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Information Display

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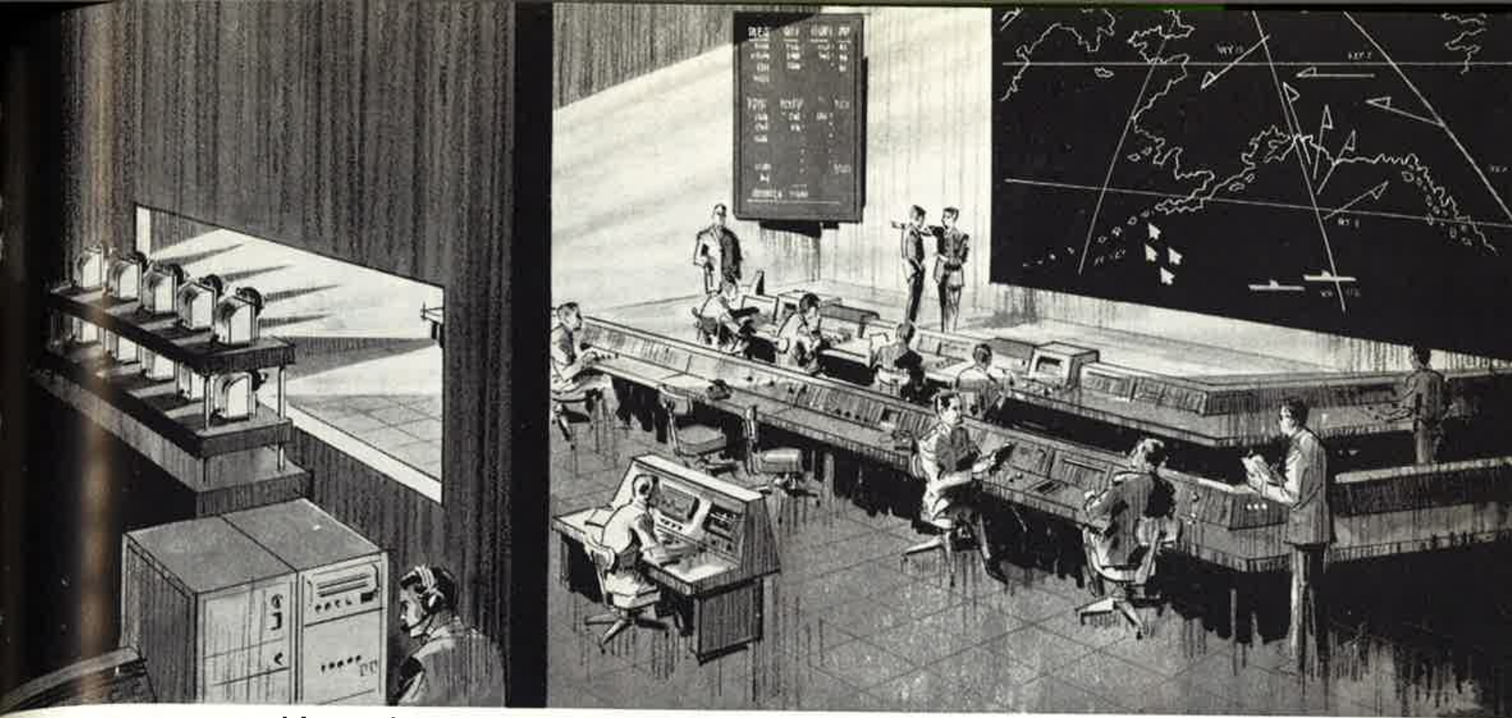

Volume 2 Number 3 May/June, 1965

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ARTICLES

FEATURES

THE COVER

Elements of a complex Information Display system are integrated here in concept by artist George Guon, Graphic Design Group, TRW Space Technology Laboratories, envisioning field plot, electronics, and human controller.

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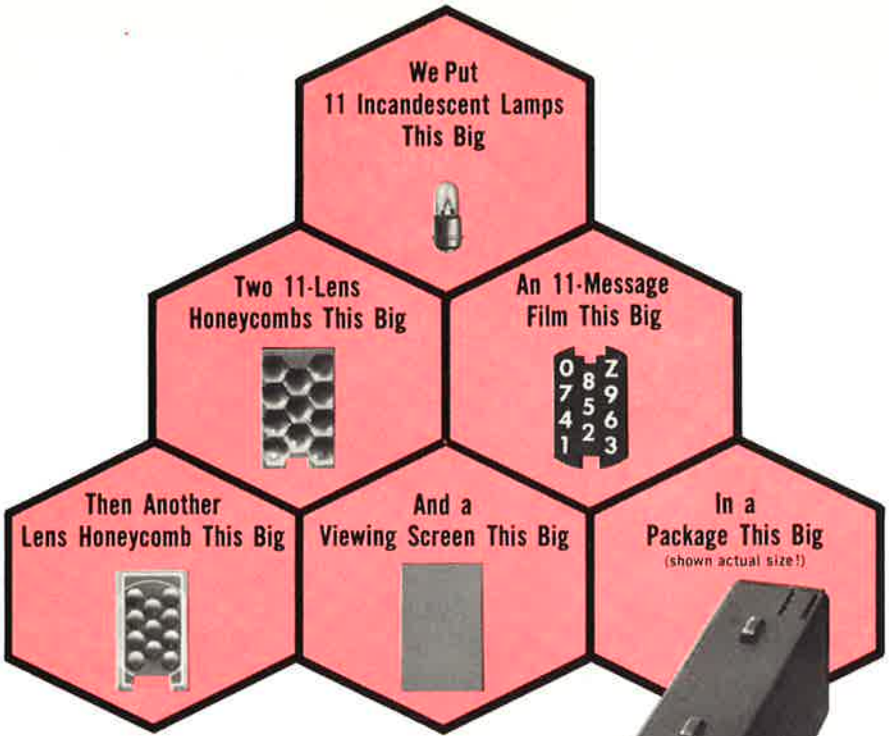

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EDITORIAL

SHOULD WE TRUST OUR COMMON SENSE?

I was recently privileged to see a very large seven color display system whose screens covered an entire wall. It was one of the latest creations in the display art and I was immediately impressed.

Not having any idea as to what kind of information was to be displayed nor who was going to look at it and take what action, my impressions were based on those things that were visible and obvious.

Even after cleaning my glasses I found the characters difficult to read. I wondered why the blue colors were so dark. The reds weren't too bright either compared to green or white. Some of the colors had a noticeable color fringing which I promptly attributed to inferior lenses.

I was a little confused about one color and wasn't sure whether it was blue or green. After finding both a blue and a green on the screen, I decided it was half way between, that is, blue-green.

By this time the neck muscles had tired a bit from looking up at such a steep angle. I thought what a shame it was that the best viewing positions were occupied by projectors instead of people. Sure enough, when squeezed in between the projectors and looking through a small window I found I had an excellent view.

Since I was already squeezed up against a projector, I looked inside and was embarrassed to discover that the designers had indeed used good lenses and the highest quality dichroic filters. I could see the three primary colors, red, blue and green. I recognized this as the classical additive color scheme where by addition you make all the other colors.

Scientifically speaking, these were the finest possible filters and this was the correct way to record, transfer and reproduce colors. This technique is well established in color photography, color printing and in color television.

What was wrong? My common sense tells me that the colors I saw on the display were of nonuniform brightness and were unpleasant and difficult to identify. Should I trust my common sense in the face of all the scientific and engineering back-up? The measurements, charts and curves, tell us these are the correct techniques for reproducing color.

All of a sudden it occurred to me that color systems are not intended to create color, but to reproduce it. Color represents an input. A good color system has no color of its own. Of course, if you look inside the system you see various colors and color filters, but these are part of the internal record keeping process and are not necessarily pleasant to look at.

The color display system must have a suitable color input, otherwise you should change the rules (and filters) to permit the display to create those lively colors which occur in nature.

The customer who bought a seven color system may not know that it is capable of reproducing all those lovely colors one sees on the color charts at the paint store. There is little reason not to select colors that are equally bright, pleasant to look at and readily recognized.

I like color. It is expensive, but it evokes an emotional response. I was wondering if it was necessary to display seven colors or would four nonadditive, nonfringing colors do as well?

That big screen bothers me a little. I saw the same movie on my 21-inch TV set that I had previously seen on a 142-foot drive-in screen and, as I recall, I got about the same information in both cases. Of course, there probably isn't any connection between movies and information display systems. No doubt, there are good reasons why a screen should be a certain size. Ordinarily you would think it was related to the size of the audience.

I asked my wife about it, not expecting an answer, but she promptly replied with a smile, "Big screens are for big people and little screens are for little people."

PETRO VLAHOS
Editorial Advisory Board, SID

Petro Vlahos is a Charter Member, Society of Information Display, and past Chairman of the Los Angeles Chapter. He is presently a member of the Editorial Advisory Board.

Mr. Vlahos holds an EE degree from the University of California. He is currently on the Special Studies Staff, Defense Systems Division, at System Development Corp., which he joined in 1960. He initially worked with displays as an engineering group head at Douglas in 1941, and later with radar displays at Western Electric in 1944.

From 1946-60, Mr. Vlahos was engaged in R&D for the Motion Picture Research Council, where he did extensive work in acoustics, lighting, projection optics and screens, camera rate stability, 3-D, and special photographic processes. This work resulted in several patents, including three widely used systems for traveling matte photography which led to his receipt of a Motion Picture Academy Award with two associates at the most recent presentations.

Mr. Vlahos has lectured on information display at UCLA, and on television recording techniques at USC.

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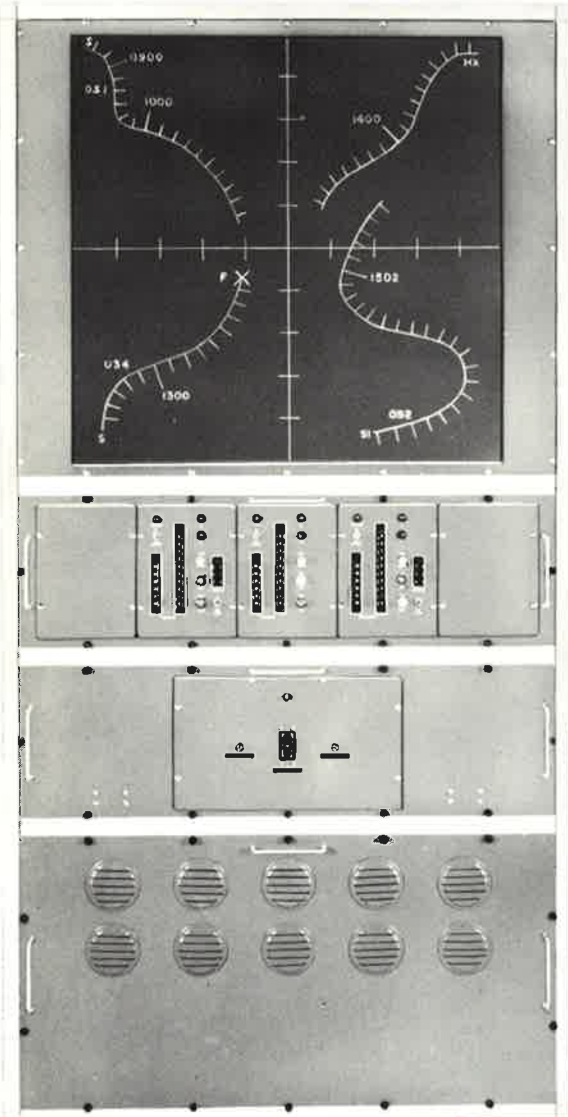

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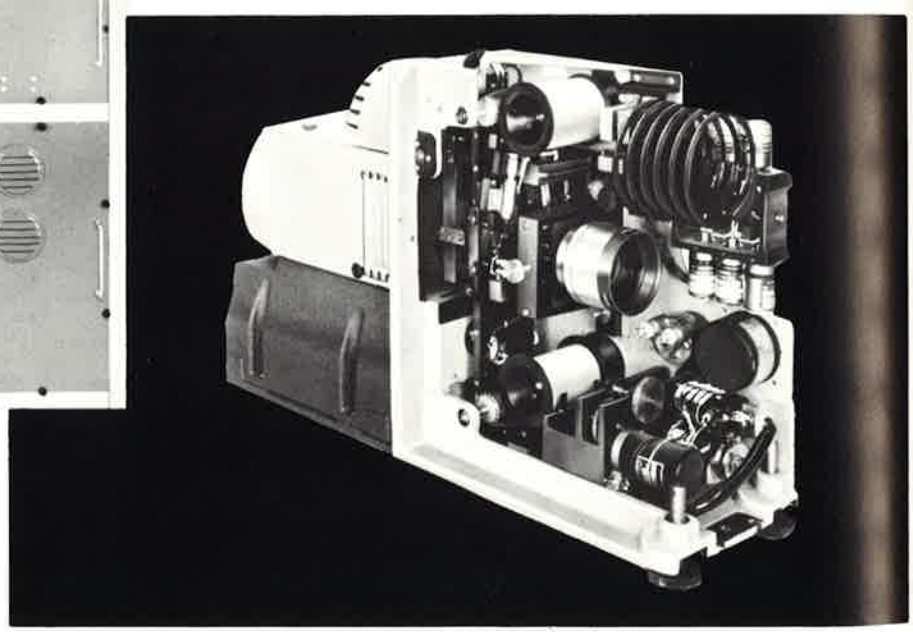

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This is the conclusion of an originally-planned three-part article. The balance is being published in a single unit, instead of two installments, because of extreme interest in this topic by the Journal's readers. Part I was published in Volume 2 Number 2, Mar./Apr., 1965 issue.

Scan Converter Tubes And Their Applications

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.

by G. T. Nagy

Single Gun Storage Tubes

The single gun tubes are built with electron gun control electrodes, electrostatic or magnetic focusing and deflection, similar or identical to conventional CRT. The storage tubes, however, don't have phosphor screens and don't produce visible images. Instead, they have a dielectric target which stores the electrical information while scanning with the electron beam. This modulated beam forms a pattern of electrostatic charges on the target surface.

There are three types of single-gun storage tubes with different target systems and, therefore, with different read, write, and storage functions. The three types of single-gun storage tubes are:

1. Barrier grid storage tubes
2. Transmission grid modulation tubes
3. MTI storage tube

Barrier Grid Storage Tube

The barrier grid storage tube, is designed for storing electrical input signals and delivering electrical output signals. This type of tube was first developed 20 years ago; and since, with several improvements, a number of manufacturers produce a comparable tube of this type. The characteristics of this tube were inflected to special applicational requirements. The applications vary from single-tube to multiple-tube arrangements for storage, scan conversion, MTI and many others.

Physical Description

The barrier grid storage tube (Figure 15) differs from other types of single gun storage tubes in the target and storage assembly. The tube, built in a glass envelope as a conventional CRT, consists of three basic assemblies:

1. Electron gun and primary optics
2. Target assembly
3. Secondary optics

Electron Gun and Primary Optics

The electron gun, a relatively conventional design, is a high resolution – cathode, grid, anode-triode or tetrode type located in the neck of the tube. The cathode is an axial type indirectly heated. The acceleration high voltage in a range of –1000 to –2000 v is connected to the cathode. The heater transformer should have, therefore, insulation of a minimum of 2500 v. The control grid cut-off voltage is about 100 v below cathode voltage. The anode is not grounded and is about on –150 v potential. The tube employs electrostatic focusing and uses a low-current consumption, symmetrical-type focus electrode. There are two pairs of deflection plates for x and y beam deflection. The deflection plates are enclosed in a deflection plate shield. This shield provides an attenuation of the capacitive coupling of large, high-frequency signals between deflection plates or control grid and target section which include actually the output signal electrode. There are applications where the requirements are to store a large number of bits of information. This requires an electron gun providing a spot small enough and well-focused. Naturally, it requires also a target surface where the stored charge will not spread by leakage or secondary emission dissipation. The target of this kind will be discussed later. The current electron gun design can produce a spot size less than 0.003 in. with a beam current of about 5 uA and a drive of 30 to 70 v.

Target Assembly

The target assembly of the barrier grid tubes are composed of three main components:

1. A conductive backplate, as a solid thin metal disc.
2. A thin sheet of insulator, as a high quality mica to serve as dielectric. This insulator can be sprayed on one side with an emitting material but can be used with or without it.
3. A metallic screen, the barrier grid, as a woven or electro formed mesh.

Those parts of the target assembly are formed into a sandwich whose cross section is shown in Figure 16.

One side of the dielectric film is contacted with the thin metallic backplate. The other side of the dielectric sheet, the side which eventually is coated with emitting material, is in contact with the metal mesh, the barrier grid. The ratio of the spot size and the size of the areas or "fields" formed by the barrier grid are resolution problems. The resolution is a primary parameter of the storage tube; and, therefore, a further discussion of this component is worthwhile.

The mesh as an integral part of the target have fields, areas formed by the squares of the mesh and the thickness of the mesh, called "fence." By scanning the target with the electron beam, with a spot size in order of 0.001″ dia., it is a very remote possibility that the active spot should fall into the area of one field. Even with a smaller spot size, the finest spot would fall, at least, on four adjacent fields. This is, in fact, the case if the spot size is not greater than one field of the barrier grid.

The function of the barrier grid is to localize the spread of secondary electrons into the field from where they came.

The reading phase, however, does not allow higher fence size above some value, because at this point the fence would collect most of the secondary electrons during scanning with the reading beam. Here, at this point an optimum size of mesh fields has to be determined.

A finer mesh certainly would increase the resolution; however, it becomes difficult to collect the secondary electrons on the collector electrode below a certain minimum size. If the fence is too high and the field too small, only the secondary electrons from the center of the field would be able to clear the fence. All other electrons from the side of the field become trapped and pass only to the mesh. An experimental optimum value of the ratio of field/fence is between 1.0 and 3.0. For a proper design of the mesh, the two most important factors are the high optical transmission and the rugged construction.

Another important design consideration is the capacitance formed by the target elements to each other and to the secondary optics and output electrodes. Figure 17 shows the target capacitors of the tube.

$$C_s \cong 2000 - 2500 \text{ pF}$$

$$C_p \cong 5000 - 5500 \text{ pF}$$

$$C = 1000 - 1500 \text{ pF}$$

$$C_L = 5 - 10 \text{ pF}$$

$$C_{coll} = 8 - 12 \text{ pF}$$

Secondary Optics

The secondary electrons from the target surface are collected by the collector electrode. This is a cylindrical electrode close to the target. The outside wall of the tube is metallized and forms a shield around the collector. This shield makes it possible to apply input signals to the backplate without being capacitively transferred to the collector.

Principle of Operation

The scanning electron beam is focused on the target surface by the electrostatic focus electrodes and is deflected by two pair of electrostatic deflection electrodes. With such focused and deflected scanning electron beams, the writing and reading of information can be accomplished in various modes:

1. Successive or Sequential Write and Read Modes:

a. Input signal fed to the backplate and output signal taken from the backplate.

b. Input signal to the backplate and output signal from the collector.

c. Input signal to the control grid and output signal from the backplate.

d. Input signal to the control grid and output signal from the collector.

D-c bias should be applied to the electrodes during both writing and reading.

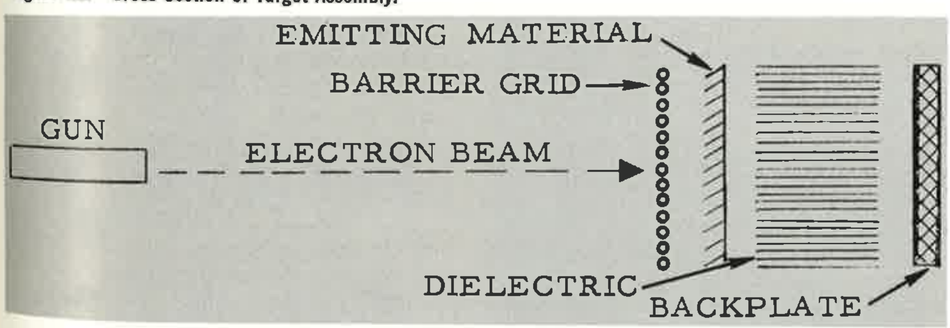
2. Simultaneous Write and Read Mode. An input signal is fed to the backplate and an output signal is taken from the collector. This arrangement is for a MTI or a radar fixed target cancellation operation. Here the output signal is proportional with the difference of two successive input signals.

3. Erase Phase. There are two ways to erase or remove written information:

a. Destructive reading

b. With change of d-c bias if electrodes as backplate, collector and control grid while scanning with a high energy unmodulated electron beam.

Figure 16. Cross Section of Target Assembly.



Target Behavior Analysis

The distribution of the space current to various electrodes in a field of secondary emission depends only upon electrode geometry, space charge effects and electrode voltages. It can be obtained either by energy distribution Is (E) or angular distribution Is (Ø) of secondary electrons. Figure 18 shows a typical energy distribution curve where an energy interval (E, E + △E) is plotted against the energy E. It is assumed that the electrons emitted by the target occur in this energy interval. This general curve can be distinguished in three sections.

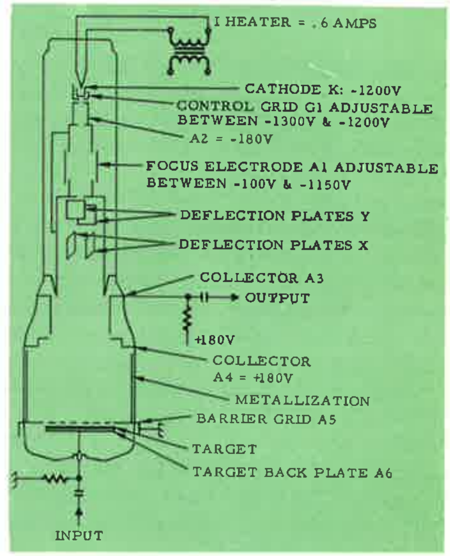
In Section I, the secondary emission energy is equal to the primary beam energy. The section II, is a secondary electron field distribution caused by a rediffused primary beam. The primary beam here is reflected to the surface only after passing through a more or less thick layer of a target material.

The third section III, is the field of interest regarding the storage tubes. This is the energy electron volt region where true secondary electron emission occurs and where the secondary emission ratio is greater than unit. An analysis of the secondary electron energy distribution based on the Maxwellian energy distribution theory would result in some indications to discharge currents.

Disregarding the angular energy distribution, assumptions can be made regarding the secondary electron field before the target. First, the Maxwellian energy distribution will be analyzed with secondary electrons leaving the target with "Z" axis directed energies. Second, an equipotential plane, closely spaced and parallel to the target, will approximate the effect of the screen on the electron optics in front of the target. Further assumption is the scanning beam rectangular across section with constant current density.

Nonuniform parameters, as screen transmission ratio variation, secondary emission variation, dielectric uneveness or nonuniformity, are disregarded. The secondary emission ratio is K > 1. The electron beam scanning beam is constant.

Figure 15. Barrier Grid Storage Tube.



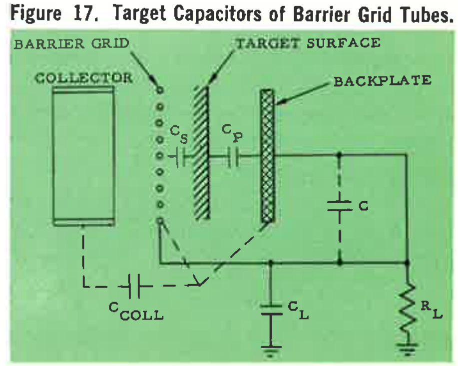
The Maxwellian energy distribution for the parallel plane geometry of the storage tube target system is shown in Figure 19.

The total integral of this curve gives the total secondary emission current density or, in other words, the product of the beam current and the secondary emission ratio.

The Maxwellian energy distribution curve shown in Figure 19 is expressed in the form:

$$\frac{di}{dE_z} = A\ \Sigma^{-E_z} \text{ where } E_z \geq 0$$

Figure 17. Target Capacitors of Barrier Grid Tubes.



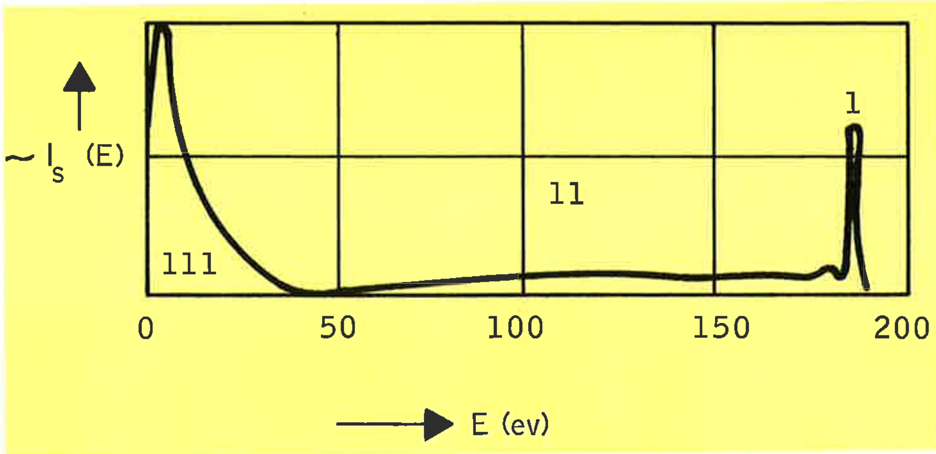


Figure 18. General Shape of the Energy Distribution of Secondary Electrons.

Figure 19. Maxwellian Energy Distribution.

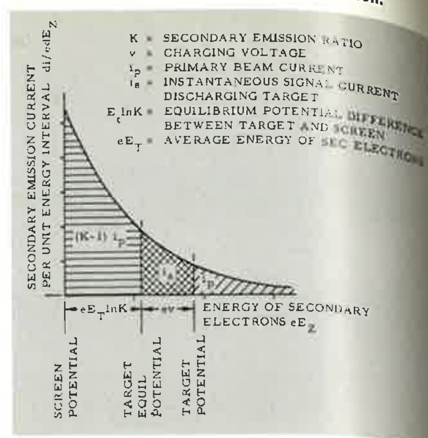


Figure 20. Writing Phase.

