directives from higher echelons. These decisions and actions are extremely sensitive to the Headquarters Organization and the organization within the various operational commands, and to their own reaction on the political climate and objectives.

CONSOLE, SMALL DISPLAY, INDIVIDUAL – A display used by one or two individuals at most; usually for tracking, composing messages, monitoring, or information retrieval.

CONTRAST – That parameter which is concerned with difference of luminance; difference in brightness between two portions of a visual field, change in apparent brightness of color of a visual field as a result of recent stimulation of this field, or a neighboring one, with an effect of enhancing opposing characteristics.

CONTROL (MILITARY) – Those decisions and actions which attempt to achieve a specific military objective in accord with the policy and guidance established by command. These decisions and actions are extremely sensitive to the restraints of the physical environment and equipment which must operate in the environment.

COPY, HARD – A printed copy of machine output; printed reports, listings, documents and summaries.

COPY, SOFT – The image of a display screen, characterized by impermanence.

CURSOR – A device manually operated by the display operator to identify a particular X and Y position on the display screen (CRT) to the computer. Often it is in the form of crosshairs. A mark does not usually show on the display.

DECAY, LUMINANCE – The decrease in luminance with time lapse after excitation.

DISPLAY – Any mechanism by which information is presented to the user via one of the senses.

DISPLAY, AUTOMATED – A display either controlled and/or at least partially generated by an electronic computing device.

DISPLAY, DYNAMIC – A display within which data appears to move continuously along some path; a display in which data or information are continuously changing, often at high rates of speed. A dynamic display is not necessarily a real-time display.

DISPLAY, GROUP, LARGE – A large screen presentation for viewing by a group (more than two) as opposed to a console or small screen display.

DISPLAY, PANEL – A non-projection, large scale, display surface which may be either self-luminous or reflect external ambient light.

DISPLAY, PROJECTION – A smaller image is rendered larger, the input brightness usually being provided by an auxiliary light source (e. g., the projection lamp of a slide projector).

DISPLAY, REAL TIME – A display in which the time required to generate and present a display frame is within the sensory reaction time of the observer (i. e., 40 msecs.).

DISPLAY, VISUAL – A picture; a configuration of symbols, alphanumerics, etc., arranged so as to portray a situation; a status board indicating schedules, inventories, etcetera

DISPLAY, VISUAL (ALTERNATE DEFINITION) – A mechanism that presents information via the eye, which can receive information in terms of angular and depth perception, of luminance and chrominance discrimination, and coding in shape, size, orientation, blinking, and motion.

ELECTROLUMINESCENCE – The characteristic of some materials to emit light at a given frequency when subjected to an alternating electric field.

ELECTRONIC – Pertaining to that branch of science which deals with the motion, emission and behavior of currents of free electrons, especially in vacuum, gas or phototubes and special conductors or semi-conductors.

ELECTRONIC TYPEWRITER – A device consisting of a CRT display, a keyboard, digital storage, and digital logic, designed to display messages as they are composed, and usually prior to release to the system, thus permitting verification, correction, or erasure. Format can be displayed on demand and appropriate data entered in some designs.

ENTRY, KEYBOARD – An element of information inserted manually, usually via a set of switches or marked punch levers called keys, into an automatic data processing system.

FLICKER – The sensation resulting from continued intermittent stimulation of the visual mechanism over a limited range of alternations.

FORMAT – Format refers to the positioning of information within a display.

FORMAT, FIXED – A format in which the location of the various elements of data or information are predetermined and cannot vary; e. g., tabular.

FORMAT, FREE – A format in which the position of any element of information is not fixed and may depend on the information itself; e. g., display of an identification symbol or character, display of a segment of a curve; free formats generally must have some frame of reference.

INDIVIDUAL CONSOLE, INTERCOMMUNICATING – The individual console forms part of an intercommunicating display system such that an operator at any given console may change the display at any other console, or have his display so changed. Intercommunications are under operator control.

KEYBOARD, PROGRAM – An arrangement of keys or buttons used to communicate with the computer associated with a display. Each key, when activated, causes the computer to perform some pre-programmed operation.

LANGUAGE, PROBLEM ORIENTED — A machine independent language where one needs only to state the problem, not the how of solution.

LANGUAGE, PROCEDURE ORIENTED — A machine independent language which describes how the process of solving the problem is to be carried out.

LINE GENERATORS — A device which generates arbitrary line drawings on the cathode ray tube face. Some line generators will accomplish this by defining enough adjacent points (dots) to form a continuous line; the vector method describes a starting point and a sequence of direction and distance.

LUMINANCE — The luminous emittance in one direction from an extended source, measured in lumens per unit area per steradin.

MATRIX — An array of coupled circuit elements; a mathematical arrangement of elements in columns and rows, the whole being capable of mathematical manipulation.

MODULE — An interchangeable plug-in item containing components; an incremental block of storage or other building block for expanding the computer capacity (or display system capability).

MONITOR — To supervise and verify the correct operation of a program (display of information) during its execution.

MULTIPLEXING — The transmission of a number of different messages simultaneously over a single circuit; utilizing a single device for several similar purposes, or using several devices for the same purpose.