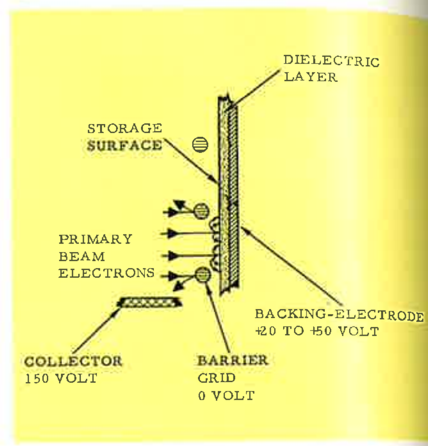


Figure 21. Reading Phase.

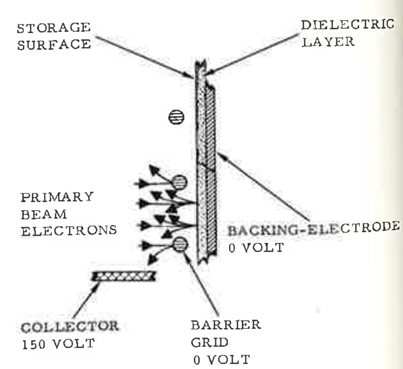
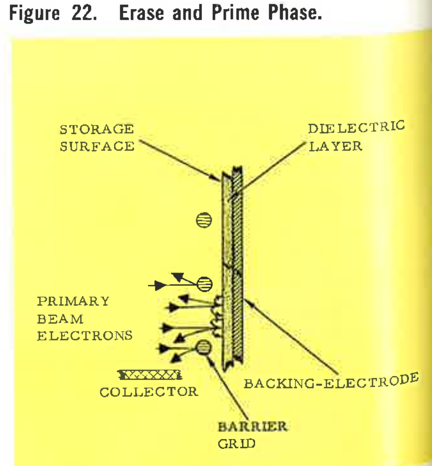


Figure 22. Erase and Prime Phase.



In this expression "i" is the current density, E_z is the target potential and eE_z the secondary electron energy in the direction of "z" axis. The symbol "e" is the electron charge.

Discharge Factor

The discharge factor is a ratio of a voltage difference $V - V_b$, which is the change in voltage of one target element during one passage of the beam and the target initial voltage difference from equilibrium

$$d_f = \frac{V - V_b}{V}$$

where

V = charging voltage applied to the target or the initial potential difference of target from equilibrium.

V_b = potential difference of target from equilibrium after one scan with the electron beam.

Seqential Operation

Writing Phase (Figure 20)

The backplate potential in writing mode is +20 to +50 v, while the barrier grid is at ground potential. The dielectric target surface following the backplate potential initially becomes +20 to +50 v more positive. The electron beam modulated with the input video signal scans the target. Because of the backplate potential, the barrier grid prevents secondary emission at points where the beam current is high and charges the storage surface negatively. According to the beam currents varied by the modulation, a charge pattern will be written in the storage surface depositing negative charge carriers. It is assumed that before the writing phase the target was brought to equilibrium potential uniformly.

Reading Phase (Figure 21)

The backplate and barrier grid are now both on ground potential while the written pattern on the target surface is more or less negative according to the writing beam modulation. The reading beam unmodulated scans the target with an energy where the secondary emission ratio K > 1. While the read beam scans the target, the secondary emission current varies from point to point according to the written pattern or number of electrons deposited during writing. This varying secondary electron current will appear on the collector capacitor as the output video signal. The collector electrode potential in both reading and writing phase is highly positive relative to target potentials. The reading process discharges the target toward the equilibrium potential. To control the noise from the barrier grid, the mesh is treated in such a manner that the secondary emission ratio from the barrier grid is unity. Generally, the noise is an a-c component related to the target diameter and fine grain noise caused by surface irregularities. Usually the ratio of the output signal to one-half the total noise amplitude is in order of 16:1. The approximate possible gray level is, therefore, 15.

Erase and Prime Phase (Figure 22)

The storage surface is positive with several volts in respect to the screen. The modulated beam scans the target, bringing it uniformly to equilibrium potential. The secondary emission ratio will then be unity.

Simultaneous Operation

The principle of this type of operation such as MTI was discussed earlier. The barrier grid tube operates in this mode as a signal subtractor and does not use modulated electron beams. The input signals are applied to the backplate and proper shielding has to be provided to prevent capacitive coupling to the collector. With this provision, the output signal is taken from the collector. This output signal is proportional to the difference between two successive input signals. D-C bias should be applied to the electrodes also.

The cancellation ratio is in order of 25 to 1 in the barrier grid tubes. This cancellation ratio means the ratio of a recurrent input signal to the residual output signal. Under ideal conditions, a recurrent input signal of constant amplitude on the backplate does not create any output signal on the collector.

Transmission Grid Modulation Tubes

This type of single-gun storage tube is also based on the secondary electron emission such as the barrier grid tube but with a different target system and different operating principles. This tube was developed and is presently manufactured by Raytheon Corporation and is similar to the barrier grid tube having several applications in storage, scan conversion and radar fields.

Physical Description

This single-gun storage tube (Figure 23) is also a form of a CRT which offers no visual display but stores electrical information. This tube is built with two major assemblies:

1. Electron gun and electron optics
2. Target assembly

Electron Gun and Electron Optics

The recording storage tube is built with a high resolution tetrode-type electron gun. The acceleration voltage is about 5000 v. The tube requires magnetic deflection. It has an electrostatic focus electrode or magnetic focus soil to be used by either one or a combination of both. In front of the target is a lens system so that the incident primary electron beam stays perpendicular to the target during scanning. A large potential difference between the accelerating anode shield and the storage screen causes a retarding electric field between the first screen and the storage screen. In this electric field, during scanning and different deflection angles, the primary beam electron trajectories are effected by the angle of incident and the beam is reflected at too large incident angles (Figure 24).

This effect of refraction, caused by the decelerating electric field, can be avoided if the primary electron beam strikes perpendicularly the first screen in all positions during scan. The two collimating electron lenses between the anode and the first screen is located at the center of the deflection. The electron beam with this collimation will strike the screen perpendicularly for all deflection angles.

Target Assembly

The target assembly of the storage tube has a decelerating screen, a storage screen and a collector plate. The first or decelerating screen is placed in the plane where the primary beam is focused. It is a woven wire or electroformed mesh with an optical transmission as high as possible. Behind the first screen is the storage screen. This comprises a thin woven wire or electroformed mesh, similar to the first screen. One side of this screen is coated with the storage material, a dielectric. This is done by evaporation in vacuum, and the thickness of this coating is controlled to a size which just leaves the holes of the screen open (Figure 25).

Figure 23. Single-Gun Transmission Modulation Tube.

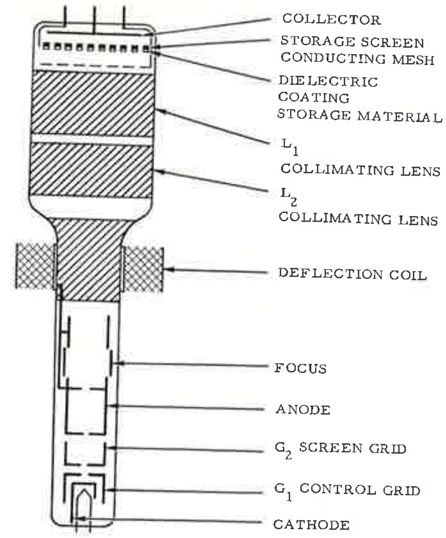


Figure 24. Refraction Effect Without Collimation.

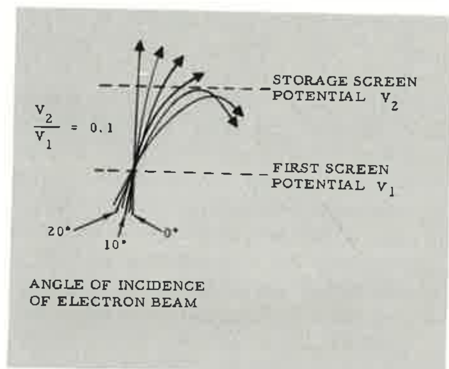


Figure 25. Storage Screen.

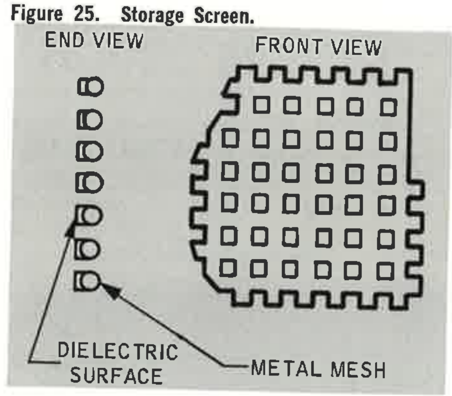
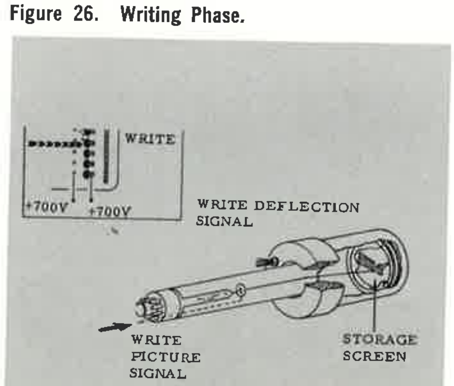


Figure 26. Writing Phase.



In the earlier model (Raytheon QK357), this vacuum-evaporated coating was on the side of the screen that faces the collector plate. The later developments find many disadvantages of this arrangement.

1. Between write and read phase, the collector plate has to be switched from −300 v to +300 v which caused switching transients in the output video amplifier.
2. The erase speed becomes very slow.
3. Ringing of the storage screen which increases the noise.
4. The primary beam, which was focused on the screen, has to pass the aperture of the screen and return to the storage surface facing the collector after reaching the reflecting field between screen and collector.

The electron beam spot size, passing the aperture of the storage screen, increases in diameter 50 percent or larger and returns to the storage surface. This results in a decrease of the resolution.

The improved QK464 or QK685/CK7571 tubes have the storage surface on the electron gun side of the storage screen, and the electron beam impinges directly on the storage surface. The resolution increase in the collector plate can be kept on a fixed-positive potential and eliminate the switching transients.

Principles of Operation

The various modes of operation of the tube CK7571/QK685 are:

1. write phase
2. read phase
3. erase
4. prime

Writing Phase

The modulated electron beam scans the storage surface with a beam energy where the secondary emission ratio K > 1. The decelerator screen collects the secondary electrons and the modulated beam creates a positive charge pattern on the storage surface. The potential of the storage surface at each point corresponds to the modulation of the electron beam (Figure 26).

The storage screen is switched to a high-positive potential from the low potential of the prime phase. The storage surface, by maintaining a more negative potential than the screen established by the prime phase, simultaneously increases the potential by the same amount. Then the modulated electron beam writes a pattern as a positive charge on the storage surface.

The writing can be accomplished also

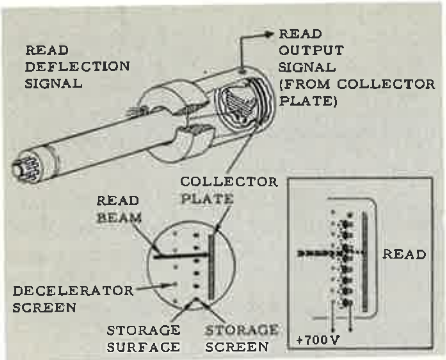


Figure 27. Reading Phase.

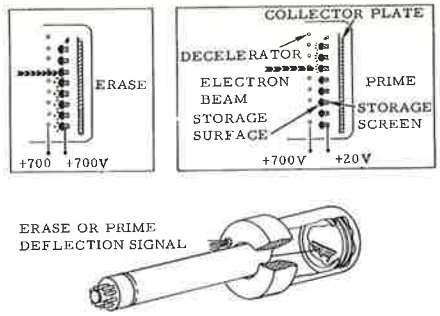


Figure 28. Erase and Prime Phase.

by modulation of the storage screen element with the information to be written. A simultaneously scanning continuous electron beam stores this information on the dielectric surface. The advantage of such a writing mode is that the d-c potential of the storage screen remains the same through all operating phases and does not need switching. The higher the writing video voltage applied to the storage screen in this writing process, the more negativity will be charged on that particular point of the storage surface by the simultaneously scanning electron beam. In this writing mode, therefore, the storage surface can be discretely charged more negatively, determined by the position of the electron beam at any particular instant. By scanning one frame, a complete charge pattern will be written.

Reading Phase (Figure 27)

The unmodulated electron beam scans the target and passes through the screens to the collector plate. The potential on the storage screen is switched to a low value, lower than which will be seen by the priming. The storage surface follows this potential change, maintaining the written in potential differences. During read mode, therefore, the stored charge pattern on the storage surface is actually negative with respect to the cathode, except at the points where no video information was written in. The electric field formed by this charge pattern modulates the passing through an electron beam, similar to the control grid in an electron tube. The output current of the collector plate will vary as the function of the stored charge pattern as the beam scans the storage surface in the reading phase. Because the potential on the storage screen is actually negative to the cathode, the charge pattern will not be destroyed with the reading beam and can be read several times over an extended period of time.

Erase and Prime Phase (Figure 28)

Erasing the written information means the same as "writing until equilibrium," if the writing is accomplished with modulated electron beam. In fact, the same process occurs by a modulated storage screen writing mode; but, in this case, the writing potentials are not the same as the erase potentials. With high beam current density, the unmodulated electron beam scans the target with high K secondary emission ratio and the storage surface becomes positive until it reaches the decelerator screen potential. At this time the whole storage surface is uniformly positive charged and any previous written pattern disappears. To erase in both writing modes, the storage screen potential is switched to a high positive potential, well about the critical potential where K = 1. The storage surface follows the screen potential, while the high energy scanning electron beam raises it to the equilibrium potential.

The priming phase is necessary only if the stored information is in a form of a randomly writen mode and not, for instance, at a TV raster mode. The prime phase brings a uniform charge distribution to the storage surface. The storage screen potential is below critical potential. The scanning unmodulated electron beam, therefore, deposits negative electrons until the storage surface potential uniformly decreases to cathode potential.

An automatic prime or destructive reading can be achieved with control of the collector potential and control of the reading beam energy. This will control the amount of reflected electrons from the collector back to the storage screen. The number of electrons reflected varies inversely with the collector potential. Figure 29 illustrates a complete periode with modulated electron beam and Figure 30, a periode with modulated storage screen.

MTI Storage Tube

This tube was developed recently for MTI. It has a small size, 1 in. in diameter and 6 in. in length. The acceleration voltage of the electron beam is only a few hundred v. Compared with the barrier grid tube and in addition to the above mentioned advantages, it has a continuous dielectric target without any screen and, therefore, higher cancellation ratio, less noise and higher resolution in MTI operation.

Physical Description

In Figure 31 the outlines of the tube are shown with electrostatic deflection and focus. However, in most applica-

Figure 29. Modulated Electron Beam Process.

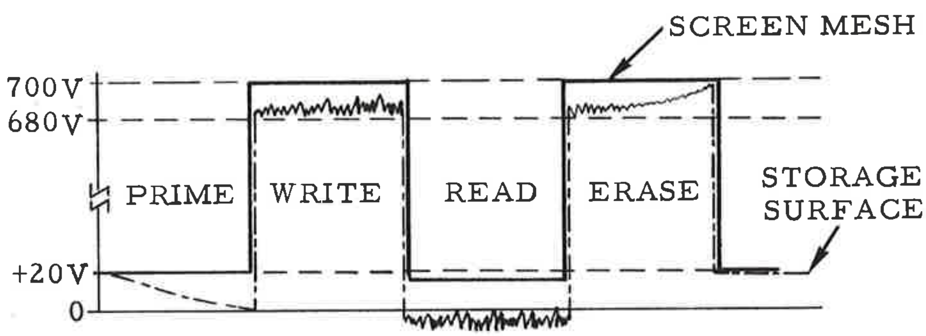
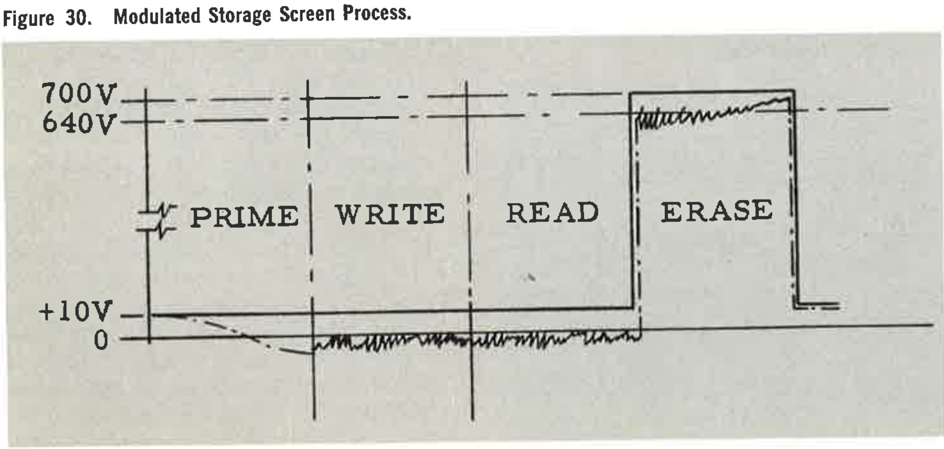


Figure 30. Modulated Storage Screen Process.



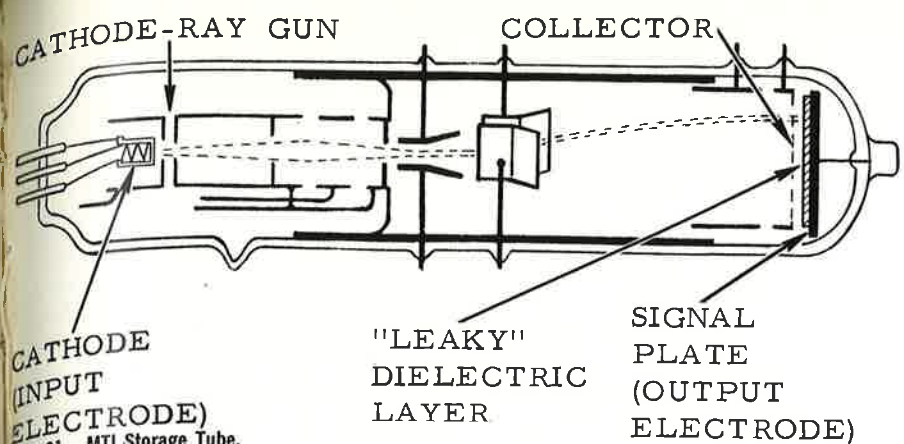


Figure 31. MTI Storage Tube.

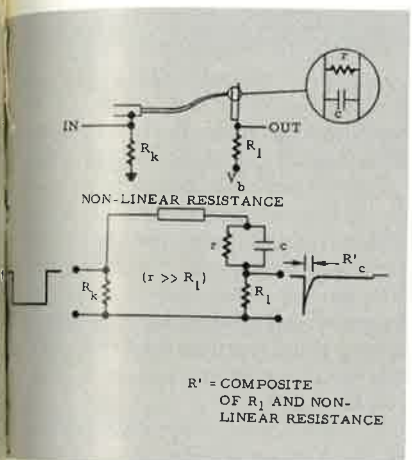


Figure 32. Equivalent Circuit.

...s, this tube used magnetic deflection and focus coils which provided better performance. The tube, in a size similar to a Vidicon pickup tube, uses a conventional electron gun. The target is a metal backplate in contact with a dielectric layer. The collector electrode and shielding is in front of the target similar to the barrier grid tube. The continuous target surface, without any screen in front, gives advantages to this tube for MTI operation.

Principles of Operation

The scanning electron beam focused on the target surface is a low energy beam. Assuming a square raster scan, a radar signal is applied to the cathode modulating the electron beam energy, and the output is taken from the backplate. In writing with synchronized scanning beam, this system results in difference of signals between two successive scans. This difference constitutes the output signal.

There are some considerations which have to be established in order to understand the signal cancellation techniques of this tube. First, an equivalent circuit is shown in Figure 32 which gives the relationship between a cathode and a target with the nonlinear characteristics of the electron beam. This equivalent circuit represents one single element of the dielectric layer. As seen from the circuit, the dielectric target such as semiconductor has an RC time constant as an element and an RC time constant as the whole target surface. As indicated, the dielectric resistance R is much higher than the output load resistance R_1. Therefore, R, the high resistor in series with R load resistor, limits (to a very small value) the output current in case of d-c or very low frequencies. However, the capacity of the dielectric constitutes a short circuit for the high frequencies.

A square wave or step input, furthermore, causes a pulse output due to the differentiating network consisting of C and R_1. This is the basic signal cancellation at each point of the target surface. The dielectric layer, with the backplate biased to positive potential with respect to cathode, forms a rectifier action for the charging process of the low energy beam in a negative direction. It emits a conductivity through the dielectric to the backplate so an equilibrium voltage between dielectric surface and backplate can be established.

In Figure 33 there are the curves of charging rates versus the dielectric surface potentials. The static load line theoretically represents the resistivity of the whole dielectric, the dynamic load line, and the output resistor R_1. During every scan for each of two points of the storpoint of the storage surface during each scan, the output current is Δim which indicates a moving target on a change in input for one point.

Performance

According to the manufacturer's preliminary specification, performance of this tube is given as:

1. Resolution: for MTI functions, approximately 250 x 250 picture elements in a square on the storage surface.
2. Cancellation Ratio: from 50:1 to 300:1 according to the desired resolution.

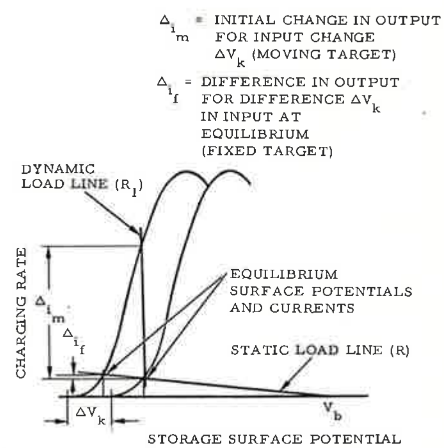


Figure 33. Charging Rate Diagram.

Figure 34. Single-Gun Tubes.

Tube Type	Manufacturer	Target System	Target Diameter Inch	Deflection	Focus	Max Acceleration Voltage	Resolution TV Lines	Applications: MTI	Applications: Scan Converter	Applications: Storage
7225	WESTINGHOUSE		2.6	EL.STAT.	EL.STAT.	3300V	1000	X	X	
CK6835	RAYTHEON		2	MAGN.	EL.STAT.	5000V	1200		X	X
CK7571	RAYTHEON		2	MAGN.	EL.STAT.	5000V	1200		X	X
RW-1	WARNECKE		2.5	EL.STAT.	EL.STAT.	1500V	1200	X	X	
6499	RCA		2.25	EL.STAT.	EL.STAT.	1500V	1000	X	X	
MTI-R	HUGHES		1	MAGN.	MAGN.			X		
WX-5320	WESTINGHOUSE		1	MAGN.	MAGN.	1000V		X		X
WX-4293	WESTINGHOUSE		1	EL.STAT.	EL.STAT.	350V		X		X

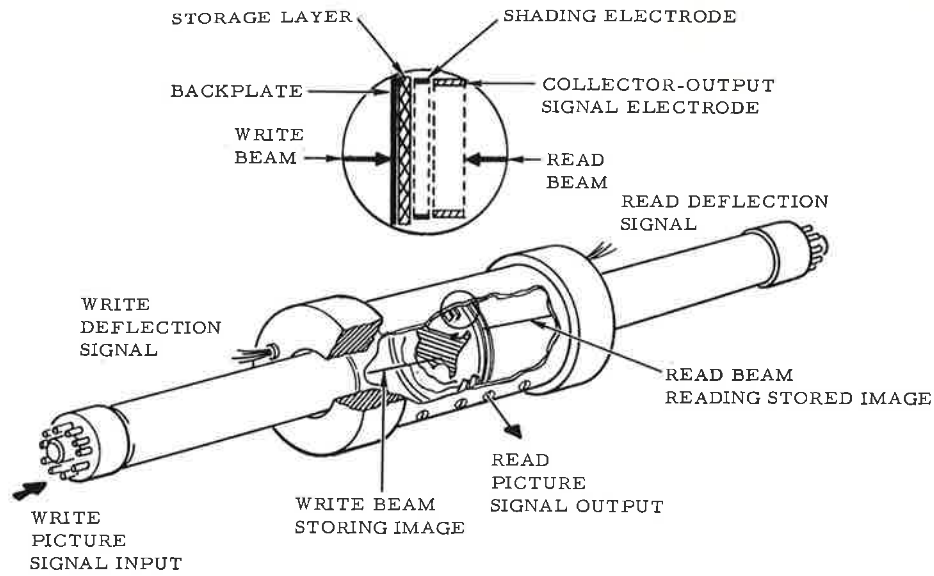


Figure 35. Dual-Gun Storage Tube (EBIC).

3. Cancellation Time: 1 to 10 scans.
4. Repetition Rates: TV horizontal frequency to 60 sec.
5. Output Current: Approximately 0.5 µA max.

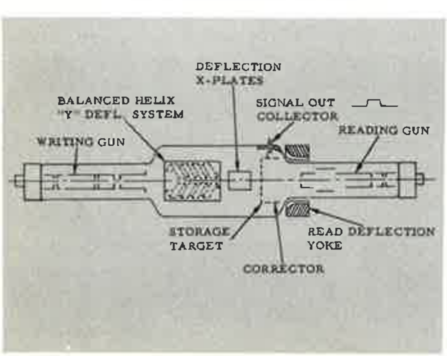
Dual-Gun Scan Converter Storage Tubes

Where electrical signals for video information should be converted into one scanning rate or scanning mode to another and this process has to be performed simultaneously, dual-gun scan converter tubes should be used. The simultaneous high-speed writing, reading and erase capability makes this type of tube more versatile than the single-gun version (Figure 34) for conversion of a number of display patterns. They are designed for data processing applications for continuous transfer of signals with high resolution, controllable storage time and scan conversion.

With different target systems and operating principles, there are three types of dual-gun tubes:

1. EBIC tubes
2. Transmission grid modulation tubes
3. Fiber Optics Photon Transfer (FOPT) tube

Figure 36. Very High Writing Speed Dual EBIC Tube (Rauland R6253).



age surface, the cathode voltage difference $\triangle Vk_1$, if the output current is a very small $\triangle i_r$, is the difference also in equilibrium currents. If this $\triangle V_k$ voltage difference occurs, however, by the same

EBIC Tubes

The development of the EBIC system and tubes with target, operating under this EBIC principle, started in 1946 when the TELRAN Airborne Navigation System was developed. The basic need for the tube and system was the conversion of radar PPI displays into TV raster format to increase the information content through storage integration and high brightness. The early models of this tube had two electron guns but both on one side of a target. They were experiments with magnetic and electrostatic deflection systems. The later developments, and this is also the recent form of the tubes, built the two guns on common axis on opposite sides of the target (Figures 35). This type of tube is manufactured by several manufacturers with some differences in specification and size.

Physical Description

The dual-gun tubes with EBIC target system can be described in three major assemblies:

1. Writing electron gun and optics
2. Reading electron gun and optics
3. EBIC target system.

Writing Electron Gun and Optics

The electron gun of the writing side is a high resolution tetrode or pentode type. The acceleration anode is grounded and the cathode on the high voltage negative potential. The indirect-heated cathode heater should have a filament transformer insulated for about 10 kv because this high velocity writing beam operates usually at 6 to 10 kv. This high velocity writing beam is focused usually with an electrostatic focus, which electrode is built into the gun; this can be, however, magnetic focusing also. It was found that the high voltage side of the electrostatic focusing is adequate for most of the applications. For good resolution, the writing side uses magnetic deflection.

There are some very high writing speed, dual-gun scan converter, storage tubes which employ electrostatic focusing and electrostatic deflection with a special constructed Helix "y" deflection system (Figure 36). The tube was developed

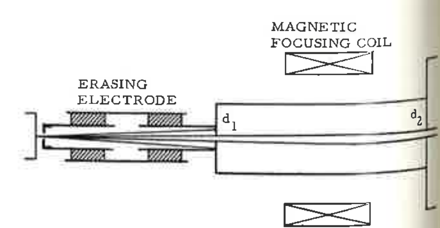


Figure 37. Normal Operation of Read Gun.

by Rauland Corp., a subsidiary of Zenith Radio Corp., Chicago. The R-6253 tube is said to have recording capabilities on the order of one-third the speed of light with high speed transient phenomena storage retainability up to several seconds for displaying viewing by the unaided eye on ordinary television monitors. Telemetering high speed space research phenomena is seen as a prime application for the tube's capabilities. The tube measures 27 in. in length and 4 in. maximum diameter.

Reading Gun Assembly and Optics

The reading gun assembly is generally similar to the writing side; however, it generates a medium velocity electron beam with the cathode at negative 1 - 2 kv potential. To achieve a high resolution with this lower acceleration voltage, most of the EBIC tubes have magnetic focus and magnetic deflection on the reading side. Some of the latest EBIC tube types add to the gun construction an "erasing electrode" which is used for fast erasing of the written information. This fast erase should be used if it becomes necessary to remove written

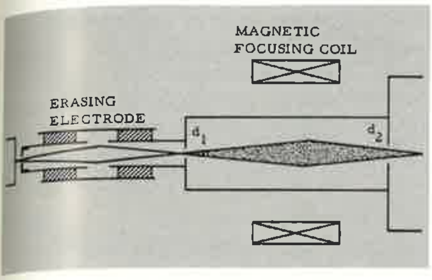


Figure 38. Erasing Operation of Read Gun.

information before it fades away by itself. The storage surface has to be brought to equilibrium fast with a high current reading beam where large numbers of electrons impinge on the storage surface. This erase operation of the reading beam doesn't have to be well focused, and the reading gun has to supply only the high current electron beam. The reading beam in normal reading phase is in any order of 1 or 2 μa. The beam used for erase should be approximately 100 μa. The new type of reading gun and its operation, which includes the special erase electrode, is shown in Figure 37 and Figure 38.

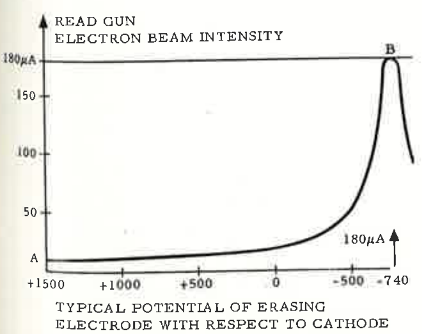


Figure 39. Read Beam Current with Erase Electrode.

The erase electrode is a cylindrical electrode in addition to the focus lens. The erase electrode is at anode potential at normal reading phase. The d_1 aperture let through only a fraction of the electron beam, which is further focused by the focus lens and leaves the gun through the aperture d_2. This electron beam leaving d_2 is approximately 1 μa. The erasing electrode is switched to a negative voltage when operated in erasing mode. This turns this electrode into a prefocus device, and almost all the electron beams go through aperture d_1. In focusing this beam with the focus lens, all the electron beams enter and leave aperture d_2 also. This beam, focused twice in order to get through most of the generated electrons, is not focused anymore on the storage surface while scanning to erase it. However, this is a high energy electron beam and removes the written information fast by bringing back the storage surface to equilibrium. The beam intensity can be controlled by the control grid also. The beam current reaches almost 200μa by having the control grid at cathode potential.

The curve in Figure 39 shows the beam current versus the cathode-erase electrode potential. Point A of the curve is the normal reading phase operation where the control grid is on zero bias and the beam current is approximately 8 to 10μa. The B point on the curve with the high beam current indicates the fast erase mode.

Target System

The EBIC target system in a dual-gun tube is shown in Figure 40. In the EBIC dual-gun scan converter tubes, this target system is built and located in the center of the tube between the two electron guns. The backplate, in contact with a dielectric, or in the recent development doped semiconductor storage layer is a thin metal plate. The very thin backplate faces the writing gun. Two cylindrical electrodes, the shading corrector and the collector electrode, are between the target and the reading gun.

The simple target construction and the continuous solid storage material without mesh construction eliminates the need of a collimating lens system. The tube used "stiff" beams on both the write and read sides without collimation before approaching the target.

Principles of Operation and Performance

The basic principles of the EBIC system were discussed earlier in the paper. This signal recording system is utilized in the dual-gun scan converter storage tubes with EBIC target.

Assumed a start of operation with the reading electron beam, which unmodulatedly scans the target with medium energy, about 1 to 2 kv acceleration voltage. The collector electrode is positively biased with respect to the backplate. The backplate is on ground potential. The acceleration voltage for this primary electron beam is chosen so that the secondary emission ratio K is larger than unity. The positive biased collector electrode creates an electric field and attracts the secondary electrons leaving the storage surface. Those electrons leaving then and arriving at the EBIC target, therefore, become more and more positively charged to a certain potential, which is the equilibrium with the collector potential. At equilibrium potential the secondary emission ratio "K" is unity. The secondary electron current then becomes constant and does not result in a video output signal through the capacitor of the output circuit on the collector.

The shading corrector between the collector electrode and dielectric surface provides a correction for the stored information on the edges of the target. The cylindrical shape electric field created by the secondary electrons extracted by the collector is too high in highlight pictures at reading phase and shows distortions at the edges of the target. The shading corrector with a different d-c bias than the collector is shaped and located so that its electric field creates a compensating distortion to correct the collector field.

Next the electron beam from the writing gun strikes the positive charged target on the backplate side. The electron beam is modulated with the input video signal. The high energy beam has an acceleration potential of about 6 to 10 kv. This high energy beam is able to penetrate the thin backplate and reach the storage material. The storage layer, as an insulator in contact with the backplate, represents a high resistivity from backplate to storage surface in absence of the electron beam. The beam, however, penetrating through the backplate ionizes atoms along its path, induces a conductivity in the storage material at the point of impact.

The writing beam in this way creates a number of moving electrons. A current is induced at the written point and creates a short circuit between storage surface and backplate. This point of the storage surface is, therefore, brought to a less positive potential toward the backplate potential according to the beam energy varied by the modulation. At points where the writing beam modulation brought the beam energy to zero, the storage surface remained on equilibrium potential.

By actual operation, the writing and reading beams scan the target simultaneously on each side. The reading beam activity tends to charge the EBIC target in the positive direction, while the writing beam short circuit tendency, at the same time, decreases this potential at one particular point. In order to operate this simultaneous scan into an output signal, the intensities of both beams and the backplate to collector voltage have to be adjusted properly. It emits a "remanence" or "persistence" effect which is the time during which a written new bit of information fades out below the noise level.

The simultaneous scan of the target

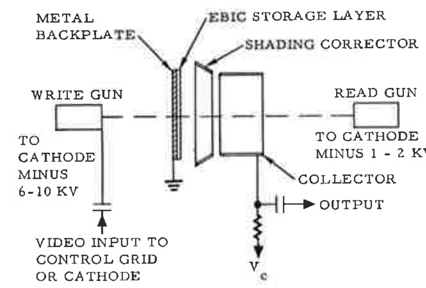


Figure 40. EBIC Target System.

by both electron beams raises the possibility of a cross talk as it exists by other types of storage tubes or in some extent in earlier EBIC tubes.

In the EBIC target cross talk can exist if electrons created with the writing beam go through the storage surface into the reading side, directly or indirectly by creating fast re-emitted electrons. In such EBIC tubes a video cancellation circuit can be used. The writing electron, which causes cross talk by reaching the storage surface, results in a signal of the same polarity on the collector and on the backplate. The reading beam electron, however, by re-emitted secondary electrons causes a signal of one polarity on the collector and the opposite polarity on the backplate. The cancellation takes place by subtracting opposite polarity output signals.

The recently developed EBIC tube targets, with their material and thickness, prevent any cross talk; therefore, no need exists for any such protective circuitry.

The previously mentioned remanence or persistence of the EBIC tubes are adjustable by controlling the backplate to collector bias voltage. The persistence is proportioned with the collector equilibrium voltage, as the larger the voltage, the longer the persistence. The reading beam energy, however, is reversed with the persistence — the higher the beam energy, the shorter the persistence.

To erase written information while being read, the following steps should be taken:

1. The erase electrode should be switched from ground to a negative potential.
2. The control grid bias should be lowered toward zero, corresponding to the erase speed to be achieved.
3. The backplate should be switched from ground potential to a negative voltage.
4. The AGC circuit keeps the output video voltage on a certain level.
5. With all previous potential charges, the reading gun scans the target surface.

The erase time of written information can be varied with the above control process from 1/30 sec to one minute.

Dual-Gun Transmission Grid Modulation Tube

The early development of storage tubes with transmission modulation targets produced experimental one- to three-gun devices. For several reasons, regarding the field of applications, the production settled for some time by the single-gun tube type.

The desire of advanced air traffic control systems demanded later a scan converter tube which stores radar pictures simultaneously and doesn't need three or four steps for a full cycle of writing, reading, and erasing processes.

The dual-gun recording storage tube was designed specifically to perform simultaneous input and output of video signals. This scan conversion tube offers a direct conversion of a number of scanning patterns. The dual-gun tube erases and primes continuously at a wide range of rates while reading. It has the ability of high speed erase and prime operation also.

Physical Description

The dual-gun tube (Figure 41) actually is an exact combination of two

Figure 41. Dual-Gun Transmission Modulation Tube.

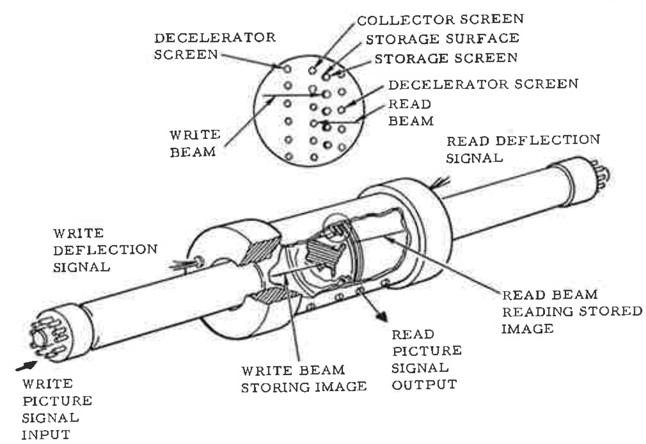
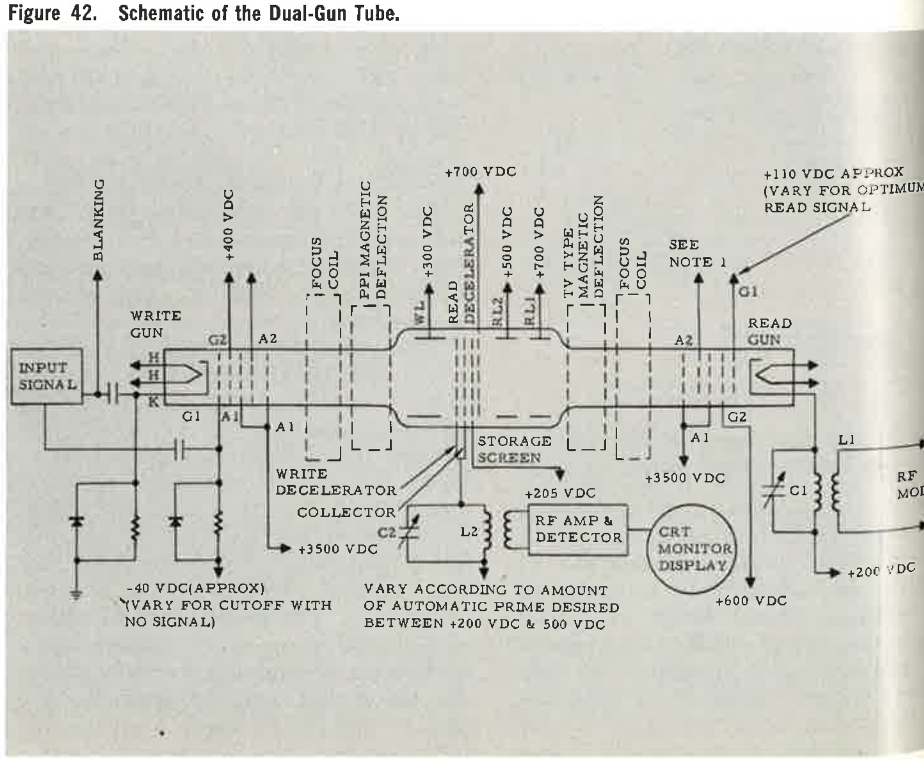


Figure 42. Schematic of the Dual-Gun Tube.



single-gun transmission modulation tubes. The writing and reading sides are essentially identical between them in the center of the target system. The tube, therefore, possesses three basic assemblies:

1. Write side gun assembly and optics
2. Read side gun assembly and optics
3. Target

Write and Read Side Assembly

There are two tube types in production which differ in the write side assembly only. One of them has electrostatic focus electrodes, the other, however, uses magnetic focus only. The gun construction of the write and read side is the same high resolution tetrode type as described by the single-gun tube. Figure 42 shows a schematic of the tube electrodes and electronic lenses. Both sides provide electronic lenses for collimation of the beams. Both the read and write electron beams acceleration voltage is 5 to 6 kv.

Target

In Figure 41 there is an expanded view of the target assembly. There are four screens with a fine mesh structure, made with an electro-forming process or woven wire. The mesh is about 750 to 1000 wires per in. The center screen, which is the storage screen and similar to the single-gun target, is coated on one side with a thin layer of dielectric material. The dielectric surface faces the writing gun side. It has to be noted that in this operation the writing electron beam has the erase function, and the reading beam reads the stored information only. This operation will be discussed later. The storage screen of the dual-gun tube is identical with the single-gun tube described and is shown in Figure 25. As shown in Figure 41, the write side of the storage screen is the collector screen and the write decelerator screen; and on the read side, the read decelerator screen.

Principle of Operation

In many applications, the dual-gun storage tube has several advantages as compared with the single-gun tubes. In operation, the dual-gun tube can read out information continuously, even during the simultaneous writing with the writing gun. The single-gun tube requires electrode voltage switchings for different phases of operation. The dual-gun tube, however, does not need any potential change on the electrodes during normal operation while writing, reading and erasing simultaneously. At partial or total prime of the storage screen, only the writing gun needs potential change and can be read out during priming operation.

Writing

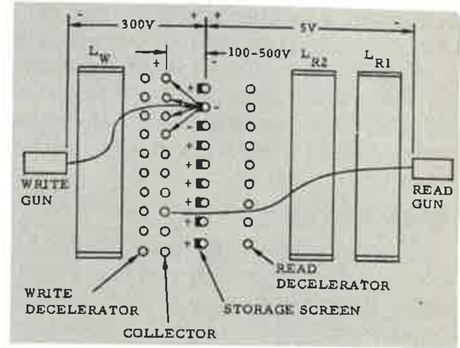
The writing beam modulated with the input video signal scans the target (Figure 43). The collimating lens system L_w provides an orthogonal incident angle of the electron beam passing through the decelerator and collector screen. The writing side operates with a cathode, and storage screen voltage will provide a secondary emission ratio $K >> 1$. This corresponds on the secondary emission curves (Figure 44) to a point above the critical potential and is approximately 300 v for fast writing speeds. As will be seen later, the total primed storage surface is negatively charged. The writing beam causes secondary emission and the storage surface loses electrons. While the writing beam scans the whole storage surface according to the modulation, it becomes more or less positively charged and a stored charge pattern will be established.

Reading (Figure 45)

The written charge pattern leaves the storage screen modulated with points negative, less negative or positive charged. The scanning unmodulated reading beam through collimation system L_{r1} and L_{r2} passes the decelerator screen with 90 deg incident angle. The reading beam also passes the storage screen to the collector electrode. The storage screen with its 5 v dielectric surface to cathode potential and its negative charged points is more negative actually than the read cathode. The beam at the negative charged points can be completely cut off, establishing the "black" level, while the positive charged points let through the full energy reading beam establishing the "white" level. The charge pattern between the two extreme points represents the various grey shades. The storage dielectric is negative with respect to the electron gun cathode, the electron beam, therefore, does not strike the storage screen, allowing a long readout time.

One of the difficulties at the dual-gun transmission modulation system is the cross talk. Figure 42 schematic shows that the reading beam signal is collected on the collector electrode as an output signal. Simultaneously, the writing beam strikes the same screen by crossing it while scanning the storage surface. This crossing of beams results in a cross talk. This situation can be eliminated by RF modulation techniques. The RF cancellation method uses a 30 to 60 mc high frequency carrier signal to modulate the reading beam. This results in the output of a high frequency carrier, the output is sensitive to the high frequency only cancelling any cross talk.

Figure 43. Writing Beam Operation.

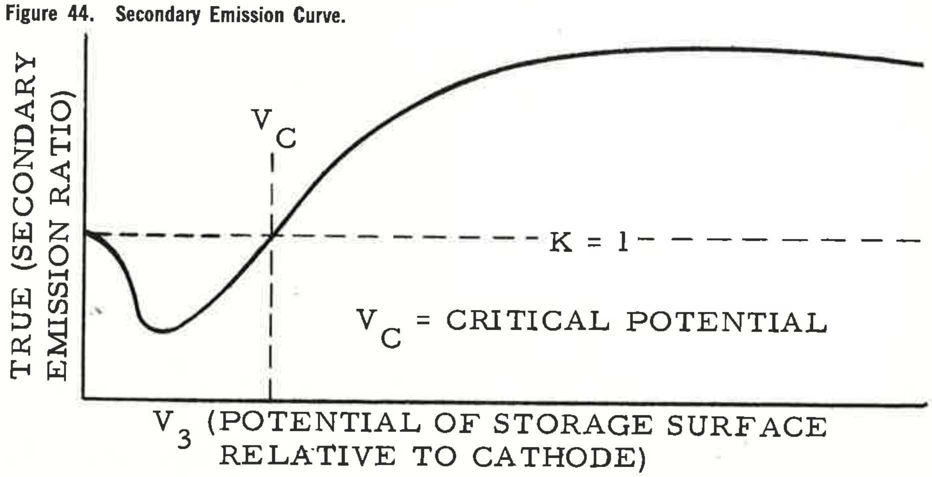


Erase and Prime

To remove a written piece of information from the target in order to write a new one, priming or erasure of the charge pattern is necessary. The priming or total removal of a charge pattern could be accomplished by scanning the target with an unmodulated electron beam. For this process, both the writing or the reading beam can be used. The storage screen in this phase has to be operated below the critical potential (Figure 44) so that the secondary emission ratio $K < 1$ and storage surface become uniformly negative charged. In case of selective priming, the portion of the target has to be scanned only where it is desired to remove the written information.

To erase information, the storage screen potential has to be raised above that value used for writing. The storage surface, scanned with an unmodulated

Figure 44. Secondary Emission Curve.



beam, will be brought to a uniform positive equilibrium potential. For subsequent writing after such erasure, the storage surface has to be primed.

FOPT Tubes

The FOPT is another type of target used in this third type of dual-gun scan converter storage tube. This tube is actually a small CRT on the write side and a vidicon pickup tube on the read side coupled through a fiber optics and built in a common glass envelope. The CRT portion, with a high velocity modulated beam, writes the information into a storage type phosphor screen, actually producing a visible picture. The low velocity modulated read beam, actually a vidicon pickup tube, reads the written information through the fiber optics coupling. The resolution of such tubes is about 600 TV lines due to fiber optics limitations.

Physical Description

Figure 46 shows the outline of the tube and the construction of the FOPT target. Both the write and read gun are conventional high resolution electron guns, both sides with electrostatic focus electrodes. In the center is the FOPT target with the fiber optics, on one side the vidicon photoconductor, and on the other side the CRT phosphor screen.

Principle of Operation

The fiber optics, with a diameter of 1 in., and 0.1 in. thickness, have about 10 μ fibers. The fiber optics disc conducts the light with very little loss of light energy.

The electron beam actually excites the phosphor on one side of the fiber optics and photons are emitted and transferred through the glass fibers in the fiber optics to the photo conductor. The read gun reads the transferred information similar to a Permachon type vidicon pick tube.

Writing

The high energy writing beam scans the phosphor screen and generates light as in the CRT. The photons emitted from the illuminated phosphor screen are transferred through the fiber optics and excite the Permachon photoconductor. It is assumed, that prior to the writing, the photoconductor potential was brought to equilibrium with the read gun cathode potential.

Reading

The reading of the stored information is similar to a Permachon type vidicon storage tube. The illuminated areas of the photo-conductor have increased conductivity, and the electrons move the positive signal electrode. During scan, with the read beam on the illuminated and more positive areas, negative electrons are deposited and the result is a video output signal.

Erasing.

The phosphor screen will be illuminated with an unmodulated writing beam above the level required for normal writing. The target, therefore, can be erased with or without reading the target. Figure 47 shows the available dual gun tube.

Figure 45. Reading Beam Operation.

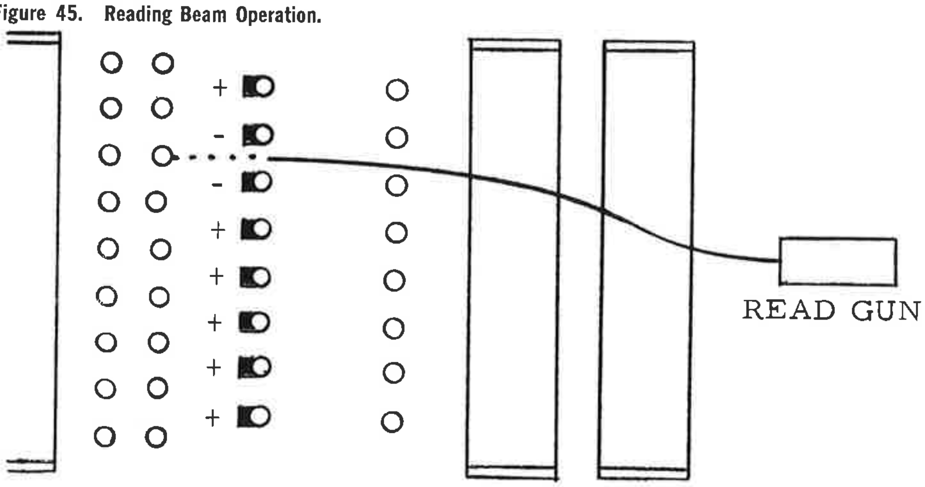
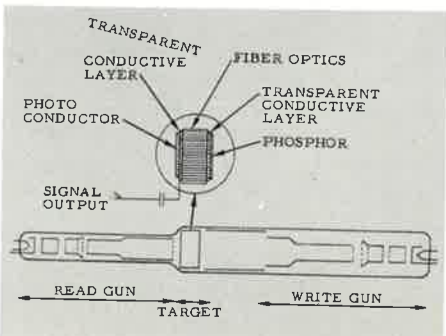


Figure 46. FOPT Scan Converter Tube.



Applications

The scan converter storage tubes are used in several applications, single-gun and dual-gun as well, where information would be recorded in some scan pattern and scan rate; and this information has to be read out in some other scan format or scan rate. It should be able to update in whole or selectively by erasing the written information in a fraction of a second. The applications vary from a one tube version to multiple tube arrangements, depending on the nature of the input signals and the required form of the output.