OPERATION, REAL TIME — The use of the computer as an element of a processing system in which the times of concurrence of data transmission are controlled by other portions of the system, or by physical events outside the system, and cannot be modified for convenience in computer programming. Such an operation either proceeds at the same speed as the events being simulated, or at a sufficient speed to analyze or control external events happening concurrently.

PLOTTER — A visual display or board in which a dependent variable is graphed by an automatically controlled pen or pencil as a function of one or more variables.

PLOTTER, XY — A device used in conjunction with a computer to plot coordinate points in the form of a graph.

PROJECTOR, LIGHT VALVE — A projection display device which employs a control layer (either liquid or solid) to modulate the projection source. An essential is the reversibility of the control layer, thereby allowing for a single layer to present a sequence of display frames in near real time.

REAL TIME, DISPLAY — When the delay between the generation of the data by the data-processing system and its subsequent presentation to the audience is insignificant in relation to the operations for which the information is to be used.

REQUIREMENTS — Those qualities of an equipment, system, sub-system, etc., which define its essential performance characteristics to a given user.

REQUIREMENTS — That property of a material, device, process, or system which connotes its ability to produce or reproduce fine detail under stated conditions and that the measure of the image fineness or detail is an indication of resolution magnitude.

RESPONSE TIME, DISPLAY GENERATION — Time from initiation of computer output until the complete display can be viewed.

RESPONSE TIME, REQUEST — Time duration from a request until the display appears.

RESPONSE TIME, UPDATE — Time between the entry of new data into a display system and the resulting data displayed or ready for display.

RETRIEVAL, FALSE — The library (file) references which are not pertinent to, but are vaguely related to, the subject of the library search and are sometimes obtained by automatic search methods.

RETRIEVAL, INFORMATION — The recovering of desired information or data from a collection of documents or other graphic records.

ROUTINE, EXECUTIVE — A routine which controls loading and relocation of routines and, in some cases, makes use of instructions which are unknown to the general programmer. In display systems, the executive routine would implement executive control procedures, as the handling of priorities, interrupts, scheduling, security procedures, sub-routine access, data base maintenance, etcetera.

STORAGE — A term preferred to memory, pertaining to a device in which data can be stored and from which it can be obtained at a later time.

STYLUS — An electronically generated marker produced on a display screen, usually for the purpose of indicating where the next entered character will be displayed.

SYMBOLS — Shapes, usually arbitrary, used to represent complex thoughts, objects, or events. The alphanumeric characters are symbols.

SYMBOL GENERATION — The process of converting a coded digital description of a symbol to an image of that symbol.

SYSTEM — An assembly of procedures, processes, methods, routines, or techniques united by some form of regulated interaction to form an organized whole.

SYSTEM, INFORMATION RETRIEVAL — A system for locating and selecting on demand, certain documents or other graphic records relevant to a given information requirement from a file of such material.

SYSTEM, MANAGEMENT INFORMATION — A communication process in which data are recorded and processed for operational purposes. The problems are isolated for higher level decision making, and information is fed back to top management to reflect progress or lack of progress made in achieving major objectives.

TUBE,CATHODE RAY — ALSO CRT — An electronic vacuum tube containing a screen on which information may be stored by means of a multigrid modulated beam of electrons from the thermionic emitter, storage effected by means of charged or uncharged spots; a vacuum tube in which deflection of an electron beam indicates on a fluorescent screen instantaneous values of the alternating voltages or currents; an electrical signal to light transducer in which electrical energy is converted to visible image on a phosphor screen.

TUBE, CHARACTER GENERATOR — A cathode ray tube which has inherent facilities (such as shaped beam elements) for presentation of one or more characters at the same time. Writing speed may be 25,000 characters per second.

TUBE, DIRECT VIEW STORAGE — ALSO DVST — A cathode ray tube designed for direct viewing, and capable of retaining information displayed without regeneration for long periods of time; e. g., 60 seconds to several days, as designed. The DVST retains advantages of long persistence phosphors while having brightness required by many applications. Writing speeds of one million inches per second are possible.

TUBE, DISPLAY — A cathode ray tube used to display information.

TUBE, SHAPED BEAM CHARACTER GENERATOR — A cathode ray tube that can generate by electronic techniques, one or more numeric, alphabetic, or alphanumeric characters, or special symbols by passing the electron beam through appropriately shaped masks.

UPDATE — To put into a Master File changes required by current information or transactions.

ID Readout

Chapter News

MID ATLANTIC CHAPTER was addressed by Gerald Stone, Associate Director of Research, Hazeltine Corp., at its Feb. meeting. He spoke on "Application of Diffraction Phenomena to Modern Display Techniques". After a review of light diffraction principles, Stone discussed its application and urged more work be done in this area. He demonstrated holograms made at Hazeltine, using a laser light source and a zone plate to illuminate the subject, the resulting diffraction pattern exposing a standard photographic glass plate which was then developed in the normal way. By simply viewing the photographic plate, or hologram, by monochromatic laser light, a three-dimensional image of the subject is seen in space, the photographic plate appearing to be a window through which the image is viewed. An interesting property of the holograms is that if the plate is broken in half, the same total image is seen, but through a smaller window. WASHINGTON CHAPTER highlights have included the following programs in recent months: M. J. Spangler, Westinghouse Electric Corp., and E. E. Smith, Federal Aviation Agency, speaking on use of slow-scan TV to increase the handling and usefulness of weather radar information; Peter Seats, Thomas Tube Co., speaking on advances in conventional CRT technology; William H. Cook., Autometrics Operations, Raytheon Co., reported on developments he had seen in electro-optical and mechanical instrumentation at the Zeiss plant in Jena, Germany; Henry DeFrancesco, Westinghouse Electric Corp., discussed the use of projection displays for automated maintenance, describing a technique which will automatically monitor the operation and display indications of malfunctions, and needed remedial action.