The equipment that actually required the development of the first scan converter storage tube was the RBDE-1 (Radar Bright Display Equipment) used for air traffic control and converted PPI input signals into TV raster bright display.

The first units, the RBDE-1 and -2, were manufactured by DuMont and used RCA licensed Franchicon dual-gun scan converter tubes. Several experimental units of improved equipment (RBDE-3 and -4 manufactured by Admiral) were equipped with RCA 7539 dual-gun tubes and are presently in operation at several FAA air traffic control centers in the U.S.

Another similar unit, the RBDE-5 manufactured by Raytheon and equipped with a Raytheon CK1383 dual-gun tube, is also in operation at FAA air traffic control centers. A simplified block diagram of the RBDE-5 is presented in Figure 48. All of this equipment is used with PPI raster inputs and TV raster scan outputs for a bright CRT display.

Circuitry of Scan Converter Systems

The scan converter tubes require a certain number of circuits with high performance in order for them to function effectively. The circuitry involved is, in general, of the same nature for the basic scan converter equipment and consists of:

1. Input and output circuits
2. Deflection system
3. Electrostatic or magnetic optics
4. Switching system
5. Protecting circuits.

Single-gun, single tube, and multiple tube systems are shown in Figure 49 and Figure 50. A dual-gun tube system, Figure 51, shows the basic block diagrams. The tubes used in these block diagrams are transmission modulation type tubes.

General Electrodynamic Corp., Garland, Texas, has in standard production, the fully transistorized GEC6021 scan converter system with plug in input and output units for universal use. Figure 52 shows a block diagram of this system. This equipment is a standard item providing a PPI input or a slow scan input into TV raster output versions.

Other scan converter systems block diagrams with dual-gun EBIC tubes are shown in Figure 53 and Figure 54. Figure 53 shows the equipment for a tube 7702 and Figure 54 for a tube RW-5.

Input and Output Circuits

This includes the input amplifier, output amplifier and circuits to prevent cross talk. The input amplifier is chosen to provide the proper gain and bandwidth for the signal to be fed into the writing side or phase of the tube. The output video amplifier, besides gain and bandwidth, should be built as close as possible to the output electrode in order to prevent additional noise generation. All the amplifiers should be designed to maintain a high signal-to-noise ratio. Transistor circuits (tube or hybrid) can be used. The cross talk cancellation uses several techniques, but some use RF oscillators and RF processing circuitry.

Deflection Systems

The write or read side of dual-gun tubes or write or read phase of single-gun tubes has to employ proper deflection circuits for the tube deflection systems. For electrostatic deflection, the proper sweep generation circuits; for magnetic deflection, the higher current drive circuits. For single-gun tubes, the switching circuits switch the scanning modes for write or read phases.

Electrostatic or Magnetic Optics

This includes the circuits, usually d-c bias voltages to the electrostatic or magnetic focus systems for collimating optics built in the tubes. The voltage should be controlled manually or, in case the dynamic focus is needed, automatically. The dynamic focus circuit provides a focusing field to compensate for the difference in electron beam path lengths

Tube Type	Manufacturer	Target System	Target Diameter Inch	Write Side: Deflection	Write Side: Focus	Write Side: Max Acceleration Voltage KV	Read Side: Deflection	Read Side: Focus	Read Side: Max Acceleration Voltage KV	Resolution TV Lines
CK1383	RAYTHEON	TRANS. MOD.	2	MAGN.	MAGN.	4.5	MAGN.	MAGN.	4.5	1200
CK7702	RAYTHEON	TRANS. MOD.	2	MAGN.	EL. STAT.	3.5	MAGN.	MAGN.	3.5	1200
7539	RCA	EBIC	2.25	MAGN.	EL. STAT.	10	MAGN.	MAGN.	2	1200
R6215	RAULAND	EBIC	3	MAGN.	EL. STAT.	10	MAGN.	MAGN.	1.2	1000
R6233	RAULAND	EBIC	3	MAGN.	EL. STAT.	10	MAGN.	MAGN.	1.25	1000
R6253	RAULAND	EBIC	3	EL. STAT.	EL. STAT.	10	MAGN.	MAGN.	1.25	1000
R3098	RAULAND	EBIC	3	HELIX MAGN.	EL. STAT.	8	MAGN.	MAGN.	1.25	525
7828	GEC	EBIC	2.5	MAGN.	EL. STAT.	7.7	MAGN.	MAGN.	1.2	1000
RW-5	WARNECKE	EBIC	1	MAGN.	EL. STAT.	6	MAGN.	MAGN.	1.2	850
RW-6	WARNECKE	EBIC	2.5	MAGN.	EL. STAT.	8	MAGN.	MAGN.	1.2	1200
RW-7	WARNECKE	EBIC	2.5	MAGN.	EL. STAT.	8	MAGN.	MAGN.	1.2	1200
WX-4640	WESTINGHOUSE	FOPT	1	MAGN.	EL. STAT.	5	MAGN.	EL. STAT.	0.3	600
WX-4821	WESTINGHOUSE	FOPT	1	EL. STAT.	EL. STAT.		EL. STAT.	EL. STAT.		600
C74413	RCA	EBIC	2.25	MAGN.	EL. STAT.	11	MAGN.	EL. STAT.	2.75	
F3200	I. T. T.	TRANS. MOD.	2	MAGN.	EL. STAT.	3.6	MAGN.	EL. STAT.	3.2	1200

Figure 47. Dual-Gun Tubes.

Figure 48. Simplified Block Diagram for RBDE-5.

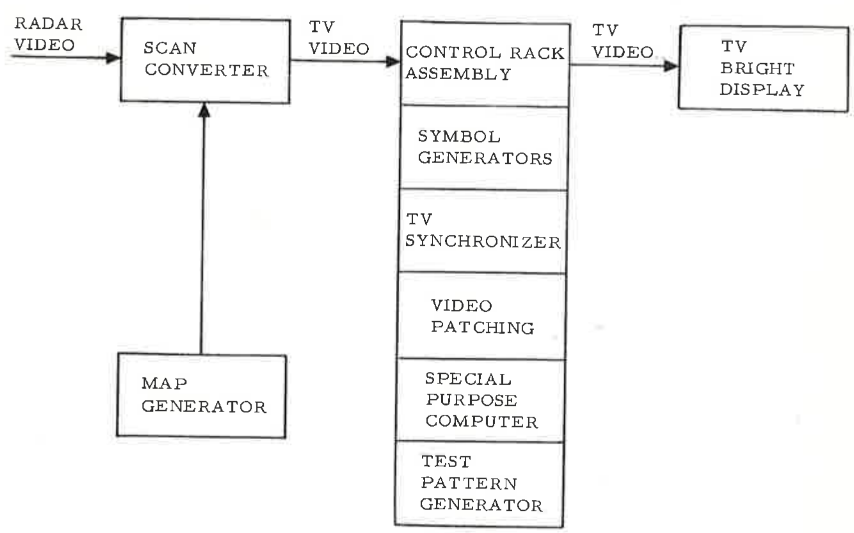
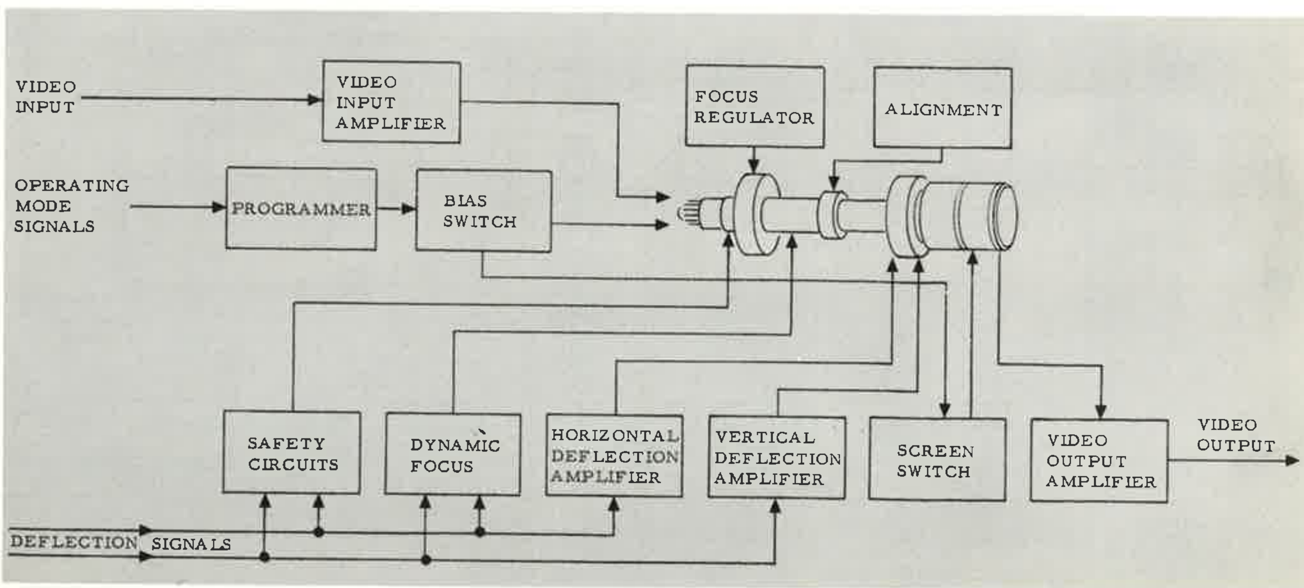


Figure 49. Single-Gun Tube Block Diagram.



for various deflection positions. This applies to either a special magnetic focus coil or to the electrostatic focus electrode.

Switching System

Because the single-gun tubes operate in sequential write and read modes, a switching circuit is required to switch the deflection system and electrode d-c biases to the proper operative modes.

Protecting Circuits

The tubes, either single- or dual-gun, use a high current density electron beam in order to achieve high resolution and small spot size. This small spot should destroy any target if it would stop for some length of time on a point of the target. Therefore, an interlock circuit should be incorporated in order to cut off the electron beam in case of failure of either sweep circuit.

Typical Examples of Applications

Single Gun Single Tube Systems

Slow Scan Input — TV Raster Output

The slow scan system, Figure 55, is used in space, military, aircraft or telephone line narrow bandwidth TV transmission applications. The slow scan television frame, in the order of a ½ sec to 2 minute frame time cannot be observed on a conventional CRT.

The scan converter tube converts this long frame time into a non-flickering TV raster, a 30-frame-per-sec display. The tube in the writing phase writes the received slow scan picture line by line into the target. The writing beam should be deflected in the slow scan rate and synchronized with the received synchron signal.

In the read mode, the written information will be received by the electron beam scanning with a 30-frame-per-sec TV rate. The TV rate picture is displayed on the monitor. The picture is a nonflickering, still picture with the duration of the slow scan frame rate.

Freezing a Single Frame Picture

From a standard TV picture any frame can be stored and frozen with proper gating of the input (Figure 56).

This one frame stored picture can be read out with any TV frame rate and displays a continuous still picture. This permits us to study any important moving scene for some length of time.

Freeze High Speed Motion Picture Frame

For research purposes, a high speed motion study can be performed by freezing one frame of a high speed motion (Figure 57). Using, for instance, a strobe light and a camera, during one flash of the strobe light, the picture can be frozen through the camera tube on the scan converter target. This written in the frame can be displayed then for viewing and study.

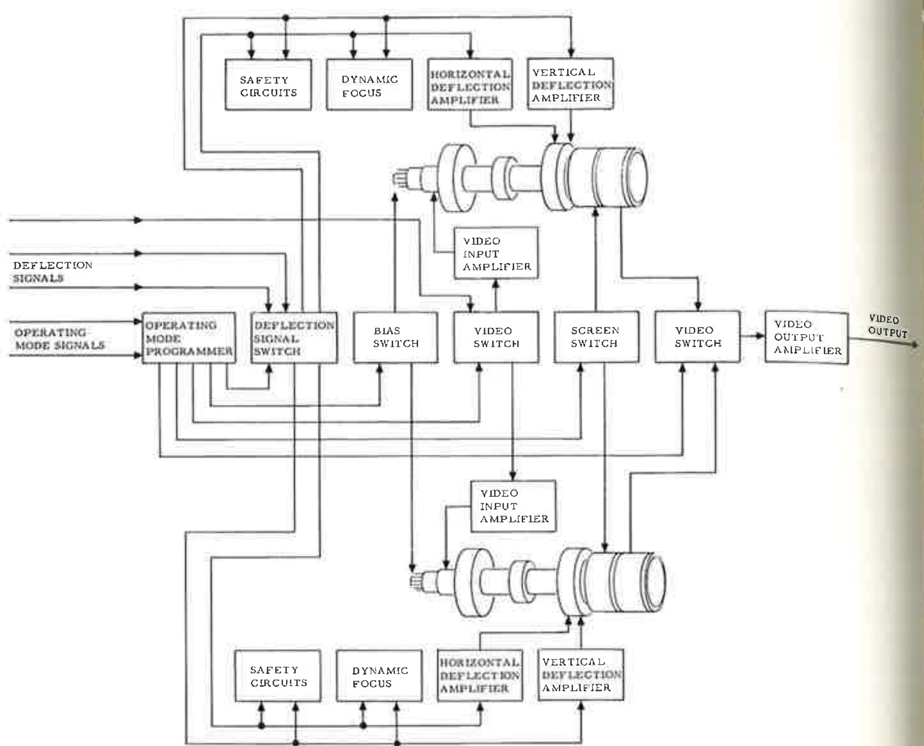
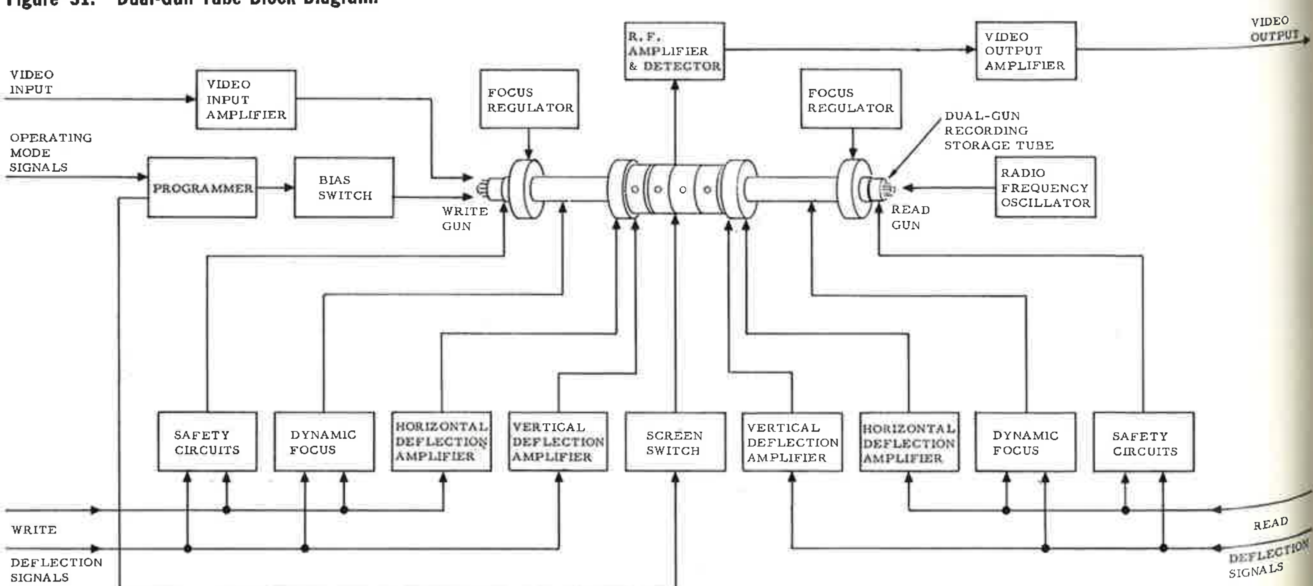


Figure 50. Single-Gun Multiple Tube Block Diagram.

Figure 51. Dual-Gun Tube Block Diagram.



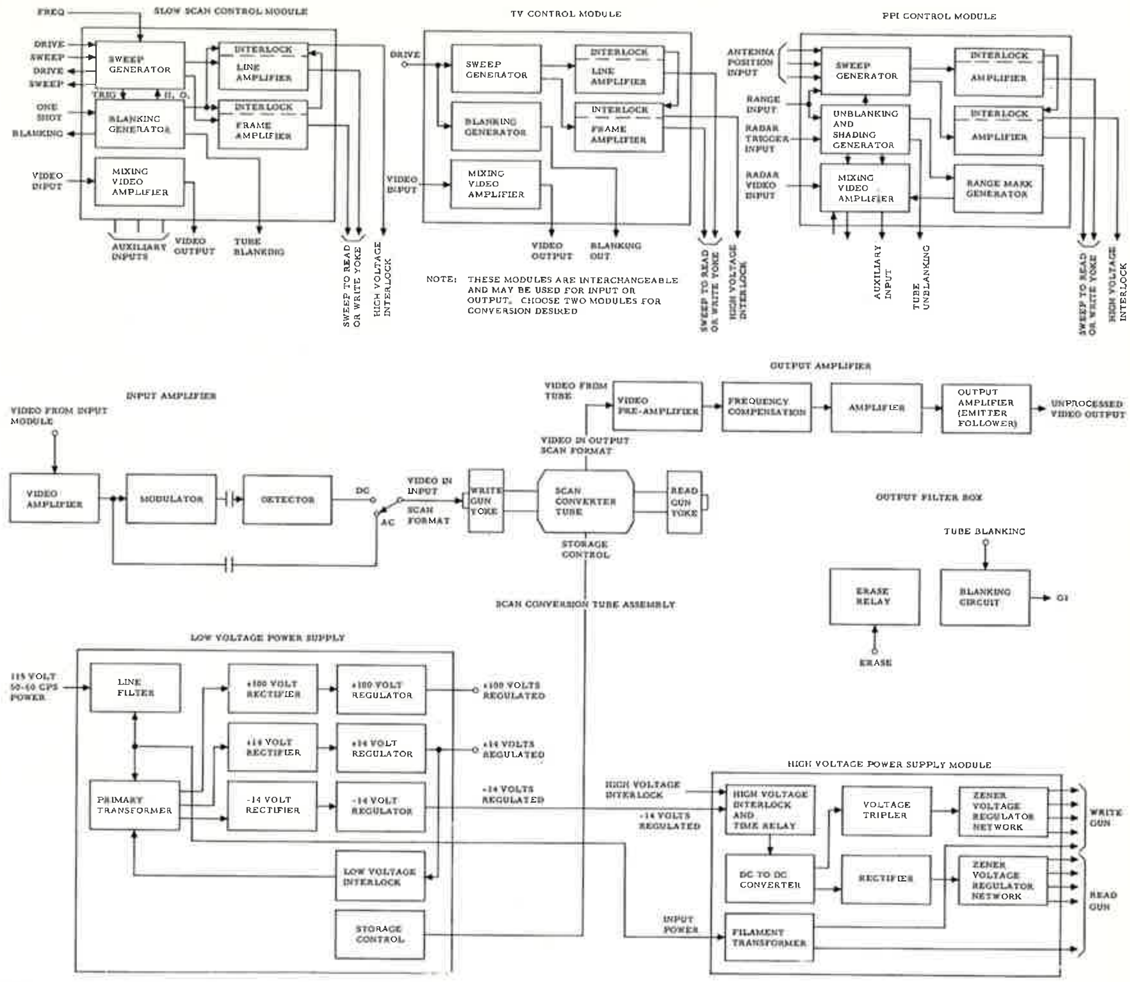
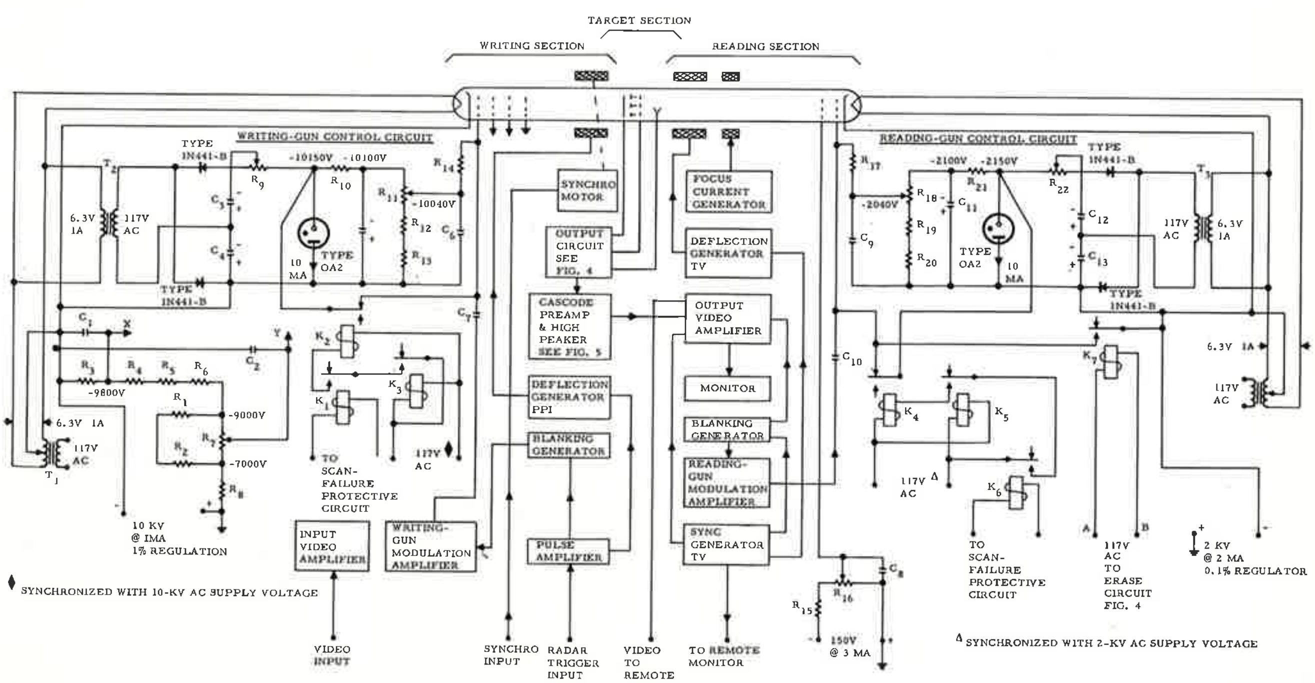


Figure 52. GEC Scan Converter System 6021 Block Diagram.

Figure 53. Block Diagram for Tube 7702.



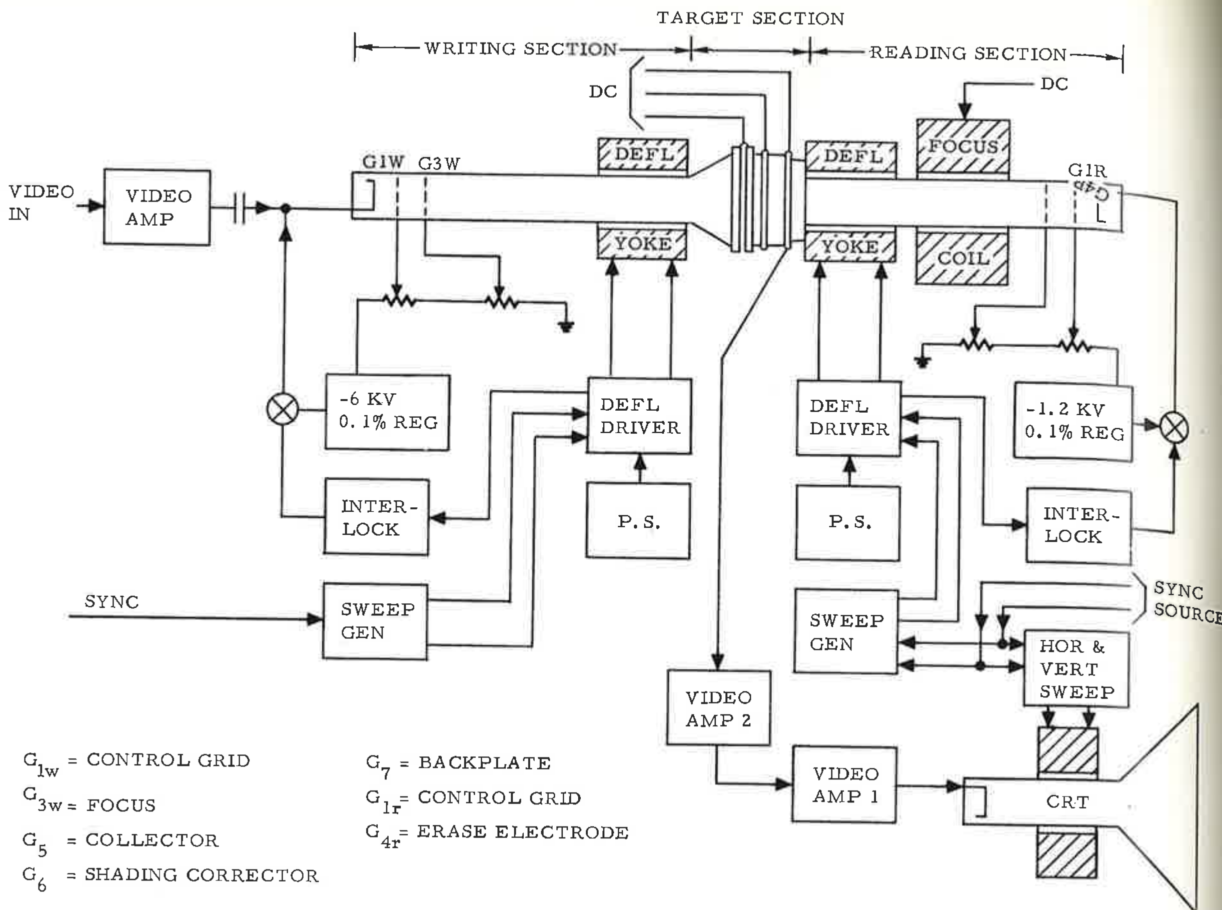


Figure 54. Scan Converter System with RW-5 Tube.

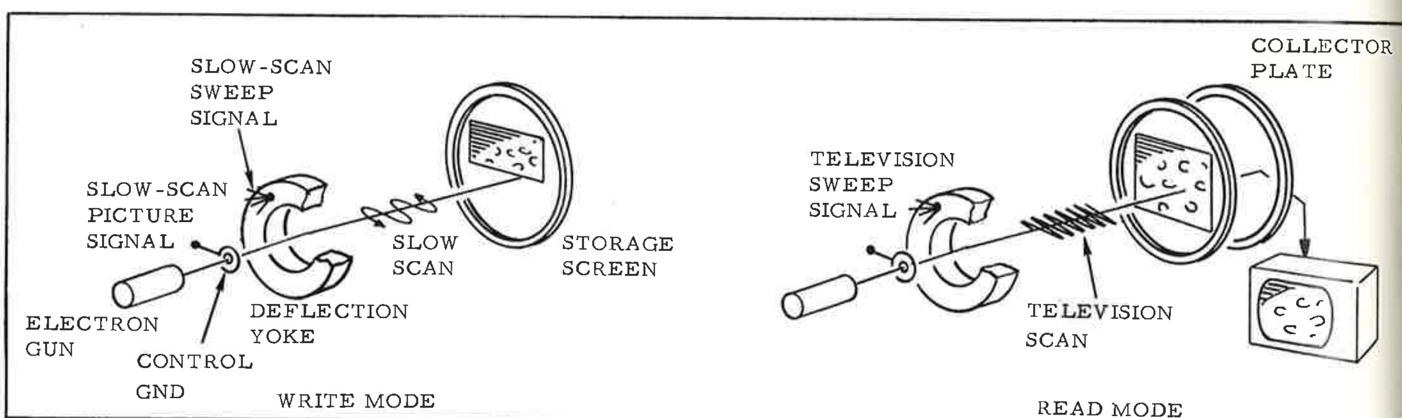


Figure 55. Slow Scan — TV Raster System.

Figure 56. Single Frame Storage.

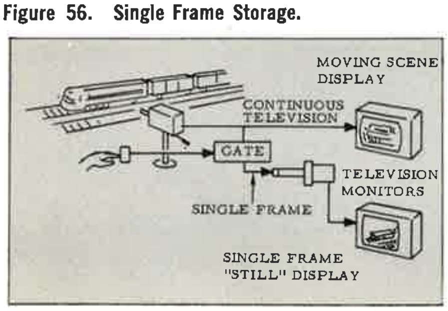


Figure 57. Freeze High Speed Motion.

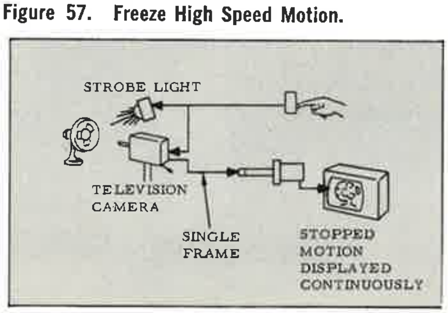
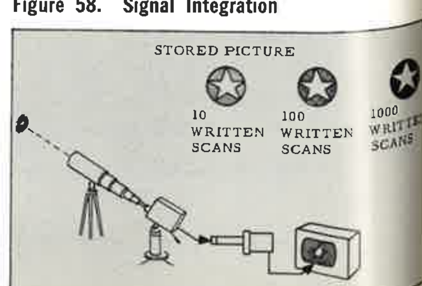


Figure 58. Signal Integration



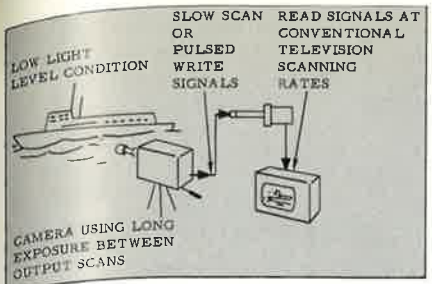
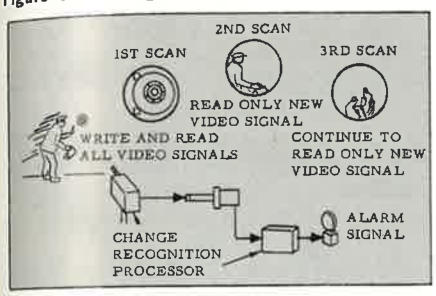


Figure 59. Low Light Level Signal Integration.

Figure 60. Change Detection.



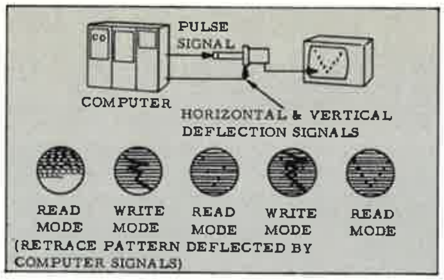


Figure 61. Random Input Display.

Integration of Low Quality and Intensity Signals

This application is a signal-to-noise ratio increase of a signal of low level (Figure 58). With several written scans each line of information, on the same line as in previous scans, is superimposed. The signal repeated several times builds up faster on the target than the noise. In many fields this application can be used; pictures, otherwise not visible, can be displayed for an extended time.

Low Light Level Picture Integrations

This is another method to improve the signal-to-noise ratio of low light level signals (Figure 59). The integration of the signal occurs in the camera tube itself through an extended time exposure. The integrated signal is scanned from the camera tube in slow scan pattern and written in the scan converter tube.

Information Change Detection

Figure 60 illustrates this application where the storage tube reads difference signals only, which have not previously been written. This is actually a MTI or fixed signal cancellation. This application is used in radar and astronomical tracking.

Random Input Signal Integrated Display

Digital computer and symbol generator sources are random inputs and should be written on the target in random scan with x and y position voltages (Figure 61). The alpha numerics or similar patterns can be displayed with the scan converter in a TV raster and flicker free form. This will prevent an additional load from the computer which, otherwise, would be forced to supply information in a 30-frame-per-sec rate. With a time share operation using the vertical retrace time to write in the information, the efficiency can be increased. The tube is switched alternately from the write mode during vertical retrace to read during the raster scan.

Single-Gun Multiple Tube Systems

With single-gun tubes and sequential write and read modes, two or more tubes can be used in a system in a time

Figure 62. Continuous Output System.

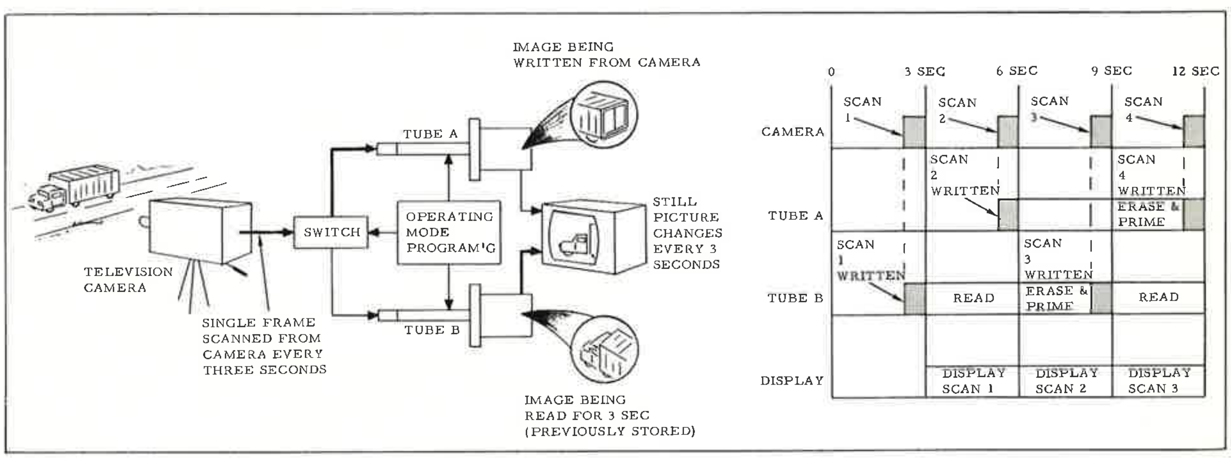
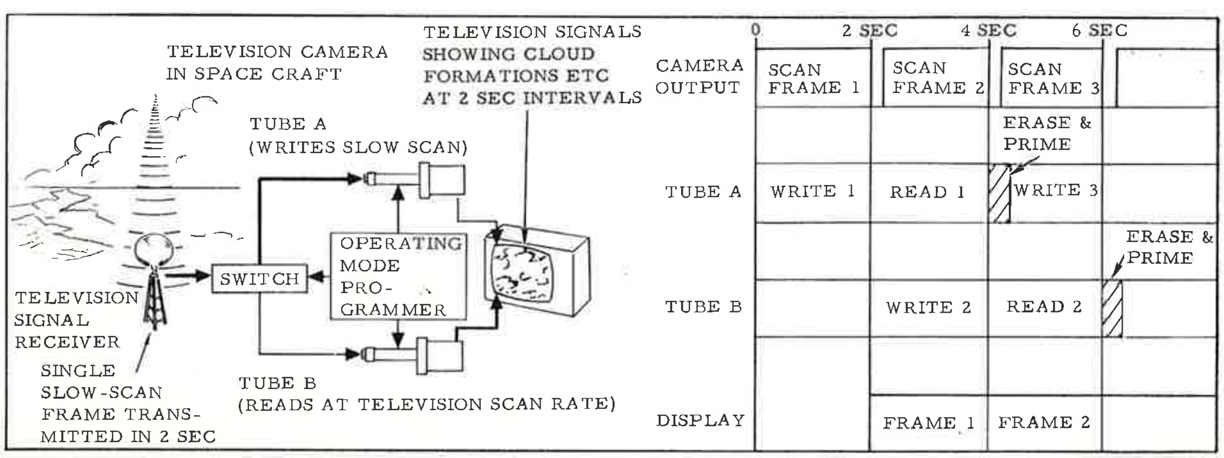


Figure 63. Slow Scan Input.



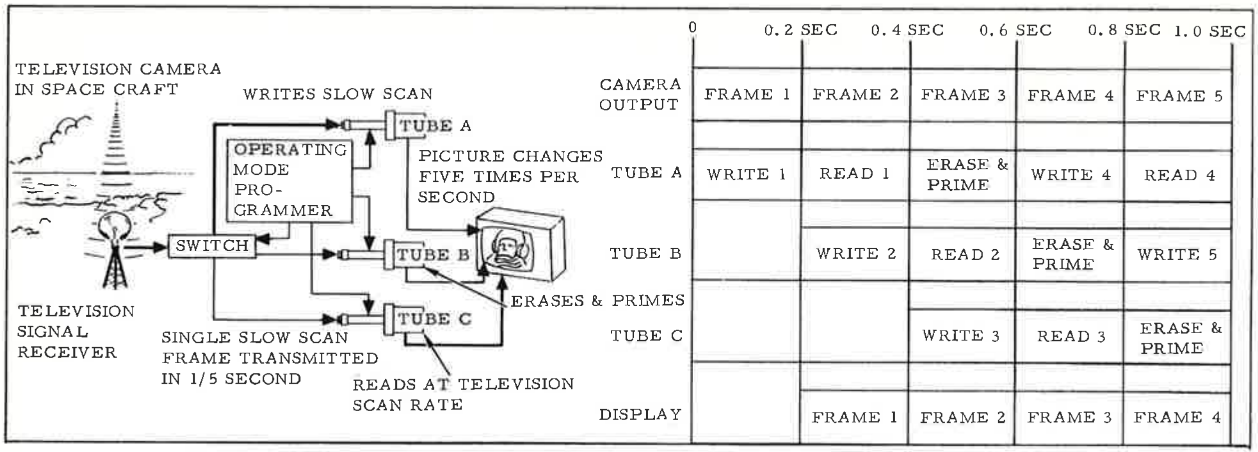


Figure 64. Continuous Output with no Break.

share operation. This will provide a continuous input or output in both without simultaneous operation required.

Continuous Output With Sequential Input

As can be seen in Figure 62, a low

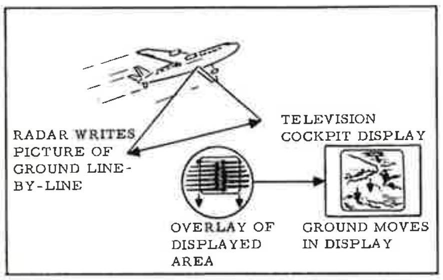


Figure 65. Side Looking Radar Display.

light level camera scans a frame every 3 sec. Using two scan converter storage tubes, each frame from the camera will be written alternately into the target in one of two tubes. In this alternate operation, tube "A" is reading a still picture, tube "B" is erased and also a new frame is written in. Next the two tubes switch functions. This operation gives a continuous non-flickering picture.

Slow Scan Input Continuous Output (Figure 63)

This is, for example, a spacecraft application where slow scan television signals are received from the space craft. Frame rate should be one frame every 2 sec. Erase phase can be inserted into the vertical retrace time. Alternately, using two tubes for writing and reading storing each received frame, a TV raster continuous display can be achieved in the form of still pictures changing every 2 sec.

Slow Scan No Break Input

This is a three-tube operation and the slow scan frame rate is 5-frames-per-sec. (Figure 64). There exists a very small break in the input signal flow. With three tubes, it is possible that this slow scan frame rate can be erased after each reading with a TV raster scan. Although the pictures received are "still" pictures, it does not appear as a break in the picture changes.

The steps taken by the three tubes are:

1. Write every third frame
2. Read the respective third frame
3. Erase and prime

The switching time for each tube and each step is every 0.2 sec, and it is a time share operation.

Side Looking Radar Display (Figure 65)

This is a gradually programming scene recording process by reading the most recently updated section of a written picture, as it is being updated. An aircraft with such equipment, passing over an area, can display such a side-looking radar picture.

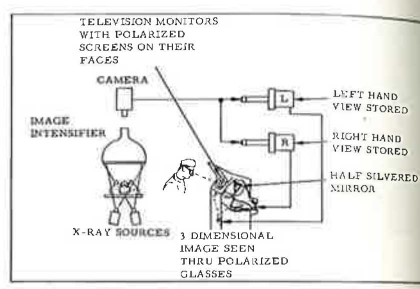
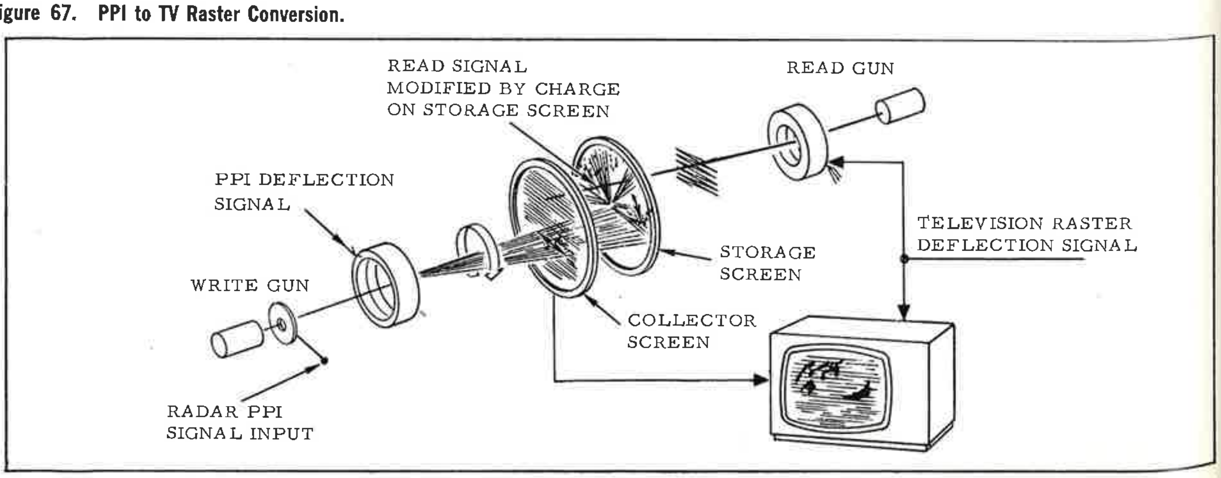


Figure 66. Three Dimensional Display.

The advancement of the selected part of the stored information is line by line, while the writing follows it line by line. This is a two-tube operation with a special circuit and gives a continuous display containing the immediate situation with some of the past information.

Figure 67. PPI to TV Raster Conversion.



Three Dimensional Displays (Figure 66)

Two-storage tubes write a stereo pair of a picture successively exposed by an X-ray source. Two television monitor displays, the stereo images and the storage tubes will be viewed through polaroid viewers. This way a three dimensional picture can be obtained. The reading of the storage tubes is simultaneous with a TV raster. This way the X-ray radiation danger is eliminated.

Dual-Gun Single Tube Applications

Radar PPI to TV Raster Conversion (Figure 67)

The first application of the scan converter storage tube for air traffic control was this radar picture conversion. The wide range of control of storage time makes it possible to gradually erase and consequently overlay successive radar sweeps and produce a trail of aircraft targets on a bright display, just as it appears on a high persistance radar display.

With this method, the radar display can be viewed in a normally lighted room. There is more control over the fading time of the target return signals; and the converted TV raster radar pictures can be displayed on remote monitors, as many as desired.

Slow Scan — TV Raster Conversion

This slow scan conversion process is completely continuous and does not need waiting for whole frames to be written in (Figure 68). However, no overlap is desirable between two successive frames received from a space vehicle. This can be done with dual-gun tubes which have the ability for selective exposure. This operates like a shutter which is moving down the display. It erases the old information along a shutter line completely, while above the line the new information will be painted on the new picture as it is being received.

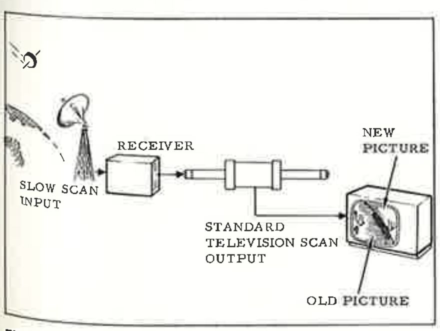


Figure 68. Slow Scan — TV Raster Conversion.

Signal Integration

This is the dual-gun tube version of the signal-to-noise ratio improvement of low level signals (Figure 69). Repetitive scans are superimposed in this operation and the simultaneously reading TV raster output emerges the desired picture slowly out of the background noise.

Sonar — TV Raster Conversion

This is also one type of a slow scan TV raster conversion with the special spiral input pattern (Figure 70). The

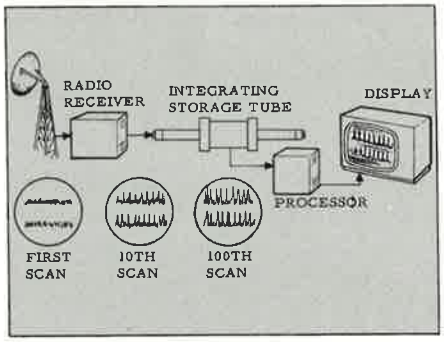


Figure 69. Integration of Low Level Signals.

input is the received sonar scan from a transducer; and the desired display is the information as received, retaining the immediate past information. With the storage tube the display is uniform all over the picture, in the center and on the edges, because of the storage ability of the tube.

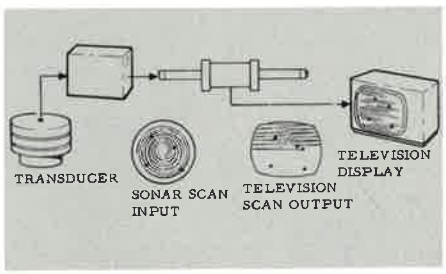


Figure 70. Sonar — TV Raster Conversion.

Airborne Doppler Radar MTI

This application of scan converter storage tubes is used in low altitude, high speed aircraft. The storage tube processor consists of electronic timing circuits, alternately read and write, and a stored matrix of range video amplitude of a 20-mi duration (Figure 71).

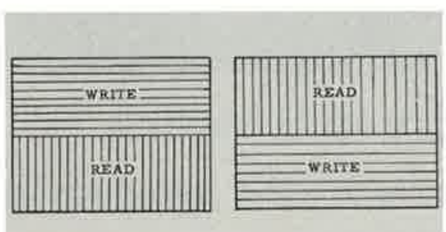


Figure 71. Airborne MTI Display.

The reading process is orthogonal to the writing, providing frequency translation of each range interval. The scan converter storage tube performs simultaneous write and read cycles and gives continuous radar scan coverage. The output of the storage tube through the Doppler processor gives the MTI.

Dual-Gun Multiple Tube Applications

Random Input Signals to Color Projections

In Command and Control Displays where a large screen color display is required, a screen color presentation can be accomplished with three scan converter tubes (Figure 72). The computer and symbol generation input is fed to three scan converter tubes. They are connected with proper registration to each gun of the color projector through an electronic switching circuit. This produces a screen color display with storage capability of the scan converter storage tubes. The picture produced can be erased completely or updated selectively as desired for such large displays.

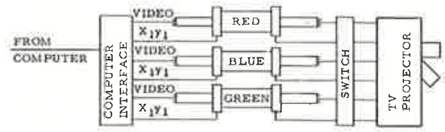


Figure 72. Color TV Projection of Random Input Signals.

Acknowledgment

The author would like to express his appreciation and thanks to Warnecke Electron Tube Corp., especially to Dr. M. de Thomason. Mr. Sam Yanagisawa and Mr. Herb Schank for their cooperation and valuable information, furthermore, to Image Instrument Inc. (Boston, Mass.) for their cooperation, permitting the use of some of their illustrations and application examples.

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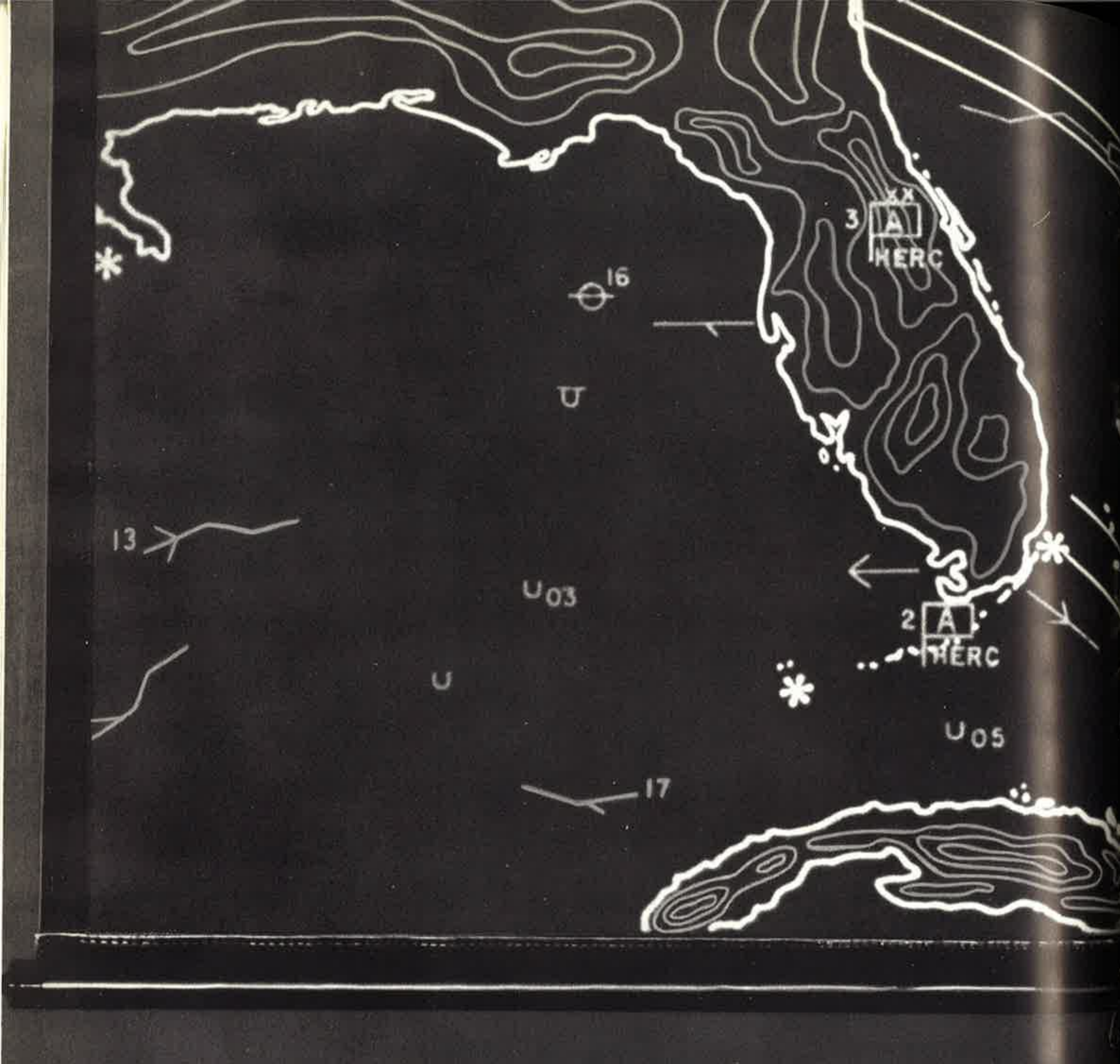


This is a moving picture in 6 colors.
It shows a commander what's happening all over the map.
While it's happening.

Imagine.

A clear, detailed picture of a defense exercise. Events happening rapidly over thousands of square miles.