Business Notes and News

RAYTHEON COMPANY'S AUTOMETRIC OPERATION is being equipped with a 440 digital computer system to be used for photogrammetric mapping and other technical services for the government and other clients . . . A new S-C 1200 system which permits display of computer-generated data at a series of locations remote from the data-processing center has been introduced by STROMBERG-CARLSON CORP. . . . UAIDE (Users of Automatic Information Display Equipment) has issued a call for papers no later than July 15 for the 1965 meeting Oct. 11-14 in New York City. One paragraph abstracts should be mailed to C. L. Bannister, R-COMP-RRL, NASA/Marshall Space Flight Center, Huntsville, Ala. . . . SPERRY RAND'S GYROSCOPE CO. DIV. has disclosed details of a modular display console which will work with any kind of radar, sonar, or computer. It is designed for a 100-target capability with range scales from four to 512 miles . . . AF Cambridge Research Laboratories has awarded FEDERAL SCIENTIFIC CORP. a contract for a delay-line-synthesized spectrum-analysis system for speech analysis . . . PERKIN-ELMER CORP. has purchased a SCIENTIFIC DATA SYSTEMS 9300 computer for multiple-station time-shared R&D in optics . . . INFORMATION INTERNATIONAL, INC., will move its headquarters from New England to Los Angeles, with Alfred L. Fenaughty assuming presidency; founder and former president, Edward Fredkin, assumes the title of VP and retains stock control . . . ADVANCED SPACE AGE PRODUCTS, INC., has been acquired by ANELEX CORP. as an autonomous subsidiary . . . DATA PRODUCTS CORP. has delivered the first RO-280 (XN-1) UYK high-speed military line printer (72,000 characters/min.) to the Navy's BuShips.

Lunar Mission Flight-Controller Displays

View of Mission Operations Control Room from the Visitors Viewing Room of NASA's new Mission Control Center (MCC) near Houston. There are 17 console positions in each of the two identical Control Rooms, one on second floor and one on the third. Information is displayed on television monitors, by lights and alphanumeric displays on consoles, and on the large screens and alphanumeric displays which make up the Summary Display Area at front of room. One Mission Operations Control Room can be used to control an actual mission while simulation exercises are being conducted in the other. Philco Corp. implemented the MCC under a $50 million contract.

Highway Safety Paper Author Recuperates

While Edith M. Bairdain's paper envisioning an electronic computer system for super-highway safety was being presented at the recent Symposium in Santa Monica, Calif., the author was recuperating at her Ramsey, N. J. home from injuries received in an automobile mishap after the paper had been completed. The author is a senior systems analyst at ITT Data and Information Systems Div., a unit of ITT. The paper was delivered by a colleague, James J. Connelly. The system proposed envisages a nation-wide traffic control network, masterminded by a large command-type center linked to a complex of electronic devices at each entrance, exit and toll point along the controlled super-highway. Display equipment giving a graphic rundown on traffic conditions would be located on the highways as well as at access approaches, in traffic control headquarters buildings and toll booths. At access points, the registration and driver's license, displayed on the windshield, would be scanned by electronic means and a real-time check would be made to a central computer containing registration numbers, and including data on license validity and law-enforcement status of the holder. The computer would initiate a "go" signal (green light) or "stop" signal (red light). In the event of a "stop" signal, the driver would be instructed to move into a "hold" area for questioning. Only one guard would be required to monitor eight lanes of traffic.

Digital-to-Video Display System

A new system which permits display of computer-generated data at a series of locations remote from the data-processing-center has been introduced by Stromberg-Carlson Corp. Designated S-C 1200, it translates digital data from a computer to a visual format for display on the screen of one or more TV consoles. In the system, the computer feeds data to a data distributor. From the distributor, the data are sent to the selected buffer which consists of a core memory, display generator selection circuitry, load and unload circuitry. The buffer continuously repeats the information to a display generator to supply sufficient repetitions to permit flicker-free viewing. Each buffer can drive four generators. The display generator presents the data on the face of a special CRT in the form of letters, numbers, symbols and lines of any kind, and can produce complex figures or curves by joining line segments (vectors) together.

Single-Pass Color Separation Printer

A new single-strip area-sharing separations printer, designed and supplied by Colorvision, Inc., has been installed by Consolidated Film Industries which anticipates a saving of two-thirds in processing cost/screen ft. The system, invented by Lionel H. Wheeler, Colorvision VP, provides archival-type protection in terms of reduced laboratory time and storage requirements. In the process, all three color components are recorded simultaneously during a single pass through the printer in three separate areas within the confines of a single 35mm full aperture frame. Three-color exposure control is also accomplished, with overall contrast control obtained during processing. According to Colorvision, results show that color prints from color duplicates made by the new separation system are superior in terms of color fidelity and image sharpness, compared to results obtained by the intermediate color positive system.

Instant Time Anywhere in World

Instant time can be read for any point in the world on a new clock unveiled at Bank of America's recent worldwide management conference in San Francisco. The clock shows simultaneously the hour, day and date in each of the world's time zones. Bell-shaped light curves in the center of a map-face automatically delineate areas of daylight and darkness. Hour band and zone arrows form a "belt" across the top of the moving map. A minute dial and a date indicator are included.

The map-clock was invented by James Kilburg and is being manufactured by Kilburg Geochron Corp., San Carlos, Calif. The first hand-built world-time indicators off the assembly line will be installed in all Bank of America overseas offices.

Integrated Circuit Character Generator

Information Displays, Inc. (formerly RMS Associates, Inc.) claims the first commercially available integrated circuit character generator. Termed Type CLX33083, it is packaged on two 8-in.-high by 3⅞-in.-wide plug-in circuit boards. Stroke writing is used for character generation. Only two formats are used in the alphanumeric unit and rounding is not available at present in the integrated circuit unit. It is capable of generating all digits, all letters (except the Q and Z), and four special symbols at rates up to 50,000 characters/sec. A crystal control clock is featured which allows the unit to be utilized as a clock source for other equipment in addition to performing the nominal function of character generation.

General-Purpose Digital Logic System

An economical general-purpose digital logic system that adds hybrid capabilities to small analog computers has been announced by Electronic Associates, Inc. The system, termed DES-30 (Digital Expansion System) may be linked to any general-purpose analog or digital computer, or may be used autonomously as an aid to digital instruction or design.

Circle Reader Service Card No. 8

Fifth National SID Symposium

The Fifth National *SID* Symposium, Feb. 25-26 at Santa Monica's Miramar Hotel, has been termed a complete success. Attendance was good, despite some interference in airline travel due to weather.

Conference Chairman R. E. Bernberg told the Journal that "All sessions, including luncheons, the annual banquet, and technical meetings, were well attended. I feel that most attendees thought it a better-than-ordinary symposium."

Bernberg paid particular tribute to the banquet address Feb. 25 by Egon Loebner, research specialist, Hewlett-Packard Associates, Palo Alto, Calif. He described Loebner's address as, "Fascinating, the sort of presentation required to inspire and motivate." Loebner's topic was, "The Role of the Interdisciplinarian in Display Technology".

Top convention officials assisting the Chairman were Louis M. Seeberger, Co-chairman; E. A. Ulbrich, Technical Program Chairman; Rudolph L. Kuehn, Papers Chairman; and Edward Ries, Exhibits Chairman.

TOP LEFT: New national SID officers are, from left to right, William P. Bethke, VP; James H. Redman, President; and William V. Taylor, Secretary. LEFT: Banquet speaker, Egon Loebner, research specialist, Hewlett-Packard Associates, Palo Alto, Calif., spoke on "The Role of the Interdisciplinarian in Display Technology". BELOW: Part of head table delegation is shown enjoying an address. From l to r: Louis M. Seeberger, President, host Los Angeles Chapter and Symposium Co-chairman; Sherman H. Boyd, new National Treasurer; Petro Vlahos; and Wendell F. Miller, Symposium Publicity Chairman.

Inspiring and Well Attended

ABOVE: Newly-elected National President James H. Redman (left) takes office from Virgil P. Barta, retiring VP. Weather conditions prevented Anthony Debons, retiring President, from attending but he spoke to the Symposium via a special telephone hookup. TOP RIGHT: R. E. Bernberg, Symposium Chairman, makes opening remarks. RIGHT: A. C. Stocker (second from right), Fourth Technical Session Chairman, talks things over with Donald Blake (second from left) and associates. BELOW: Rudolph L. Kuehn (left), former President of SID, receives Fellow award from H. R. Luxenberg, also a past President.

Sixth Symposium

Fordyce Brown, pres., Photomechanisms, Inc., has been elected Chairman of the Sixth National Symposium.

Inquiries may be directed to Mr. Brown, c/o Photomechanisms, Inc., 15 Stepar Place, Huntington Station, New York.

The SID Sixth National Symposium is scheduled Sept. 29-30 at the Hotel Commodore, New York City. A call for papers will be issued shortly by Dr. Edward Kennedy, of Rome Air Development Center, Rome, N. Y.

10^{12} traces/sec. 500 traces/in.

is this enough—or do you need more?

This is the writing speed and resolution of a new Du Mont cathode ray tube with fiber optics faceplate (Type K2427). In addition, the tube was designed to occupy minimum space and to withstand severe environmental conditions.

Maybe you don't need this kind of performance—or maybe you need more. In either case look to Fairchild's Du Mont Laboratories first. Du Mont has designed and built over 4,000 discrete tube types — CRTs, Storage Tubes, PMTs and Power Tubes. Many of these are off-the-shelf, the rest quickly available. If the tube parameters of your job are so far-out that no existing tube meets them, that's all the more reason to talk to Du Mont first. No one is better equipped to design and build it for you. That's how most of our 4,000 types came into being. Call your Du Mont sales engineer or get in touch direct with the Electronic Tube Div. of Fairchild's Du Mont Laboratories, Clifton, New Jersey.