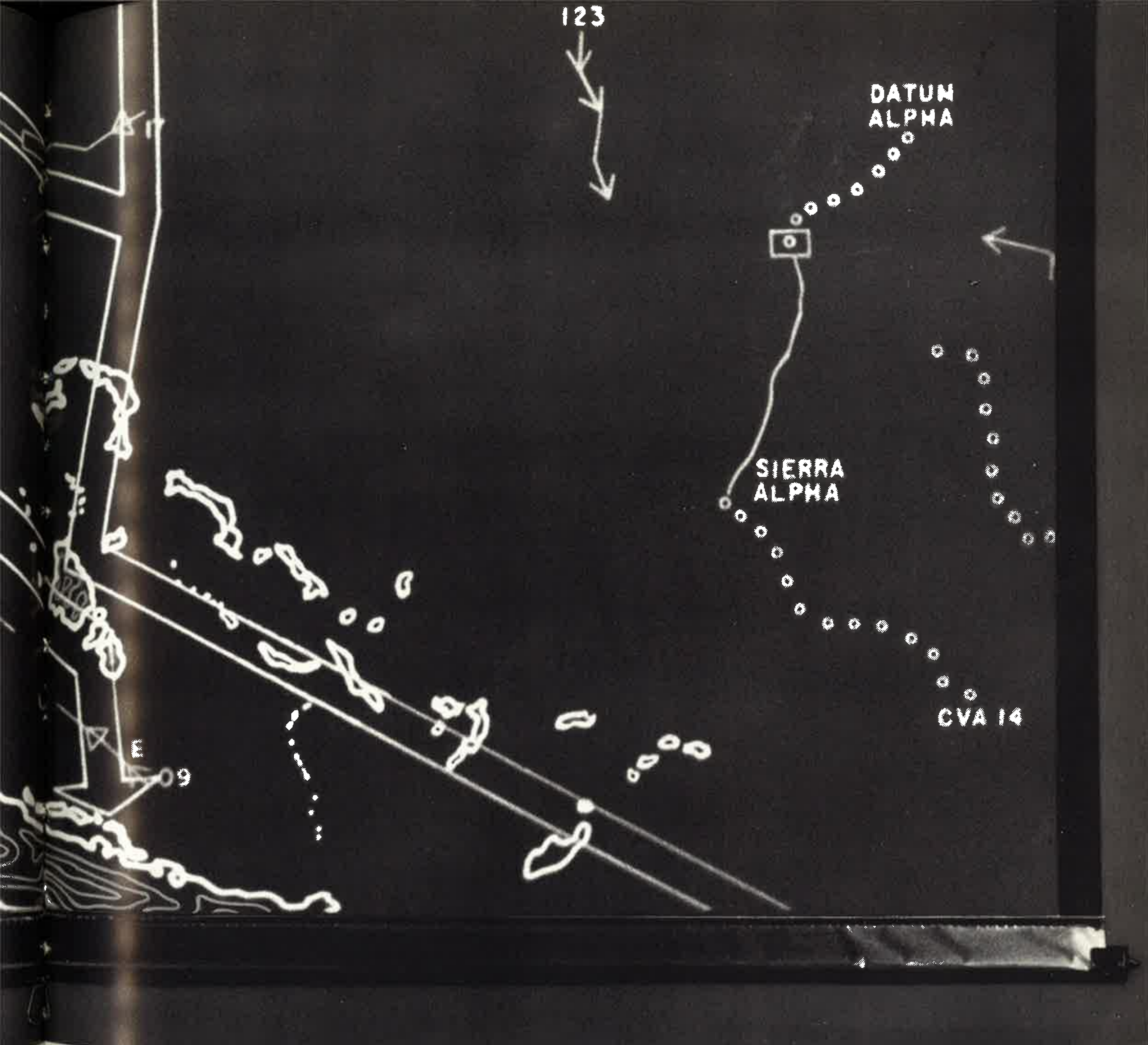
All the information the command-and-control center needs, graphically displayed in any desired size at any number of locations.

In real time, continuously updated by high-speed computers.

In enough colors to clearly identify all elements of the situation.

An unlimited range of numbers, symbols and words. Any kind of line, straight, curved, irregular.

Only the information that's essential for a decision. Superfluous data removed or restored at will, any portion of the display blown up for concentration. The big picture or a



detailed closeup.

Small screen, large screen, multiple screens. Any number of remote monitors showing all or portions of the information on the main display.

A permanent record, recallable at any time for review and analysis, or for problem simulation.

Extreme accuracy. Extreme reliability. Very moderate cost.

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NORTHROP

Abstract

This paper proposes the application of systems analysis and design techniques developed in space and military systems technology to the problem of national highway vehicular traffic control. A control system, comprised of computer and electronic peripheral equipment, information display equipment, highway traffic enforcement personnel and regulatory procedures is described, with emphasis on design considerations that must govern the information display components of such a system. A Vehicular Traffic Control System would be designed to control the overwhelming increase of vehicular traffic over the nationwide system of highways projected into the next few decades. Information display in such a system will represent perhaps the most widespread use of electronic information display technology in the post-1970 era.

by Edith Bairdain

Information Display in a Vehicular Traffic Control System Of the Post-1970 Era

Introduction

A system to provide a means for control of highway vehicular traffic is one of the most urgent requirements of the next decade. The information display components of such a system will represent a principal use of electronic information display technology in the post-1970 era. The predicted flow of traffic in this country by 1975 presents a national problem of the first magnitude. This paper (1) defines that problem, (2) describes an approach toward solution, and (3) discusses a conceptual system resulting from that approach, with emphasis on the kind of information display such a system would contain.

Requirements for Traffic Control System

Traffic control may be the nation's major internal problem. Actually, traffic control is only part of a larger problem involving the movement of people and goods from one location to another throughout the country. Treatment of the problem will require attention to means for movement of people and goods by rail, sea, and air, as well as by highway vehicle. To bring the problem into manageable proportion, however, we will confine the subject here to highway vehicular traffic control. The overall requirement is discussed in terms of (1) its background, and (2) lack of present highway system facilities to fill the need.

Background

As more people continue to drive more miles each year, more and better roads are demanded and constructed; as better roads are extended, more and more people buy and drive more and more vehicles greater distances, and so the spiral goes, with each factor – increasing population, improved roads, and increasing vehicle production – adding impetus to each other factor. According to the detailed analysis made by the Bureau of Public Roads, the 838 billion vehicle miles driven in 1964 represented a 4.6 percent increase over 1963. The 1963 figure was 4.5 percent higher than in 1962.

These statistics are stressed here because the proposed solution may seem too costly even to warrant consideration unless it is placed in the perspective of the magnitude of the problem. The problem itself costs this nation billions annually in traffic accidents and congestion. Accident statistics are alarming now and are worsening. To measure present cost in terms of human life, traffic accidents are a leading cause of death in the United States.

To measure cost in dollars and cents, highway accidents cost this country over $7 billion in 1962 and it is estimated that the annual figure will be $9.5 billion by 1975. This probably conservative estimate means that in the next decade the nation will pay over $75 billion dollars as the cost of traffic accidents if we continue our present highway behavior pattern. There is no way of calculating the loss in terms of broken lives, pain, and social disorganization. Congestion statistics are not so alarming now as they will become. We have some indication of what they will become from instances of parkway approaches to a city clogged with thousands of unmoving vehicles after a holiday period. The cost of traffic congestion in terms of lost productive effort has never even been estimated. In other words, the traffic problem is exorbitantly costly now in terms of human life and in dollars and cents; the problem, if not dealt with boldly and in whole, will come to the question of whether traffic in some areas can move at all at any cost.

No Solution at Present

The problem cannot be met by extension of some present system. While present highway systems contain isolated examples of factors that may be utilized in the future system, there is no present system that will serve the nation in 1975. A definitive effort is required now to make it possible to implement controls that must be provided within the next ten years. Engineering standards exist that will adapt construction of the highways to the needs of traffic. Our task is to develop the means of controlling traffic flow through the post-1970 network of highways. (By "controlling traffic" is meant the orderly flow of vehicular traffic with a maximum of safety and a minimum of delay.) The term "traffic" includes movement of goods, as well as vehicles.

This is restated to define the overall requirement the proposed traffic control system is to fill: The problem is to develop a means for the orderly flow of vehicular traffic with a maximum of safety and a minimum of delay over a nationwide network of highways in the post-1970 era.

Solution Approach

Techniques developed for definition and solution to problems in military and space system design can be employed in solution of the nation's vehicular traffic problem.

The traffic situation has been researched for years by people experienced in traffic control and various research disciplines. Volumes of data exist. The problem has not yielded to this many-sided attack, and the need for major changes in our approach to highway safety and traffic control has long been recognized.

The existing problem results from many specific factors and from the interaction of various combinations of these factors. It cannot be corrected by changes in any one factor, nor by uncoordinated changes in several factors. The total problem must be attacked with all individual factors and their interdependencies placed in proper perspective. The enormous complexity of this task requires the most powerful method of study yet developed — the "total systems study" approach which has evolved from large-scale military and space system research.

In this section the system approach is (1) defined, and (2) applied to traffic control.

System Approach Defined

The systems concept of design and development is essentially the synthesis of a group of components designed to serve a given set of purposes. The system components are the man, the equipment, the procedures used, all selected in terms of the total function and all functioning together within a specified environment. Because of the time lag between realization of the need for a system, design, and final implementation, components must be developed over time and often at widely separated locations. An overall system approach is necessary to insure compatibility between all components and to bring a completely integrated system into being.

System Approach Applied to Traffic Control

A system has been defined as a complex of components designed to function for a given purpose within a specified environment and for a specified user. Components of a traffic control system include man, employment, procedures, and their interdependencies. The specified environment is the network of highways operated under state and national control. The specified user is the motoring public of the nation and the public officials charged with responsibility to facilitate traffic flow. The highway system analysis would give detailed consideration to the vehicle, driver of the vehicle, and to the equipment, computer programs, and personnel and procedures which would serve to facilitate movement of driver and vehicle over the highways. These factors, (a) system environment, (b) system user, and (c) system components, are the proper subject of a traffic control system analysis.

System Environment

Major environmental factors in which a vehicular traffic control system will operate will be that of a network of highways and a complex of state and national government regulations and controls.

It is essential to plan highways now to meet the most extensive future needs. There is a limit to the urban and suburban land that can be given over to highway use. A highway traffic system analysis would consider a network of highways, those available at present, their condition and quality; those already under construction for which concrete plans exist, and those envisioned for future construction. This information, together with existing information as to predicted population growth, future population centers and transportation needs, would provide a basis for the mapping of a nationwide network of highways that should be available by 1975. Attention would be directed to such factors as weather conditions in a given geographical area (recurrent fog over a specific stretch of highway, or sudden sand storms on another), and the consequent effect on traffic safety and congestion. The effect of highway design itself on traffic flow is another example of the considerations involved in the layout of a highway net for future needs. The planning of the network of superhighways and an exact mapping of the locations and characteristics of each segment is a major portion of the system analysis. Actual provision of the highways themselves is outside the definition of the vehicular traffic control system discussed here and designed to regulate the flow of traffic on the highways.

The government regulations and procedures which control the state and national highways and which dictate issue of driver and vehicle licenses are also a part of the environment within which the system will function. Laws regulating traffic, the restrictions applying to vehicles which may be operated on the highway, individuals who may be allowed to drive on the highways and constraints applying to vehicle operation are critical factors and must receive consideration in system design. This fact makes registration and licensing procedures followed by each state a major systems analysis consideration. The standards that vehicles and drivers must meet will determine registration and the issue, suspension or revocation of licenses. The type of vehicular models in use during various time spans of the system, operating characteristics of these vehicles, their weight, speed and safety features are pertinent factors in the systems analysis. The weight of the vehicle and the range of speeds will affect the regulations enforced on the highway. These regulations, in turn, affect the design of the vehicle and its use. Driver requirements must receive attention. Today, certain standards must be met in order to obtain a license to operate a vehicle on the public roads. The level of these standards determines the kind of driver behavior we can expect and must design the system to meet. On the other hand, changes in driver requirements will affect system operation and the practices that may be employed in its use. As superhighways, automobile design and transportation needs develop, the characteristics of people who can operate vehicles efficiently under resultant conditions of speed and complexity will make driver licensing standards more stringent.

System User

Major consideration will have to be given to the use made of the present highway system. While government standards for issue of driver and vehicle licenses define system use to a large extent, other factors also furnish system user considerations. Operations research and safety and accident research data accumulated over the years can be used to arrive at the projected needs which will bring the system into being. Facts reported in long-term studies, such as those provided by the Bureau of Public Roads, furnish data required in user considerations. Research data on optimum driving procedures; on driver selection; on attitude and motivation of the driving public; on human abilities and limitations in relation to vehicle design and highway safety; on alcohol, drugs, fatigue, and sleep in relation to driver behavior, must be part of the analysis.

System Components

System designers must be aware of the most sophisticated communications equipment and techniques. Various types of equipment must be assessed in terms of filling system requirements. Capabilities and limitations of various computer equipment of programming techniques would figure in the system analysis. Major attention would be directed to the human component of the system, and documentation of the procedures required to operate, maintain, and use the system. Analysis must include specification of the skills, background, and training required for the new jobs the system would generate, and the training methods designed for use in upgrading skills to enable present highway system personnel to fuction efficiently in the future system. The kind of information received and transmitted by system personnel and user would dictate system design. The needs and requirements of personnel in various areas of highway control, such as maintenance personnel and traffic enforcement personnel, would receive intensive consideration.

System analysis is a continuing process. Modifications taking place in any part of the system must be assessed for effect on other parts of the system. As the system is developed, the system analysis would serve as a tool in assessing the implementation phases of the system, and as an evaluative instrument in determining the degree to which components meet specified requirements.

A Vehicular Traffic Control System

The envisioned vehicular traffic control system resulting from this systems study would, in brief, involve a complex of electronic devices associated with a large central computer containing all driver and vehicle registration numbers, programmed information display for output to motorists, system personnel, enforcement personnel, highway maintenance personnel and state highway and traffic authorities. The motorist would receive electronically displayed information before and after entering the controlled superhighway giving current conditions of road accessibility, weather conditions, unusual delays and the current speed limits which assure smoothly flowing traffic under those conditions. Highway agencies and system personnel would receive automated record keeping assistance and the information on highway and traffic conditions required for their function.

The system is discussed here in terms of (1) a brief functional description of the equipment and (2) an overall description of the operating system.

Equipment

Major equipment components would consist of (a) computers, (b) communications network, (c) peripheral input devices and (d) peripheral output devices.

Computers

The computer equipment required would have to provide enormous storage capacity. It would contain data on all licensed drivers and vehicles and provide other computer capability. Computer programs would provide the computer routines used to scan and check registration numbers; to output lists and reports (driver information, license expiration dates); to place special requests for hold or stop information on a specific car or driver; and to output the necessary display information to system personnel and the motoring public. This could be furnished by a satellite system of computers, together with sophisticated switching center equipment. Because the system would require the greatest storage capacity that computer technology permits, data processing and storage equipment now in the design stage would be anticipated for use in system implementation.

Communications Network

The communications network would consist of transmission lines interconnecting large-scale computers, input and output devices and automated switching centers. These would be capable of carrying the number of messages necessary to provide almost instantaneous check of traffic entering the superhighway.

Peripheral Input Devices

Input equipment must be available at each location where driver and vehicle registration licenses are issued or revised. This input device would consist of a modified electric typewriter keyboard and would transmit the typed symbols through electronic impulses to the central computer at the same time a typed copy was produced. Similar input devices would be provided for use by system personnel to address the system with data or weather conditions, special hazards, car or driver wanted for inquiry, or to input information applicable to specific functions such as maintenance or special reports.

The electronic scanning device located in each car check area would be a major input equipment item. The electronic scanner would be capable of sensing registration numbers displayed for the purpose, as the vehicle rolled through the check station, and transmitting the numbers to the computer for legality check.

Counting devices on the highway would input traffic density data to the computer automatically. This information would be used with other input data under program control to specify current highway accessibility and driving regulations.

At some time in the future, equipment will include input devices within the vehicle so that the motorist can query the system directly.

Peripheral Output Devices

The requirement for information display immediately responsive to changing conditions would dictate electronic control associated with the computer system, and the most succinct display format consistent with intelligent decision making.

Output devices would consist of various types of electronically generated information display to convey up-to-the-minute information as to road condition, weather condition, speed allowed, and accessibility of road segment. These types of display would include roadside signs, large wall display and readout and printout display of information required at traffic control headquarters, agencies and highway stations, and audio display to both system personnel and motoring public.

The Operating System

The operating system can be discussed from the viewpoint of (a) the motoring public and (b) highway agencies and system personnel.

The System for the Motorist

The system will provide for the motorist the information required for responsible driver behavior. The first information the driver will receive will be that informing him of the condition of the portion of highway he is about to enter. This information will be displayed to the driver before he reaches the access road and in time for decision while an alternate route may be chosen. The second use of the system by the motorist would be at the highway entry check point. The information display portion of the electronic registration scanning device would inform the driver if he is to continue highway entry, wait for a specified time, pull off in the hold area for manual check or leave the highway. As the vehicle enters the highway the especially equipped car check station would scan the driver and vehicle license electronically; the number would be transmitted to the central computer for check as to legality and as to possible "wanted for inquiry" stop attached, then a "go ahead" or "stay" signal transmitted to the check point for the motorist's view. If the restraining signal should be transmitted, pertinent information would be sent to control and enforcement output devices simultaneously for appropriate action. This information display could consist of color coded lighted signals with a simple message written in the lights, such as red "move to hold area," yellow "wait for green," or green 'go.' The yellow light would serve to space entering traffic as conditions dictated. This spacing would be under computer control in response to level of highway congestion.

Determination of highway saturation would be based on the number of cars per lane, spaced so as to maintain traffic flow under current conditions. The driver would have information before entering the highway not only as to accessibility but also as to speed limit under current conditions. Thus, on highway entry the driver would be assured of smoothly flowing traffic at the speed designated.

The driver will be provided information while travelling on the highway and at exit points. Electronically generated illuminated displays located at roadside points would furnish information as to special conditions the driver must consider en route on the controlled highway. Fixed roadway displays could be used to indicate unchanging information such as exit points, destinations and distances. At the exit point, the driver would again drive past a scanning device which would serve to inform the computer that the driver had left the road. This data would be used in the computer-generated statement of toll charges prepared for periodic billing to the holder of the registration, and also stored for historical information for control agency use. A printout card showing distance travelled and amount of charge would be output. The driver could take this card for his records if desired.

Major changes in future motor vehicle design will change the mode of vehicular operation. The system will have to be adaptable to such changes. For example, speeds will be greater; the vehicle will lock onto a moving conveyor-type roadway for portions of travel. The nature of information display required, the display locations, and symbology used will be dictated by the characteristics of the new highway, vehicle, regulations, and driver.

Use of the system will itself bring about changes in addition to normally evolving change. One such expected change, given the highway control system suggested, is the display of traffic control information within the vehicle. The same computer-generated information that would appear on an approach access road or on a control headquarters wall display could also generate a display within the vehicle itself.

On planning a trip, the motorist could obtain a report of traffic conditions in much the same manner as rush hour radio reports are received now giving current conditions. These post-1970 decades reports would provide "trip maps" showing the best route, when the would-be traveller queried the system by inputting proposed departure time, point of departure, and destination. Taking into account all of the conditions prevailing and projected, a routing would appear on a video display within the vehicle, showing best point, travel route, and exit point within a specific time range.

When the motorist actually initiated the trip of whatever distance, he would depart from the garaging point, over local streets and roadways not a part of the controlled highway system. On nearing an approach road to the access point he had chosen, he would tune in the Vehicular Traffic Control System. Here audio-visual display would furnish information to direct his travel. Here the analogy can be made to present day air traffic control when a plane prepares for approach and landing at a particular location and may be diverted to another terminal if conditions warrant. It is appropriate that we look to aerospace design standards that will serve vehicular traffic control, considering speeds future vehicles will employ and the more responsible attitude required of drivers.

We may also expect vehicular highway traffic to be planned in coordination with available water, air, and rail transportation facilities in the post-1970 era.

The System for System Personnel

Highway agency and system personnel would receive all of the information concurrently with its transmission for driver display on the area of highway under responsibility. This would be provided by large wall screen displays, showing the area of the highway network under scrutiny, in map form and would reflect conditions being signalled to motorists on the road. System headquarters would receive tabular wall displays giving a summary of conditions over specified time periods, giving details as to accidents or other unusual occurrences, or notifying of an attempt by an illegal driver-vehicle to enter at a specific access point. The same information would appear concurrently in printout, readout and audio form as required. Enforcement personnel (highway patrol, checkpoint and highway station monitor personnel) would receive information by readout and audio display of conditions requiring their attention.

Various functional areas such as highway maintenance headquarters would receive information as to conditions requiring maintenance attention and current status of specific highway segments by wall, printout, readout and audio display as appropriate. The computer would also furnish records to keep maintenance scheduling and records current. All control agencies would draw upon the computer for current and historical records and for data processing functions.

The system would provide invaluable records for use in future planning by system control headquarters.

The use of presently available design tools and techniques may be expected to bring second generation changes in traffic control and basic highway design. The basic queuing theory developed for predicting the utilization of communications networks is directly applicable to traffic control. Our highway of the future can have deliberately introduced delays at the access points and toll booths to keep traffic moving smoothly on the highway. The computer would contain data on performance of the various types of vehicles and would sort the queued vehicles so that the slower moving would be prevented from entering certain access points during periods of peak traffic and redirected to alternate routes, under computer control.

The computer would contain complete historical data on each section of the highway. These data would be used to schedule highway maintenance so that those sections most likely to introduce traffic delays would receive highest priority. Similarly, methods of detection and removal of disabled vehicles from the highway could be modified to minimize traffic delays and danger to other vehicles.

Finally, the computer would maintain long-term historical records of the traffic handled and the causes of delay for each section of highway. These records would serve as a guide for the design of the next generation of highways and traffic control system. The computer will furnish the measured capabilities of the post-1970 highway control system for design of the post-1985 system.

Summary

To summarize, we have discussed the urgent need today and the absolute demand tomorrow for a control system to provide for orderly movement of vehicular traffic over nationwide networks of highways projected into the future. We have said that the most feasible approach to solution of the gigantic problems ahead lies in the application of system analysis and development methods to the problem.

The control system will operate in an environment of superhighways honeycombing the nation, accessible to every population center, and will consist of a giant computer with associated electronic equipment that will receive, transmit and display information necessary to travel the highway and to control that travel in orderly flow.

However, it is necessary to build for present modes of transportation bearing in mind the fact that both vehicular design and the need for motor vehicular transportation will change drastically. We have looked at what some of these changes may be.

It is our task to bring into being the system that will meet the needs of the future, and make use of the technical skills and design abilities that are represented in impressive concentration here today.

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Summary

Even a casual investigation of the literature of the display-allied fields, e.g. optics, photography, photometry, and psychology, to name but a few, reveals that a wide variety of photometric units are in current use. Furthermore, many identical units have two or three common names; and it is not uncommon to see the units incorrectly used or defined in both technical papers and procurement specifications. This paper shows that there are only four physical quantities for which units are required, defines the most commonly used units, provides some notion of their magnitudes by citing typical values for familiar situations, categorizes these units as being either in the MKS, CGS or English systems, and relates alternate names for identical units.

Photometric Units

by H. R. Luxenberg

[This paper is one section of a report entitled *Display Techniques for Digital Weapons Control Systems*, prepared by Q. L. Bonness and H. R. Luxenberg of The Bunker-Ramo Corporation for U.S. Naval Ordinance Test Station (NOTS), China Lake, California, under contract number N60530-10519.]

Introduction

Even a casual investigation of the literature of the display-allied fields, e.g. optics, photography, photometry, and psychology, to name but a few, reveals that a wide variety of photometric units are in current use. Furthermore, many identical units have two or three common names; and it is not uncommon to see the units incorrectly used or defined in both technical papers and procurement specifications. Table I, Photometric Units, has been prepared to clarify the interrelaticnships.

It will be observed that there are three systems of units — the English, the MKS, and the CGS — but that there are only four physical quantities of significance. These are luminous flux, luminous intensity (also called candle power or intensity), luminance (also called photometric brightness or simply brightness), and illuminance (or illumination). There are two sets of units of luminance, one is generally used for self-luminous surfaces, the other for non-luminous surfaces. This distinction, however, is unimportant and either set will suffice. Furthermore, since the English system is customary in engineering applications, the most useful set of units for display systems work consists of the following: the lumen, the candle, the foot-lambert, and the foot-candle. In the following sections, these units will be defined, and some notion of their magnitude will be given by citing typical values for familiar situations.

Conversion factors between the various sets of units will not be given here; their derivation should be obvious from the definitions. While tables of conversion factors do appear in various handbooks, the blind use of such tables is not recommended because the simple relationships between the various units become obscured. Nothing that one square meter is approximately ten square feet (more nearly 10.76), the following rule-of-thumb relating luminance and illuminance units is easy to recall:

1 English unit $\cong$ 10 MKS units = 1 milli-CGS unit.

The conversion factor of π between the two types of luminance units is easily found from the relation

4π steradians = 1 sphere, hence,
1 lumen/steradian = π lumens/quarter-sphere.

Very frequently when brightness in per-area units appears in a formula, it is associated with a factor of π; lambert units absorb the π factor. This is one of their major advantages (another will be given below. For example, if B is the brightness of an object, the illumination on the retina of the eye in trolands, through a pupil of D mm, is given by $\pi B \left(\frac{D}{2}\right)^2$ if B is in candles/m^2, and by $B \left(\frac{D}{2}\right)^2$ if B is in meter-lamberts.