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book reviews

Optoelectronic Devices and Circuits by Samuel Weber, Senior Editor, Electronics. 358 pages plus index; 480 illustrations; 8⅜ x 11; McGraw-Hill; $15.00.

"Optoelectronic Devices and Circuits," a compilation of 98 articles, deals with the subject of light and its application to electronic circuits and systems. It provides a background in optical techniques for the practicing engineer and presents examples of circuits and systems which have been tried and proven in a variety of applications. Included in the 12 chapters of the book is data on the latest devices in optoelectronics, i.e. the use of light-emitting diodes, and all types of lasers, fiber optics, and electroluminescent devices. The main body of the book is supplemented by an Appendix composed of letters and comments on the various articles.

Chapter 1 provides a basic grounding in optics, fundamentals of fiber optics, and an understanding of how the major types of lasers work. Chapter 2, a series of articles describing system applications of lasers and general design considerations necessary to implement them, gives examples of actual circuits and some graphic design aids for lasers. Examples of devices and circuits used in the generation, modulation, and detection of light for point-to-point communications are presented in Chapter 3. Military and space applications are covered in Chapter 4.

The specific application of infrared to a wide variety of functions is the subject of Chapter 5. Chapters 6-12 are: Display Systems – discusses modern display systems utilizing the phenomenon of the electroluminescence and describes some unusual approaches to the realization of three-dimensional displays; Pattern Recognition – how optoelectronic devices and circuits may be used to duplicate the human sense of sight and recognition; Computers and Digital Applications – how optoelectronics may be applied to the computer functions of data storage, switching, and counting, and includes a speculative article on prospects for an all-optical computer; Industrial Applications – how optoelectronics may be used for control in a variety of industrial processes; Instrumentation – how light and electronics combined can provide versatility and utility in sophisticated measurement problems; New Concepts in Television; and Unconventional Optoelectronic Devices.

Electronic Analog and Hybrid Computers by Granino A. Korn, Ph.D., Professor of Electrical Engineering, University of Arizona, Tucson, Arizona, and Theresa M. Korn, M. S. 564 pages plus index; 442 illustrations; 6 x 9; McGraw-Hill; $17.50.

"Electronic Analog and Hybrid Computers" presents authentic, up-to-date design information on hybrid analog-digital computing devices and systems, including circuits for instrumentation, control, and data processing as well as for general-purpose problem solving. The authors introduce improved computing techniques made possible by ultra-fast hybrid analog-digital computers, and they present new successful applications of electronic analog/hybrid computers.

Chapter 1 and 2, comprising Part 1 of the book, intrduce classical electronic analog computation and tried programming and scaling procedures. The second part of the book, Chapters 3 through 9, deals with the actual design of modern analog computing elements. Part III, Chapters 10 and 11, covers the design of complete analog and hybrid analog-digital computing systems, and Part IV, Chapter 12, introduces the novel mathematical techniques opened up by the new iterative differential analyzers. Chapter 12 begins with accurate perturbation methods for space-vehicle-trajectory computation and steepest-descent methods for continuous optimization and improvement of computing accuracy and ends with a brief account of analog/hybrid techniques for solving partial differential equations and integral equations. The major part of the chapter is devoted to circuits for automatic parameter optimization.

Among the recent advances in computing circuits covered, are design of wideband feedforward amplifiers; design of low-drift and wideband transistor d-c amplifiers; design of diode and transistor analog switches; design of fast track-hold circuits and integrator-mode switches; and design of fast comparators. Turning next to complete computing systems, the book treats the design of iterative differential analyzers, philosophy and design of digital control circuits, and digital expansion systems.

ID Products

Microminiature Variable Delay

A microminiature variable delay line has been developed by Computer Devices Corp. The V981, with a total volume of 0.072 cu. in. (0.3 x 0.3 x 0.8 in.) is considered the smallest unit of its type ever produced, according to the manufacturer. Designed primarily for use as a trim delay in variuos computer circuits, it has numerous other potential applications where time-coordination is critical.

Four delay ranges are offered, with the -1 unit having a range of 3 to 25 nanoseconds at an impedance of 1000 ohms, to the -4 unit with a range of 5 to 100 nanoseconds at an impedance of 50 ohms. Resolution of all units is less than 1/100, temperature coefficient is less than 50 ppm/°C and attenuation is less than 1 db.

Additional information may be obtained by writing to Computer Devices Corp., 6 West 18th St., Huntington Station, N.Y. 11746.

Circle Reader Service Card No. 25

Automatic Retrieval Device

A new system, easily adaptable to almost any retrieval or display problem needing a readily accessible library of information, has been developed by the Houston Fearless Corp. Designated CARD (Compact Automatic Retrieval Device), it is a simple, compact storage retrieval device for rapid random access to large quantities of film slides or cards.

CARD can be tailored for self-contained reference viewers with front or rear projection systems. It may also be integrated as a peripheral device with computers for data and image storage. CARD modules are versatile enough for almost any application requiring from 1½ to 2½ seconds average access time.

Further information may be obtained from Houston Fearless Corp., 11801 W. Olympic Boulevard, Los Angeles, Calif. 90064.

Circle Reader Service Card No. 26

New 10-Inch CRT

A new 10-in. cathode-ray tube, for use in numerous industrial and military applications requiring high resolution, is now avaliable from the Westinghouse Electronic Tube Div. Photographic recordings and alphanumeric displays are included among its many uses.

The WX30176 is capable of tracing a 0.002-in. line width over the entire screen. Auxiliary deflection plates permit small-amplitude deflection of the electron beam independently of the normal magnetic scanning. The round, flat-faced tube is aluminized, and can be supplied with most of the JEDEC registered phosphors.

For further information, write to the Westinghouse Electronic Tube Division, Elmira, N.Y. Circle Reader Service Card No. 37

RFI-Shielded Readout

A new readout which features RFI suppression over most of the usable radio frequency spectrum has been announced by Cal-Glo Co., manufacturer of a complete line of projection-type readouts. The design includes suppression of spurious RFI radiation from the incandescent lamps used as light sources in the readout. Designated the Shelly "Gold-Band" readout, it is designed especially for use with missile systems, radio astronomy, and in other areas where radio interference must be minimized.

It features a gold-plated condenser lens housing, a phosphor bronze contact strip, redesigned readout housing, electrically conductive projection screen, and a special electrically gasketed bezel. It is claimed that attenuation in excess of 100 decibels is provided at frequencies up to 15 gc by the combination of suppression techniques employed.

For detailed information, write to Cal-Glo Co., 111 Eucalyptus Dr., El Segundo, Calif. Circle Reader Service Card No. 27

Jumbo Numerical Readout

A new jumbo-sized numerical readout tube has been introduced by National Electronics, Inc. NL-7037 is a long-life, cold-cathode neon-glow tube displaying 2-in.-high numbers from 0 to 9. The tube has an ionization voltage of 250 v dc min., and can be used at higher anode voltages with the proper anode resistor. Anode current ranges from 6 to 10 ma dc with a typical value of 8 ma dc.

The manufacturer states the large character size and bright neon glow give excellent readability at viewing distances greater than 100 ft. The side view configuration, small over-all size, and light weight are said to make it excellent for wall-panel displays.

For further information, write Joe S. Kirk, National Electronics, Inc., Geneva, Ill. 60134.

Circle Reader Service Card No. 28

Datastrobe Multicharacter Readout

Raytheon Co. has introduced Datastrobe, a new standard line of electronic readout devices with a wide range of data processing and instrument applications. Stroboscopic techniques are employed in the system to project multicharacter presentations with steady, bright illumination. Specialized symbols and alphabetical and numerical characters of any font, type face, or language can be specified.

Datastrobe offers in-line, in-plane readout; well-defined, nonsegmented characters; wide-angle viewing; and a fail-safe display feature. The new readout system can be used with computers; digital test equipment; digital control, range radar, and air and sea navigation systems; and remote readouts for countdown, airline arrival/departure, and brokerage data.

Inquiries may be directed to V. Stevens, Components Div., Raytheon Co., Lexington, Mass. 02173.

Circle Reader Service Card No. 29

Flatbed Digital Plotter

A Model 502 digital incremental flatbed plotter with a plotting area 31 by 34 in. has been introduced by California Computer Products to complement the firm's drum plotter series. Model 502 is designed for high-speed high-resolution plotting of digital computer output where decision-making requires full and continuous view of the plotting area in situations such as real-time tracking, navigation or testing. It may be used either on-line or off-line with most digital computers.

The digital incremental principle incorporated provides long term, stable, drift-free operation. Alphanumerical and special symbols may be drawn at full plotter speed (18,000 steps/minute, 0.01 in./step).

For additional information write Marketing, California Computer Products, Inc., 305 Muller Ave., Anaheim, Calif.

Circle Reader Service Card No. 30

Transistorized Video Monitor

A 9-in. transistorized video monitor has been introduced which provides professional signal quality though it draws less than 50 w power, reducing heat generated in the racks. The Conrac Model RNB9 general-purpose unit is smaller and lighter than conventional small-screen monitors, and utilizes a newly-developed tube which provides improved geometry and a small spot size.

The tube provides 800-line center resolution and 700-line corner resolution. Picture height and width can be adjusted from the front of the monitor to show all four sides and corners, providing a picture about 2 square in. larger than on conventional 8-in. tubes.

Additional information can be obtained from Ted Michel, Conrac Div., Giannini Controls Corp., Glendora, Calif.

Circle Reader Service Card No. 31

Radiation-Tolerant TV Camera

Production of a Series 2500 radiation-tolerant TV camera has been announced by Kin Tel Div.., Cohu Electronics, Inc. Quality pictures can be televised from radiation environments up to a cumulative dosage of 10^8 Roentgens and/or 10^{15} neutrons/cm^2. The small number of electronic components in the 3-in.-diam. cylindrical camera head assures minimum circuitry exposure to radiation. Components and materials in the camera head are able to withstand gamma and neutron dosage up to stated levels with no degradation of system performance specifications.

Horizontal resolution of the 10-mc system exceeds 600 lines. The camera head will operate in a temperature range of —20° to 55°C without auxiliary heating or cooling, and in humidity up to 100%. Camera head and pre-amp may be separated by as much as 100 ft. of radiation-resistant cable.

Additional information may be obtained from Kin Tel Div., Cohu Electronics, P.O. Box 623, San Diego, Calif. 92112.