Luminous Flux: The Lumen

The fundamental photometric unit is the lumen. It has the dimensions of power, and may be converted to power units, e.g. watts, by applying an appropriate conversion factor. The conversion factor varies with the spectral distribution of the radiant energy. For ultraviolet and infrared energy, there are zero lumens per radiant watt; for spectral green (555 mu) light, there are 680 lumens per radiant watt. If only radiant watts in the visible range are considered, the number of lumens per visible radiant watt is a measure of the efficiency of a radiant source as a visible stimulus. A typical incandescent lamp produces 100 lumens per visible radiant watt. This number should not be confused with the efficiency of a lamp which is given in lumens per input watt. For a typical incandescent lamp the efficiency measured in this manner is around ten. The difference between the two numbers represents the input power which is dissipated by conducted and convected

TABLE I
PHOTOMETRIC UNITS

Physical Quantity	Physical Significance	English	MKS	CGS
Luminous Flux	visual power, analogous to wattage	lumen	lumen	lumen
Luminous Intensity (for point sources)	lumen/steradian in a specified direction	candle	candle	candle
Luminance (for extended sources)	candles/unit area or lumens/steradian/unit area in a specified direction	candles/ft^2	candles/m^2 nit	candles/cm^2 stilb
Luminance (for non-luminous surfaces)	lumens/quarter-sphere/unit area in a specified direction	foot-lambert	meter-lambert apostilb blondel	lambert
Illuminance	lumens/unit area	foot-candle lumen/ft^2	meter-candle lumen/m^2 lux	centimeter-candle lumen/cm^2 phot

Other Units:
1) milli-lambert: 10^{-3} lambert
2) nox (obsolete): 10^{-3} lux
3) skot (obsolete): 10^{-3} apostilb
4) candela: correct name for the current standard candle. (In 1948 the luminance of a black body at the temperature of solidifying platinum was defined to be 60 candelas/cm^2.) This was equal to 58.9 $\pm$ 2 international candles. The terms candle and candela are used interchangeably today; although, strictly speaking, candela is correct.
5) troland, luxon, photon (obsolete): Illuminance units (all are equal) for retinal illumination in experimental psychology. The illumination on the retina through a pupil of diameter D mm of the image of an object of brightness B meter-lamberts is defined to be $B\left(\frac{D}{2}\right)^2$ trolands. Thus the retinal illumination produced by an object of 1 meter-lambert luminance when the pupil diameter is 2 mm is 1 troland.
6) apparent foot candle (obsolete): foot-lambert
7) effective foot candle (obsolete): foot-lambert

heat and non-luminous radiation. The lumen is useful to describe the power of a projection system. A typical 8 mm home movie projector (500 watt lamp) has a useful[1] output of 50 - 75 lumens. A typical 35 mm slide projector (500 watt lamp) has a useful ouput of 500 - 1000 lumens.

Luminous Intensity—The Candle

The candle is a measure of the luminous power emitted by a point source per unit solid angle, the steradian. The steradian is the solid angle included within a circular cone whose apex half-angle is approximately 33 degrees. A hemisphere encompasses 2π steradians, an octant $\pi/2$ steradians.

In general, intensity is a function of the direction from the point source. A 60 watt incandescent lamp is approximately 60 candle power (1 candle power/watt); larger lamps are more efficient, smaller ones less so. A uniformly radiating source of 1 candle power radiates 4π lumens into space, since there are 4π steradians around a point.

Luminance: The candle/foot^2 And the foot-lambert

Since practical emitters have extended surfaces, their luminance may be described in terms of the number of candles per unit projected area of the surface. Since luminance, like intensity, is a function of the direction being considered, projected area rather than actual area is used, the projection being on the plane normal to the direction considered. Note that a surface which appears uniformly bright from all directions actually emits less flux (fewer lumens) in the directions away from the normal to the surface. For definiteness assume a area surface with a luminance in all directions of one candle per unit area. When viewed from a direction making an angle Ø with the normal to the surface, the apparent or projected area is cos Ø units. The intensity in this direction must be cos Ø lumens/steradian, in order that the luminance remain one lumen/steradian/unit projected area (i.e. one candle/unit projected area). Because of this fall off of intensity of radiation with departure from the surface normal (while apparent brightness or luminance is constant), a surface of unit area with one candle per unit area luminance radiates only π lumens into the forward hemisphere, while a point source of one candle radiates 2π lumens into a hemisphere.

Candle per-unit-area luminance units are customarily used in rating lamp filaments or other light sources for projection systems. Lambert units (centimeter-, meter-, and foot-) of luminance are physically smaller than the corresponding candle-per-unit-area units of luminance by a factor of π; thus one candle-per-unit area unit and π lambert units represent the same luminance. Thus a surface of unit area with a luminance of 1 lambert unit radiates 1 lumen into the forward hemisphere.

While the two sets of units may be used interchangeably wherever a measure of luminance is required, the foot-lambert is customarily used to describe the brightness of a display surface whether it be self-luminous or not.

[1] Useful output is defined as that reaching the screen.

TABLE II

TYPICAL BRIGHTNESS, FOOT-LAMBERTS[3]

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

Note that pulsed EL mosaic panels have brightness comparable with TV raster or open gate theatre screens.

[3] Brightness values compiled from:
D. G. Fink, TELEVISION ENGINEERING HANDBOOK, McGraw-Hill, 1959.
IES LIGHTING HANDBOOK, THIRD EDITION, Illuminating Engineering Society, 1959.
REFERENCE DATA FOR RADIO ENGINEERS, I. T. and T. Corp., 1949.
MEASUREMENTS AND CALCULATIONS BY THE AUTHOR.

Illuminance: The Foot-Candle

Illumination level or illuminance is measured in terms of lumens per unit area of a surface illuminated from an external source. In English units, one lumen of incident light per square foot of surface produces an illuminance of one foot-candle. For a perfectly reflecting, uniformly diffusing surface, the screen brightness in foot-lamberts is numerically equally to the illuminance in foot-candles, by definition. This is because the one lumen per square foot implicit in the one foot candle illuminance is "re-emitted" into the forward hemisphere by a one foot lambert radiator.

Note that actual rather than projected area is involved here. Thus the illuminance of a given surface will be lowered if it is turned away from the light source fewer lumens will be intercepted.

An MKS unit, the meter-candle-second, is used in photographic work to measure film exposures, while most available exposure meters are calibrated in English units.

Brightness and Contrast

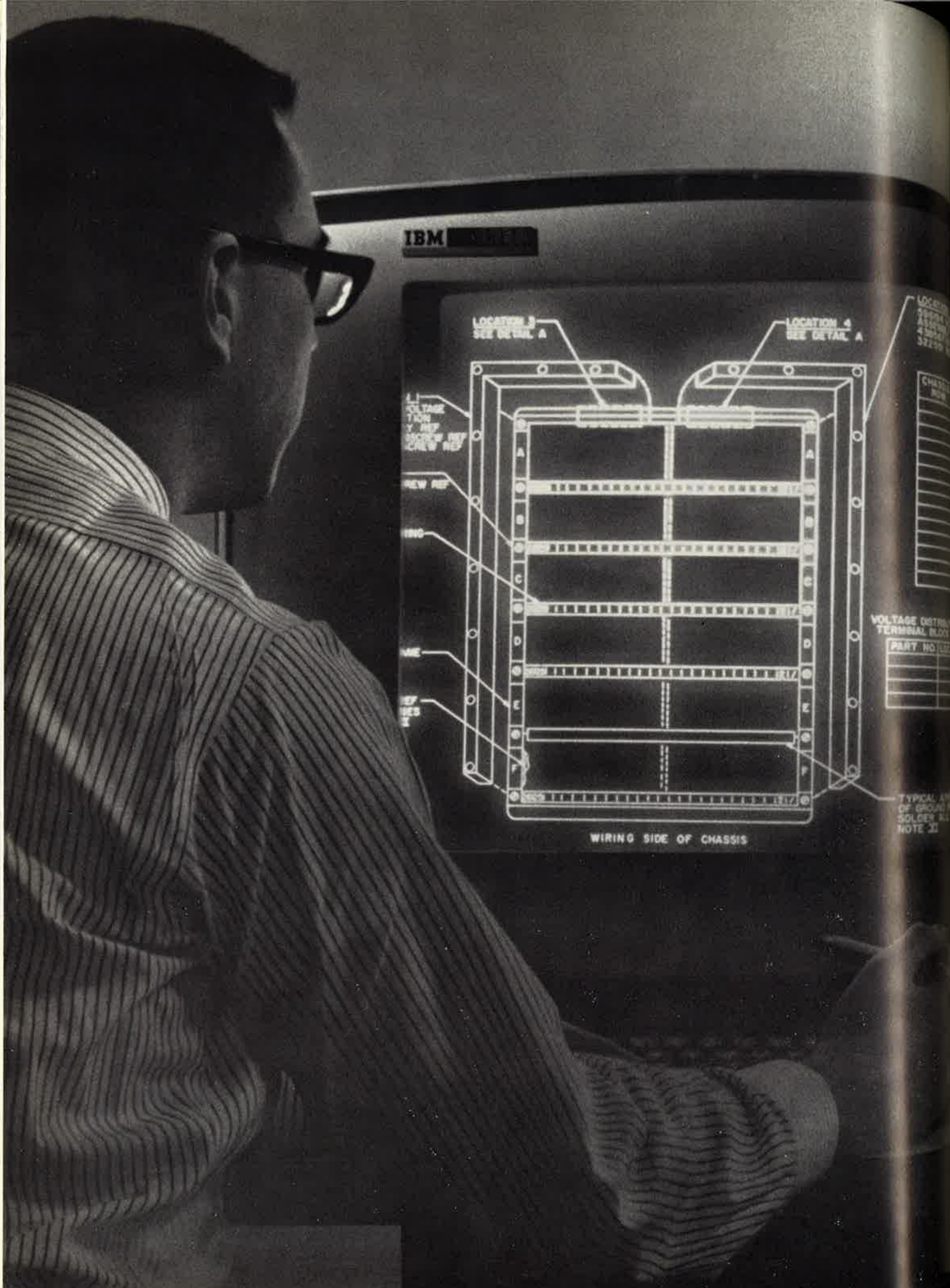
Brightness is *not* the significant factor in display legibility. Contrast is. Brightness is generally specified because it is a relative invariant of the equipment whereas contrast is generally a function of ambient lighting. Brightness is also specified because it is obvious (!) that the higher the brightness, the greater the visibility under higher ambient light. This is not necessarily true, since some displays of lower intrinsic brightness have better visibility than far brighter ones.

Furthermore, unnecessarily high brightness may be a luxury where ambient lighting is subject to control, since it has been determined experimentally that where observers have control over ambient lighting for reading they tend to choose lower values than are generally considered optimum. For example, under a controlled test[2], when the maximum available illuminations were 10, 30, and 45 foot-candles, the observers selected 5, 12, and 16 foot-candles as the optimum values.

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

From a knowledge of the reflectivity of the display surface (unless it is glossy, unity is a conservative estimate) the brightness of the background is obtained, and multiplication by the desired contrast ratio will specify the brightness required of the symbols. For example, if the ambient illumination on an electro-luminescent alphanumeric display whose luminance is ten foot-lamberts can be held below two foot-candles, the resulting contrast of 5:1 will be adequate for good legibility. If, however, the observer is working at a desk where the illumination is 50 foot-candles, a sheet of white paper will have a luminance of 40 foot-lamberts and the 4:1 brightness difference between paper and display may prove annoying. Since the display brightness cannot be raised, the working lighting can be reduced. If the observer is given control over the ambient lighting, he will find an optimum (for him) working level.

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



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ID Authors

G. T. Nagy

Mr. Nagy's biography appeared in the last issue of *Information Display* with the first installment of his article.

Dr. Edith M. Bairdain

Dr. Edith Bairdain is currently Supervisor of the Command and Control Personnel Subsystem Section of the ITT Data & Information Systems Division.

Included in her professional responsibilities are systems analysis, development of design criteria and operational requirements, and direction of human factors studies for large-scale information processing and display systems. Additional experience during the past few years has involved activity in the area of group interaction, human perception and learning.

Prior to her current affiliation, Dr. Bairdain was Project Director in group development research at Columbia University in N. Y. and a consultant to several governmental and industrial agencies.

Dr. Bairdain received B.S. and M.A. degrees from Columbia University. She was awarded a Ph.D. degree from Emory University.

Dr. H. R. Luxenberg

Charter member and first president of the Society for Information Display, Dr. H. R. Luxenberg is currently a member of the technical staff at the Bunker-Ramo Corporation, Canoga Park, Calif.

Previously, he was Vice President and Dir. of Engineering at Houston-Fearless Corp.; Manager, Display Dept. Ramo-Wooldridge Corp.; Manager, Computing Center, Litton Industries; Head Simulation and Analysis Group, Remington-Rand UNIVAC Division; and (1951-52) Research Physicist.

From 1942-45, Dr. Luxenberg served as Weather Officer and Instructor in Meteorology, in the Aleutian Islands.

His computer experience ranges from operation, checkout and maintenance of the Natn'l Bureau of Standards Western Automatic Computer to programming, logical design, system analysis and simulation for many command and control systems. He has recently been concentrating on problems of image enhancement, data display and data storage and retrieval.

5-BEAM CRT PROVIDES REAL-TIME DISPLAY WITH SIMULTANEOUS PHOTOGRAPHY OF DATA

Five separate and distinct displays on one tube face-plate together with a rear-view optical window for photographic recording or map projection are two of the features that make the Du Mont type KC 2296 of more than usual interest to design and project engineers. Successfully meeting a number of unusual operating parameters, the KC 2296 is utilized in a military aircraft navigational application, but numerous other uses are possible for this type and other cathode-ray tubes which may be designed around the multi-gun, rear-view window concept.

Time, distance, angular displacement, pressure, acceleration, telemetry... in fact any kind of data that can be translated into voltage format can be displayed and photographed at the same time. With PPI radar, five sets of data can be superimposed on maps projected on the face of the tube through the optical window. The data (e.g., positions of aircraft or other targets) are then viewed in real-time relationships to the map. Any standard or special phosphor, or any graticule configuration, can be supplied.

Actual phosphor used in the KC 2296 is a double layer phosphor with a high efficiency visual component and high energy blue component for maximum results with blue sensitive film.

With KC 2296, information is displayed on the internal graticule, on the inside of the tube face-plate, making both front and rear views free of parallax. A special phosphor deposition technique allows the graticule lines to be essentially free of phosphor and sharply visible from both front and rear. The five electron guns are independently controllable, and each beam is positioned to scan a separate screen area, except for two beams which coincide. The tube can as readily be designed so that each gun sweeps the entire display area, or any selected segment. Each electron gun is electrostatically focused and deflected.

The rear-view optical port includes such design innovations as freedom from distortion, and the internal graticule may be illuminated by a special side-lighting technique for sharp, clear photographic prints.

RECENT DU MONT ADDITIONS TO CATHODE-RAY TUBE TECHNOLOGY

New application requirements in instrumentation, radar, character display, and other display and readout use have seen significant advances by Fairchild's Du Mont Laboratories in essential types and characteristics. Following are several areas which may be of specific interest to systems managers and project engineers concerned with display and readout problems.

Higher Resolution

Newest designs produce tubes with resolutions of 1,000 lines per inch in electrostatic types with electrostatic deflection. Resolution of 2,000 lines per inch is achieved in magnetic deflection tubes. High resolution electrostatic types achieve deflection sensibilities of 15 mv/trace width at writing speeds in excess of 10" trace widths/second.

Deflection Sensitivity

Deflection factors in currently available tubes are 1 volt/cm and 7 volts/cm in the signal and time axis respectively when operating at a screen potential of 15 KV. These types are available with conventional or with fiber optic face-plates.

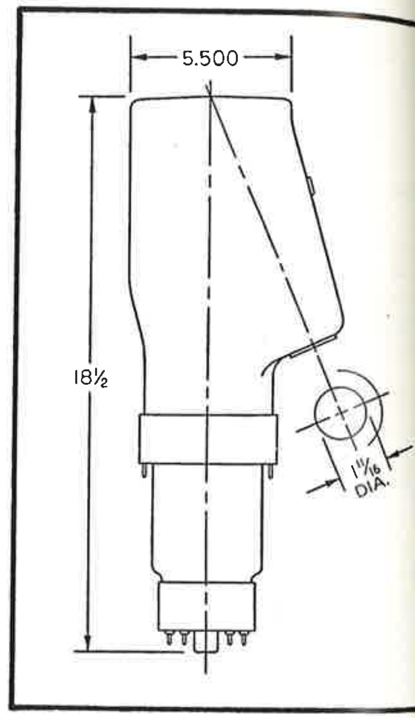
Large Screen Radar Display with High Resolution

Flat face radar display tubes have been produced for high ambient viewing with resolution capabilities of 2,500 lines across the 20-inch useful screen diameter at high display brightness.

Large Diameter All Electrostatic High Writing Speed

For high-speed computer readout, rapid random access and time-sharing radar displays, Du Mont has a complete new line of large diameter electrostatic focus and deflection CRTs with high writing speeds and high deflection sensitivities.

It makes particular sense to look to the leader for cathode-ray tubes — or for any other special purpose tube. No other manufacturer is better equipped to design and build special purpose tubes for your specific application demands.



KC 2296 is 18½" overall, has 7" diagonal, 5" square face. Deflection and acceleration electrodes are brought through tube wall to collar base to minimize L and C of leads.

ID Readout

Chapter News

LOS ANGELES: The Los Angeles Chapter enjoyed an unusually lucid presentation by Erwin A. Ulbrich, Chief Project Engineer, Advanced Technology, NAA, S&ISD, at its May dinner meeting. Mr. Ulbrich spoke on an "Advanced Lunar Spacecraft Landing Simulator" which described techniques and equipment for pilot training in a post-Apollo lunar mission. By means of slides and movies he described the various cues and displays which an astronaut would use in landing a spacecraft on the moon. Details of the simulation equipment were shown which included some of the unique engineering required to produce the dynamic cues so necessary to realistic simulation. On June 24th, 1965, the Los Angeles Chapter will hold its annual business and technical meeting at the Engineers' Club. The business event of the evening will be the establishment of a slate of officers for the 1965-1966 election. For the technical portion of the meeting, the Chapter is privileged to welcome Donald E. Butler, West Coast Project Engineer, COMSAT Corporation. He attended the "Early Bird" launch and has assembled descriptive project material including a soon-to-be released film, into a presentation that promises to be a close inside look into the past, present and future of COMSAT. MID-ATLANTIC: The Mid-Atlantic Chapter's March meeting was a double feature. First we were given a guided tour through the Bunker-Ramo Teleregister Division's facilities in downtown New York. We were shown many of the details of their stock quotation board system of both the old mechanical type and also the latest rotating magnetic drum memory system with desk-type cathode ray display units that will provide selected requested data. We also saw the system where a telephone inquiry actuates a drum with sound on film recording to provide a spoken stock quotation. The drum carries a complete vocabulary of words which are switched in the proper sequence to form the message. The second part of the meeting was a talk by Al Loshin from Airborne Instruments Laboratory. He spoke on "Commercial On-Line Computer-Display Equipments". Mr. Loshin's talk was basically a review of the state-of-the-art of computer display equipments, and he also discussed his ideas as to the future improvements that would be made in the next few years.

Business Notes and News

INFORMATICS INC., subsidiary of DATA PRODUCTS CORP., plans to acquire the assets and business of CPM SYSTEMS INC., a software firm specializing in advanced management techniques . . . MILGO ELECTRONICS CORP. has acquired CONTROL TECHNOLOGY INC., a firm which specializes in software . . . BELOCK INSTRUMENT CORP. has purchased 50% interest in INTELECTRON CORP. . . . INTERNATIONAL BUSINESS MACHINES CORP. has awarded a contract to BLAKE CONSTRUCTION CO. for construction of a 240,000 sq. ft. facility near Gaithersburg, Md., to accommodate the staff of IBM's FEDERAL SYSTEMS DIV. . . . XEROX CORP. has been awarded a contract by Rome Air Development Center to develop a selective photo-copier for use in computer systems that automatically translate foreign scientific and technical material . . . BURROUGHS CORP., ELECTRONIC COMPONENTS DIV., has announced a significant price reduction for five types of its Nixie (Reg.) indicator tubes . . . LOCKHEED-GEORGIA CO. is employing an ELECTRONIC ASSOCIATES INC. Data-Plotter (Reg.) in providing design drawings of large military and commercial aircraft . . . LFE ELECTRONICS DIV., LABORATORY FOR ELECTRONICS, INC., has received $220,000 in contracts from the Army Electronics Command for spares for various electronic equipments supplied by the firm . . . ITT INDUSTRIAL PRODUCTS DIV. has unveiled its new bargraph and all-solid-state monitor oscilloscopes . . . STROMBERG CARLSON CORP., subsidiary of GENERAL DYNAMICS CORP., has agreed to purchase for cash the business and assets of INFORMATION PRODUCTS CORP., subsidiary of RENWELL INDUSTRIES INC. . . . THE BUNKER-RAMO CORP. has announced an unusual new flight information system for airlines, called "Brite-Wall", which employs a bank of varied CRT's on a wall display 8 by 24 feet in area . . . CALIFORNIA COMPUTER PRODUCTS INC. has been awarded a $150,000 cost-plus-fixed-fee study and design contract by NASA/Goddard Space Flight Center to continue contractual work in the weather satellite field.

Technical Meetings

The Institute of Navigation will conduct its twenty-first annual meeting June 21-23, in conjunction with the *Society for Information Display,* at the Edgewater Inn Marina Hotel, Long Beach, California. Official host is the Guidance and Control Systems Div., Litton Industries. Tentative program plans include sessions on "Maps and Charts", "Navigational Displays", and "Navigational Satellites" . . . The Society of Photographic Scientists and Engineers conducted a seminar June 3-4 at New York's Plaza Hotel.

Vigicon Display System

Chuck Blaney, applications engineer for Vigicon Systems, by Northrop Nortronics, makes an adjustment on one of the Vigicons; display can be observed at the left. The Vigicons are widely used in both military and aerospace display applications. The Vigicon family was developed to meet exacting demands of a wide variety of display applications. In combination with appropriate auxiliary equipments, the ultracompact modular units form systems ideally suited to the extremely complex requirements of airborne, shipboard, and ground-based command and control centers, for purposes ranging from localized search and rescue to global combat situations. Systems consist of three major elements, data receiving, data processing, and data presentation. They utilize a wide assortment of data acquisition and data processing equipments. Presentation may be made with any of the three basic types of Vigicon systems: The Plotting Projector generates any desired form of line imagery; the Reference Projector utilizes prepared slides fom a storage magazine; the Spotting Projector places dynamic data onto the screen like the Plotting Projector, but depicts instantaneous vector position at all times without leaving a permanent trace. The modular projectors can present data in any of six colors by means of a 6-filter turret surrounding the light source within the projector; color is either manually- or remote-controlled.

High-Resolution TV System

Command Center situation displays containing a great amount of detailed information can be viewed from remote locations using a new high-resolution system introduced by Granger Associates, Palo Alto, Calif. The system displays about four times as much information as can be conveyed by conventional 525-line systems, according to Granger. It is suitable for viewing large wall displays, maps, status boards, alphanumeric printouts, TTY page printers, radar screens, and similar visual data. An alphanumeric character occupying only 1/10,000 of the monitor screen can be read

AN IMPORTANT ANNOUNCEMENT ABOUT DISPLAYS FOR UNIVAC 490 USERS

Economical CRT Computer Controlled Displays, compatible with the UNIVAC 490, are now available from INFORMATION DISPLAYS, INC. (formerly RMS Associates, Inc.).

All solid-state (except for 21" rectangular CRT), these displays write up to 80,000 points or characters per second. Light pens, vector generators, size and intensity controls, buffer memories, and other equally useful options can be included.

One typical UNIVAC 490 compatible display is the IDI Type CM10009. This unit operates over Dataphone and includes the CURVILINE® Character Generator, vector generator, circle operator, mode control, core memory, and auxiliary line drivers. The price of the CM10009 Computer Controlled Display is approximately $90,000.

Other combinations to meet each user's requirements can be assembled from the assortment of standard options.

Please write or call for complete information.

NOTE TO USERS OF OTHER COMPUTERS — IDI probably has delivered displays compatible with your computer . . . too!

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with ease. In multi-camera systems, the scene to be viewed can be selected by pushbuttons at each monitor; monitors can be located 1500 ft. from the camera or at much greater distances using accessory booster amplifiers. The system, designated Series V1000, employs a 30 mc video bandwidth in place of the 8 mc bandwidth commonly used in closed-circuit TV, consequently, has about four times the resolving power. It can be obtained with a choice of 12 line rates from 525 to 1225 lines/frame. Resolution of 800 lines in both horizontal and vertical can be obtained. Linearity is 1%; geometric distortion less than 2%; signal-to-noise ratio, 40 db or better.

Digital-to-Video System for NASA/Huntsville

Scientists in Huntsville, Ala., will soon save travel time by using TV consoles to monitor data received from space vehicles launched 700 miles away at Cape Kennedy, Fla. Instead of travelling to the Cape, many of the scientists will remain at the Alabama facilities and view TV and other graphic displays of digital launch data. The equipment which presents the digital data to the video displays has been produced by Stromberg-Carlson Corp. in San Diego for installation at Marshall's Operations Support Center.

Computer-Driven Visual Display System

A computer- driven visual display system will be installed at the Carnegie Institute of Technology computation center in Pittsburgh this summer by Philco Corp. The complex CRT system, being built to Carnegie Tech. specifications, is one of the most sophisticated known. It was adapted from Philco's Real-Time Electronic Access and Display (READ) System. It will consist of a controller and three consoles, permitting the operator to manipulate high-resolution alphanumeric and graphic digital data in a volatile manner on the face of the CRTs. Uses will include computer programming and debugging, problem solving, and instruction.

TV Pictures Played from Phonograph

Westinghouse Electric Corp. has developed an electronic system that plays TV pictures from a phonograph record. Together with a series of still pictures, voice and music come from the same long-play disc. Both the audio and video signals are present in the grooves of the record, and both are picked up by phonograph needle. Up to 400 pictures and 40 minutes of voice and music are present on the two sides of a 12-inch 33⅓ rpm recording, called a Videodisc. The system is called Phonovid. Without modification, Phonovid can be integrated into existing closed-circuit and standard-broadcast TV systems.