Circle Reader Service Card No. 32

Fourier Spectrum Analyzer

A delay-line-synthesized Fourier analyzer operating at theoretically maximum information-extraction rate has been announced by Federation Scientific Corp. The Model 4A-T high-speed, fine-resolution "SIMORAMIC" spectrum analyzer operates in real time and simultaneously covers the frequency range from 1 to 200 cps without the use of contiguous filters. Incorporation of special frequency-conversion circuits permits the 200-cps frequency coverage of the instrument to be positioned anywhere in the audio-frequency range.

A complete frequency analysis of the input signal is displayed on a 5-in. CRT each second for 1 cps resolution, or every 1/10 second for 10 cps resolution. Real-time hard-copy recordings of the analyzer can be provided on an auxiliary "Intesigraph" recorder, and digital readout accessories compatible with various computers are available.

Additional information may be obtained from Instrument Sales Manager, Federal Scientific Corp., 615 West 131st St., New York, N.Y. 10027.

Circle Reader Service Card No. 33

Square Lens Indicator Light

A new series of "Contempo 300 series" square-lens two-terminal indicator lights is now being marketed. They were designed to incorporate the advanced techniques in the human engineering and factors area. Featuring a ¾ in. square lens, Model 301 mounts in a 7/16-in.-diam. hole and is 1-11/32 in. long.

The outstanding feature of the Contempo series is push-pull installation. The square lens series is designed for replacement of a lamp from the front—"push" to install, "pull" to remove. The lens is available in red, white, blue, green and amber. Contact pressure is maintained by a silicone rubber pressure pad, designed for the Sloan Co. T-1-¾ lamp.

For further information, concerning the C-300 series, and other of the firm's subminiature, ultraminiature incandescent and neon lampholders and fixed indicator lights, contact Marketing Dept., The Sloan Co., P.O. Box 367, Sun Valley, Calif.

Circle Reader Service Card No. 34

Photo Printing System

A new photo-enhancing system which permits direct printing of line-enhanced copy from continuous-tone originals, greatly reducing time and cost of delivering usable information to troops under modern battlefield conditions, has been announced by Watson Electronics & Engineering Co. Termed Model 2832-C FLUOR-O-LINE, it can also be used as an automatic dodging printer to achieve balanced density prints from light-struck, cloud-shadowed, or otherwise badly unbalanced originals.

The first of the new printers has been delivered to the U.S. Army Geodesy, Intelligence and Mapping R&D Agency. The unit is designed to produce "maps" directly from aerial photographic mosaics, without the need for time-consuming plotting and cartographic operations; line copy produced is reproducible by conventional lithography.

For further information, write Watson Electronics and Engineering Co., Inc., 2603 South Oxford St., Arlington, Va.

Circle Reader Service Card No. 35

New Rear-Projection Readouts

A new line of rear-projection readout devices for visual data display is now available with replaceable film to exchange message displays in the field. Each piece of film contains up to 12 different message displays which may be comprised of anything that is photographically reproducible, such as numbers, letters, words, multiwords, symbols, special characters and colors. Each of the 12 messages on the film may be projected into the viewing screen at the front of the unit by lighting the corresponding miniature incandescent lamp at the rear of the unit.

For users whose display requirements change in the field, it will now be possible to remove the original film in an IEE rear-projection readout and replace it with new film containing a complete new set of 12 message displays. Replacement requires a matter of minutes.

For further information write Industrial Electronic Engineers, Inc., 7720 Lemona Ave., Van Nuys, Calif.

Circle Reader Service Card No. 36

ID Authors

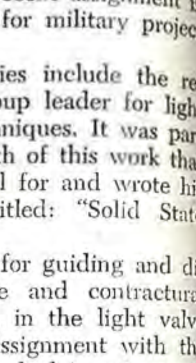
Edward J. Calucci

Awarded the prize for the best paper at *SID's* Fifth National Symposium, Mr. Calucci began his career with a BA in Physics from Syracuse University in 1953, and for the next two years served as a radar repairman for the U.S. Army. Since then he has been employed at the U.S. Air Force Rome Air Development Center, Griffiss AFB, N.Y., where he has served as a physicist, an electronic scientist, and a research physicist. His most recent assignment is in applied research for military projection displays.

Mr. Calucci's duties include the responsibility as a group leader for light valve projection techniques. It was partially as an outgrowth of this work that he compiled material for and wrote his winning paper, entitled: "Solid State Light Valve Study".

He is responsible for guiding and directing the in-house and contractural programs at RADC, in the light valve field. Prior to his assignment with the display group, he worked in microwave techniques.

George T. Nagy



Presently engaged in development of xerographic optical equipments with Electro-Optical Systems, Inc., Pasadena, Calif., a subsidiary of Xerox Corp., Mr. Nagy has extensive research and engineering experience since receiving his MSEE from the University of Technical Sciences, Budapest, Hungary. He served in the University's Research Institute (1950-1957) before coming to this country where he became associated with Sylvania Electronic Products Inc. (1957-58), Ampex Corp. 1958-1961), Optics Technology Inc. (1961-1962), and Autonetics Div. of North American Aviation (1962-1964).

Virtually all of Mr. Nagy's professional career has been in the associated fields of electronics, electro-optics and display systems. He holds patents on a Stairstep generator semiconductor circuit (1962), and an electro-optical sensing device (1964). His prior publications include "Scan Converter Tubes and their Applications", Autonetics PUB X4-986/34 1964. He is a senior member of IEEE as well as an active member of *SID*.

AIMS AND PURPOSES

- Encourage and contribute to the scientific advancement of Information Display.
- Promote the use of Information Display.
- Maintain a central file of display information for use by members.
- Provide forums for the exchange and dissemination of ideas and knowledge relating to Information Display.
- Promulgate definitions and standards pertaining to the field of Information Display.
- Stimulate new ideas in Information Display and foster their development.

INFORMATION DISPLAY ENCOMPASSES ALL METHODS AND MEDIA USED TO PRESENT SPECIFIC INFORMATION TO PEOPLE.

MEMBERSHIP IS OPEN

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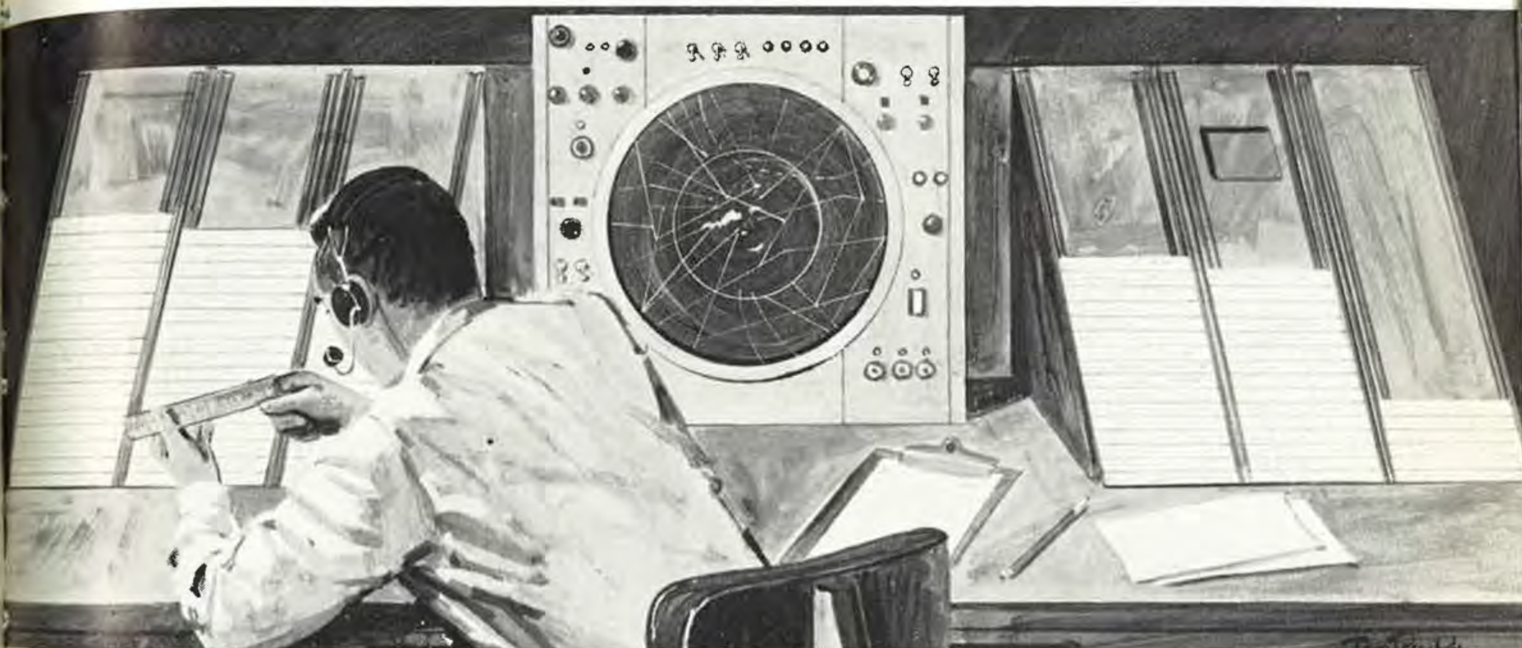
FAA upgrades area weather reporting



with a new Westinghouse picture transmitting system

Continuing its emphasis on greater air safety, the Federal Aviation Agency is conducting intensive R&D work to improve weather reporting. In an important step forward, Westinghouse has designed and built for FAA evaluation two prototype systems which transmit ultra-clear weather pictures from remote radar sites to the air traffic control centers.

The new Westinghouse system compresses radar-detected weather signals from remote stations and transmits them to the control center over a conventional telephone line. In this manner a composite weather map of the region is instantly available to air traffic controllers.

Heart of the Westinghouse system is a vidicon type storage camera which is specially designed for slow scan or delayed readout applications. For the FAA system, readout is on a two-minute frame basis, providing a brilliant, high-resolution image of slowly changing weather patterns on the air traffic controllers' displays.

The prototype systems, in operation at FAA sites on the East Coast, represent a growing family of Westinghouse equipment for civilian aircraft and airport traffic control.

These special-purpose systems are typical of Westinghouse capabilities in the design and manufacture of advanced electronic systems for defense and space. For information, write to Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh, Pennsylvania 15280. J-02368-R

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