Integrated Aerial Survey/Electronic Photo-Mapping

Kollsman Instrument Corp. has built the first prototype of a new class of advanced airborne electronic photography systems that completely integrates aerial surveying and photomapping techniques with computer control. Nicknamed an "airborne surveyor and map maker", the system is capable of photomapping 30 to 40 thousand square miles a day, and to collect detailed data about where the photos were taken, as well as from what altitude and angle.

Spaceflight Mission Analysis "Theater"

A large-screen, multicolor spaceflight display system for real-time analysis of all future space missions is now being installed at NASA's Goddard Spaceflight Center, Greenbelt, Md., by Northrop Corporation's Nortronics Div. The dynamic projection system was expected to be completed in time for use in the Gemini/Titan-4 mission. Tracking data are to be processed through an IBM computer complex and immediately projected in a variety of colors on a five-foot-square screen against appropriate reference data. The system will utilize six Nortronics Vigicon projectors, including plotting units and a reference projector loaded with a range of prepared background slides.

Small Neon Lamp

Circon Component Corp., specialists in microminiature components, has announced a new micromin series of four neon lamps only ⅝-in. long. They offer smaller size in both standard and high-intensity versions. Long electrodes create maximum light output for use in indicator and signalling applications.

Models are also available with integral internal ballast, which controls the internal resistance of the lamp at optimum value when fired, so that the current and light output remain correct. The new lamps are interchangeable in any lampholder designed to use No. 327, 328, 330 and 331 incandescent lamps.

Circle Reader Service Card No. 19

Audio/Video Modulator

DYNAIR Electronics, Inc., San Diego, Calif., has developed a solid-state audio/video modulator for closed-circuit TV applications. Termed the Model TX-4A "Dyna-Mod", the new unit features high reliability, low power consumption, and more compact construction. It is available for use with either separate video and audio inputs, a combined video and multiplexed 4.5-mc input, or separate video and 4.5-mc aural inputs. Output in each case is a standard VHF TV signal very similar to that of FCC licensed broadcast transmitters. Units are available for operation on any VHF channel and most special frequencies.

Circle Reader Service Card No. 20

Two-Gun CRT

Electronic Tube Div., General Atronics Corp., Philadelphia, Pa., has developed a new two-gun cathode ray tube especially developed for use with fully-transistorized circuitry. The new tube, termed ETC Type M1212, offers full-scan by both guns over the entire 4½-in. of useable screen on the 5-in. rectangular face. Fully electrostatic, the M1212 features new performance highs in light input, resolution and deflection sensitivity. The use of additional electrodes permits excellent geometric correction, according to the manufacturer.

Circle Reader Service Card No. 21

Transmitter Tube Socket

Connector Corp., Chicago, Ill., is offering a new Type 444 transmitter tube socket which offers low loss at very high frequencies. Excellent heat, arc resistance and loss factor are provided by the glass filled alkyd and ceramic insulations. Socket is vented to provide maximum cooling of tube base and anode contact area by convection.

Voltage breakdown characteristics are enhanced by appropriate barriers between contact positions and all-molded construction including mounting ears. For maximum life and low contact resistance, contacts are of beryllium copper silver plated gold flash. Type 444 mates with Amperex DX245/8505, DX 274/8603 and tubes that have similar magnoval basing with offset anode contact.

Circle Reader Service Card No. 22

ID Products

CRT System Components

Beta Instrument Corp., Newton Upper Falls, Mass., is now offering a wide variety of plug-in and other components for use in CRT display systems. Modules offered include: SG101 sawtooth voltage generator, an all-silicon-solid-state unit for applications requiring a linear-sweep signal; DA103/104 deflection amplifiers, solid-state high-deflection-performance packages for systems employing magnetic deflection; DF110 dynamic focus generator, a solid-state plug-in unit for display systems where dynamic focus correction is required; DF111/112 dynamic focus output amplifier; FR115 focus coil regulator, a highly stable, adjustable source of dc current to a focus coil for CRT or storage tube display applications; and BA120 blanking amplifier, for beam blanking during the retrace period of a raster scan, or for beam unblanking in a random access point plotting display.

Circle Reader Service Card No. 23

Data Synthesis System

McDonnell Aircraft Co., St. Louis, Mo., has announced development of a new data synthesis system which consists of logic circuitry, a three-axis drive mechanism controlled through a digital servo loop, the model, and a motion picture camera. The camera is equipped with a beam-splitting arrangement to allow data annotation to be simultaneously projected onto the film.

Annotation can be in many forms; analog, such as deviation from programmed flight path; artificial horizon; or in digital form, as might be presented on an electronic counter, time display, or the actual input data in engineering units. The camera, mounted atop the data annotation console, is boresighted on the cg of the model, with several mounting positions available to accommodate cg changes caused by varied model positioning.

Circle Reader Service Card No. 24

Gallium Phosphide Lamps

Ferranti Electric, Inc., Plainview, N.Y., has introduced a new subminiature gallium-phosphide junction device which emits red light when passing current in the forward direction. The new type of light source is based on radiative recombination at the PN junction. It is suitable for a variety of instrument and indicator applications where small size and low operating current are important.

The lamps are approximately 0.03-in. in diam., and provide electroluminescent radiation at 7000 angstroms. Seven lamps are presently available giving minimum light intensities ranging from 1.5 to 20x 10^{-5} candelas when driven by 50-mA pulses of 1 millisec. duration. A 1-amp. pulse of 1 microsecond may be passed to increase this brightness by a factor of 20.

Circle Reader Service Card No. 25

Electro Optic Modulator

The Isomet Corp., Palisades Park, N.J., has announced the availability of an integral electro optic light modulator assembly. Designated EOS 412, it is an integral assembly consisting of polarizer, quarter-wave retardation plate, an Isomet Electro Optic Light Modulator, and an analyzer. All elements are mounted on calibrated circles capable of independent rotation, thus allowing any combination of fast axis orientations. In addition, three adjusting screws provide for accurate alignment.

Alignment of the fast axis of the quarter-wave plate with the transmission axis of the polarizer allows the achievement of a transmitted intensity which follows a sine squared response with respect to applied voltage. If the quarter-wave plate is rotated 45°, linear response may be achieved. By reversing the entrance and exit faces, the system becomes a Senarmont compensator for calibration of the EOLM for retardation vs. voltage.

Circle Reader Service Card No. 26

Miniature Storage Tube

Warnecke Electron Tubes Inc., Des Plaines, Ill., is offering a miniature storage tube having numerous applications for the storage and processing of video signals. Termed Model RW-5, it is a miniaturized, dual-gun, electrical-signal storage tube which uses a solid dielectric film as the storage medium.

The tube, which is 13-3/16 in. long by 1-47/64 in. max. diam., has resolution capacity of 840 lines/target diam and can operate over a wide range of storage and erase conditions. It is capable of receiving an electrical input in one scanning mode, writing this information on the storage surface by the EBIC principle, then reading out this stored information in the form of an electrical signal with a scanning mode independent of the input.

Circle Reader Service Card No. 27

Reflex Autocollimator

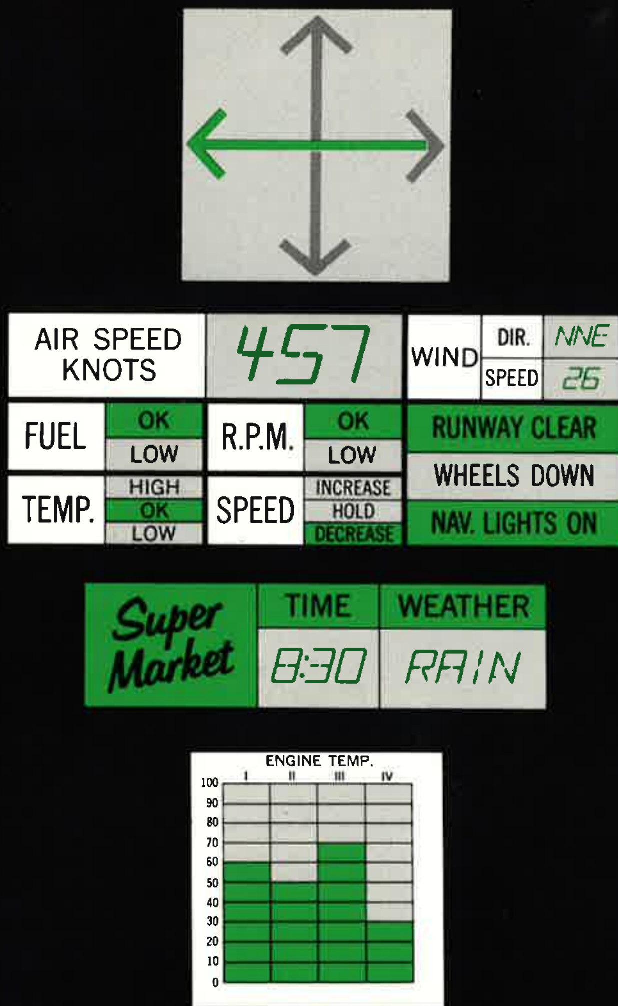
D. B. Milliken Co., Arcadia, Calif., has introduced a reflex autocollimator system that permits the user to observe image quality under high magnification directly from the film in the camera, as exclusive distributor for Richter Cine Equipment, the manufacturer.

The reflex autocollimator checks camera lens systems for 14 points: focal plane accuracy, overall lens quality, visual resolution, photographic resolution, astigmatism, chromatic correction, spherical correction, flatness of field, coma, contrast, best working apertures, correct adjustment of lens to camera, squareness of lens with optical axis, and flatness, finish and parallelism of filters.

The test pattern used in the autocollimator makes possible immediate evaluation of the image returned from the camera optical system. Since the collimator's optical elements are rigidly aligned, the user can easily examine the off-axis image quality of a lens.

Circle Reader Service Card No. 28

versatile



EL lets you create your own readout language . . . and at low cost!

The versatility of Sylvania EL makes it adaptable to so many uses. In combination with gauges and measuring devices, its high visibility is ideal for indicating readings in process instrumentation, telemetering, timing, programming, flows, pressures, levels, and so on. You name it.

Once we know your requirement, the rest is in the hands of Sylvania engineers who custom-design EL to suit the problem. The readout can be designed to fit many forms—often letters or numbers, or even bar graphs, pie charts, directional arrows or STOP-GO indicators.

Remember, too, that it's easy to add static symbols of any type or shape to your EL display, whatever its application. And because no costly tooling is involved, it's also relatively inexpensive. Using either photographic or special printing processes, the symbols of your choice are transferred to EL quickly, expertly and accurately.

The many features of EL are ideal for display requirements that call for reliability, minimum power consumption, light weight and compactness. Always clearly readable, the modern-looking numbers and letters have no lines or gaps separating them. EL's long life is directly traceable to its basic solid state design and construction using phosphors instead of filaments. And unlike other readouts, EL is not subject to catastrophic failure, nor is it adversely affected by turning the display on and off.

Consider versatile EL for your next display application. Call in your Sylvania sales engineer, or write to Electronic Components Group, Sylvania Electric Products Inc., Box 87, Buffalo, N. Y.

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Circle Reader Service Card No. 29

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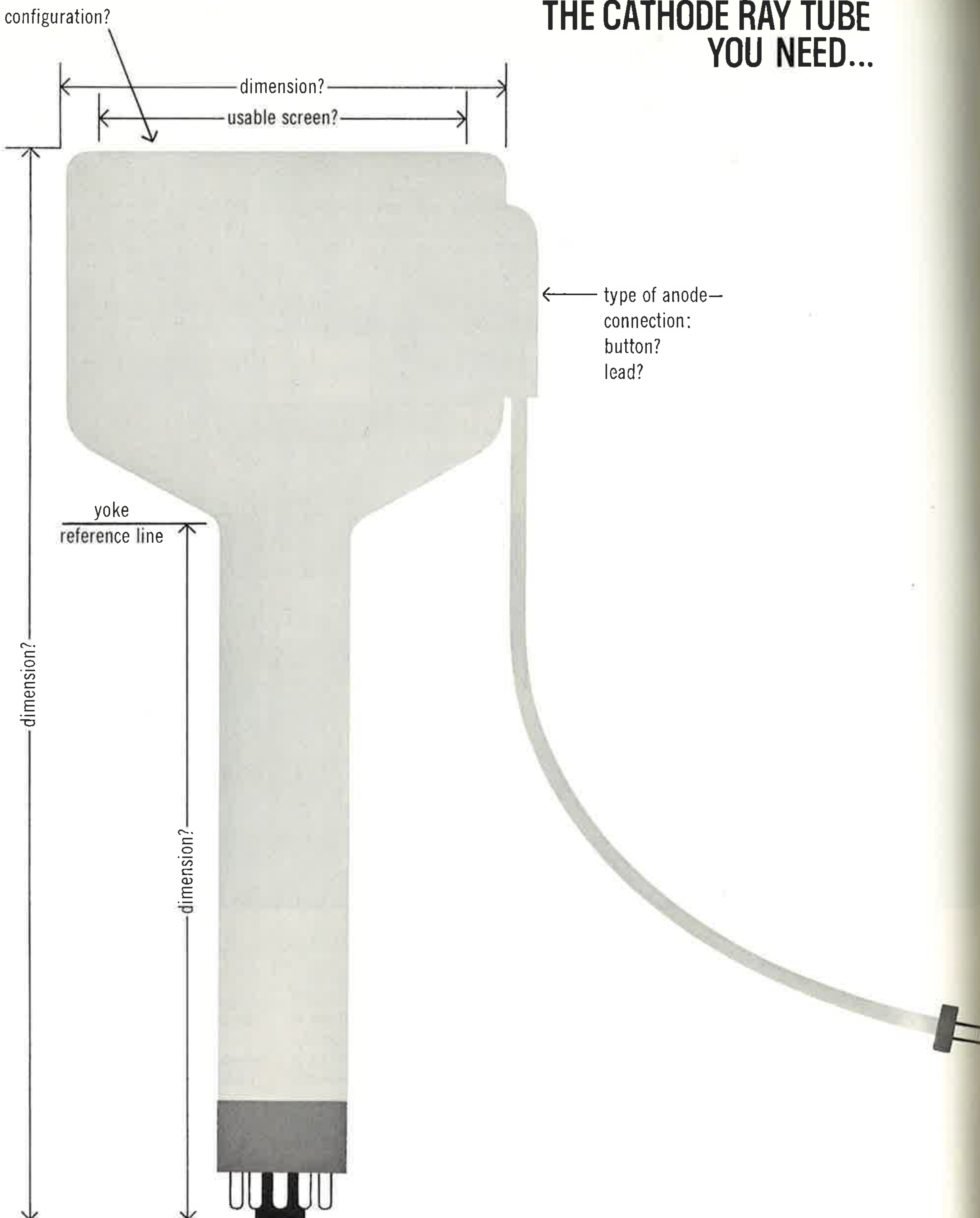

Special characteristics:

anode voltage .... ?
beam current and/or brightness .... ?
spot size: center .... ? edge .... ?
scan speeds and conditions .... ?
type of deflection .... ?
type of focus .... ?
type of phosphor .... ?
environmental conditions .... ?
application .... ?
quantity .... ?

25-In. TV Monitor

Conrac Div., Giannini Controls Corp., Glendora, Calif., has introduced a 25-in. monitor which the firm claims provides a picture area comparable to that currently available in 27-in. models. It is designed for use in closed-circuit TV installations in schools and colleges, transportation terminals, and industrial plants.

Designated CEA25, the instrument can display the same number of lines of airline information in the same type-size as the 27-in. models. Center resolution is 800 lines, corner resolution 600 lines. A separate synchronizing channel with independent gain control assures excellent interlace and stability regardless of contrast control setting.

Circle Reader Service Card No. 31

Audio Projection System

Hudson Photographic Industries Inc., Irvington-on-Hudson, N.Y., has introduced a new automatic projection system offering flexibility and quality of 2X2 slides plus the action and effectiveness of professional sound motion pictures. Heart of the new system is the HPI Controlashow (Reg.).

The Controlashow will synchronize sound from any standard stereo tape recorder with two automatic slide projectors; it will dissolve one slide projector image into the other smoothly and automatically; and it can be used to produce, as well as present, a completely automatic tape-cued slide dissolve program at the touch of a single button.

Circle Reader Service Card No. 32

New Film Viewer

Itek Corp. announces the availability of a new and versatile photointerpretation unit. It is a variable-width, rear-projection film viewer featuring a high-quality optical system, variable magnification, and a film-handling system that moves the film at various speeds without damaging delicate image areas.

It was especially designed for quick and precise examination of projected enlargement of aerial photography. The viewer handles film widths ranging from 35 mm to 9.5 in. on reels up to 10.5 in. diam.

Four standard magnifications are available, 3X, 6X, 12X, and 30X. These provide the photointerpreter a clear, exact screen projection which maintains an even, sharp image. Located within immediate reach of the seated operator are controls to select magnification, adjust focus, position film, set illumination, vary film scan speed, and vary film slew speed.

Circle Reader Service Card No. 33

Alternate Action Switch

Transister Electronics Corp., Minneapolis, Minn., has introduced a new alternate-action push-on push-off switch incorporating an independent indicator. It has been designated the ABL Series Button-Lite. A non-indicating version designated ABS Series Button-Switch is also available. ABL Series utilizes a midget flanged-base neon or incandescent lamp replaceable from the front of the panel and button lenses are available in 13 colors with Fresnel diffusing rings in transparent colors. ABS Series lenses are available in six translucent colors and black.

Rated for dry-circuit applications and loads up to 100 ma, the two series are housed in a body 9/16-in. diam. and 1⅞-in. long, with a two-circuit double-break switch to control two separate circuits.

Circle Reader Service Card No. 36

Biquinary Readout Tube

National Electronics, Inc., Geneva, Ill., has introduced a new biquinary side-viewing numerical readout tube, termed Model NL-5030. It is a long life, cold cathode, neon glow tube displaying .610-in. high numbers from 0-9. The biquinary configuration permits the use of fewer components in the driving circuitry and the use of less decoding components.

NL-5030 has a maximum ionization voltage of 160 v dc, requiring a minimum supply voltage of 160 v dc. It can be used at higher anode voltages with the proper anode resistors. The anode current ranges from 1.5 to 3.0 ma dc with a typical value of 2.25 ma dc.

Circle Reader Service Card No. 37

Line Filament Lamp

Los Angeles Miniature Products, Inc., Gardena, Calif., has introduced a new spaghetti thin-line filament lamp series which the manufacturer claims will give 40 times more light than conventional lamps. The lamps come in five T-¾ and T-1 sizes from a 1-in. by 6-v tape readout to an 11.5-in. by 48-v photocopy lamp.

A lamp and resistor, or two lamps in series, can be run off line current eliminating need for filament transformer. All lamps, aged and selected for high reliability, have 25,000-hour life at rated volts and can be operated up to 160% of rated volts. Lamps are available with silvered backs to increase intensity.

Circle Reader Service Card No. 38

Real-Time GP Computer

GFI Computers, Encino, Calif., has introduced a MARC I real-time general-purpose computer featuring integrated circuitry throughout. Primary application areas for the new machine are data reduction, data logging, process control, automatic checkout, communications control, and systems surveillance.

MARC I features a built-in multi-programming system with eight levels of priority and seven external interrupts. Also incorporated are self-checking, memory content retention after machine shutdown, command-at-a-time execution switch, and 38 discrete machine commands. It is organized around an expandable 2048-word, 16-bits/word core memory having 2.5 microseconds cycle time. Command execution rate is 50,000/sec.

Circle Reader Service Card No. 39

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We've delivered hundreds of display systems to the Air Force, Army, Navy, NORAD and FAA. They range from microfilm recorders and CRT consoles to large screen wall displays. They're used in our nation's most advanced command and control, air traffic and information retrieval systems.

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Ask for the new 20-page brochure "Display Systems from Burroughs."

Burroughs Corporation

Circle Reader Service Card No. 40

Remote CR Indicator

ITI Electronics, Inc., Clifton, N.J., has announced availability of its Type IT-271 Remote Cathode-Ray Indicator, a display device which can be easily integrated into system controls and equipment racks. The CRT has a 5-in. flat face, and is contained in a Mu-metal shield connected to the circuit chassis by a 7-ft. cable, permitting flexibility in layout of the system.

Identical vertical and horizontal amplifiers provide dc to 100 kc response with 1 v/in. sensitivity. Relative phase shift is within two degrees to 50 kc; long-term spot drift is ± ⅛-in. max. Z-axis coupling is provided. All supply voltages are regulated with a total accelerating potential of 4 kv.

Circle Reader Service Card No. 41

Remote Clock Indicator

Industrial Electronic Engineers Inc., Van Nuys, Calif., has introduced new, remote, digital clock indicator packages which utilize various models of the firm's rear-projection readout devices.

The new IEE clock indicator units are available in packages with up to 11 rear-projection readouts to indicate seconds, minutes, hours, days, etc. Each assembly is packaged in an attractive housing with a common viewing screen for the readouts. All readouts are pre-wired and ready to plug into a timing system for operation, and are available with either decimal or binary input.

Circle Reader Service Card No. 42

Photometric Microscope

Gamma Scientific Inc., San Diego, has announced its Model No. 700-10 photometric microscope which measures the light from extremely small areas, 0.0001 to 0.04 in. in diameter. It can be calibrated in foot lamberts or microwatts per square centimeter/steradian/nanometer. Either calibration is traceable to NBS. It was especially designed to measure spot size and brightness of CRTs, and the light output characteristics of electroluminescent elements and neon display indicators, but has many other applications.

The microscope couples, by means of a fiber optics probe, into either the Gamma Scientific Model 700 log linear photometer, or the Model 721 linear photometer. The microscope has X and Y positioning controls so that the measurement area can be exactly positioned with relation to the surface being measured.

Circle Reader Service Card No. 43

High-Voltage Converters

Mil Associates, Inc., Hudson, N.H., has announced availability of Series A high-voltage converters for use with photo multipliers, ion sensors, Geiger-Mueller tubes, fission detectors, and electrometers, among other applications.

Heart of the Series A converters is the monolithic multiplier developed by Mil Associates to assure high-voltage integrity. The converters occupy only 3 cu. in. of space and weigh less than 4 oz.

Circle Reader Service Card No. 44

Hybrid Vidicon

General Electric's Electronic Components Div., Schenectady, N.Y., has announced development of an unusual new "hybrid" vidicon which will permit the design of smaller, more lightweight high-resolution TV cameras for military, space, industrial and commercial use. The vidicon employs a new method of magnetic focusing and electrostatic deflection. Called Focus Projection and Scanning (FPS), the new pickup tube is particularly adapted for such space applications as star trackers and TV guidance for missiles, and for portable battlefield TV surveillance cameras. Commercial uses could include color TV cameras and educational TV, portable color TV camera, gage monitoring and plant security surveillance.

Circle Reader Service Card No. 45

Microfilm Printer/Plotter

Burroughs Corp. is now producing Digiprint high-speed microfilm printer-plotters which operate at printing rates up to 85,000 characters/sec., or plotting rates of better than 5000 line segments/min.

A variety of options allow on or off-line operation, BCD or binary input, absolute or relative designation of line drawing, electronic selection of up to four symbol sizes, and up to 225 symbols. Details are available from Burroughs Laboratories, Ann Arbor, Mich.

Circle Reader Service Card No. 46

Underwater TV

Kental Div., Cohu Electronics Inc., San Diego, has announced development of a complete underwater closed-circuit TV system that will operate down to 1300 ft. in fresh or salt water. Heart of the system is a Cohu 2000 series miniaturized TV camera 12 in. long and 3 in. diam., equipped with a special underwater housing and 1300 feet of control cable.

The camera has a fixed-focus half-inch lens with remote focus control on a Cohu 3900 control unit and a standard vidicon tube. Attached to the camera is a mercury vapor lamp (400 w) that will withstand 5000 psi and has a 75° angle pre-focused floodlight. The system is available in 525 or 729 scan lines and 10 mc bandwidth.

Circle Reader Service Card No. 47

Flange Lamp Adapter

Frank W. Morse Co., Boston, Mass., has announced a midget flange lamp socket adapter (Part No. 420) which offers a simple, effective and inexpensive means to install T-1-¾ midget flange base lamps. It holds lamps such as Nos. 327, 330 and 334 in any miniature screw-base socket without requiring added lenses or colored jewels. A nylon flange permits side lighting for full 180° visibility. Also offered are miniature screw socket shells together with speed-nut fasteners, making a complete compact assembly for panel mounting a midget flange base lamp.

Circle Reader Service Card No. 48

Table Electroplotter

Benson-Lehner Corp., Van Nuys, Calif., subsidiary of United Gas Corp., has developed a new solid-state large table electroplotter (LTE). The LTE system affords a complete contouring package for large-scale computer applications for exact delineations in minute detail of surface contours, weather maps, and topographical features.

The LTE produces report-quality graphs and maps rapidly and accurately from digital computer-generated output tapes. From either program or operator control, it plots points, symbols, or alphanumeric characters, and draws straight or contour graphs from digital input data.

Circle Reader Service Card No. 50

Phase Sequence Relays

Master Specialties Co., Gardena, Calif., now has available 84 standard configurations of phase sequence relays for automatic monitoring of three-phase power to prevent current of incorrect sequence from entering vulnerable circuitry, to prevent three-phase motors from running backward, or for automatic phase correction.

The units are designed to rigid military specs. Hermetically sealed, they are for GSE or aerospace use, and feature resistive contact ratings of 2, 3, or 10 amps; optional line-to-neutral input voltage ratings within a 69 to 277 v range; and frequency ranges of 54-66 or 320-480 cps. Units offer SPST, SPDT, or DPDT contact arrangements.

Circle Reader Service Card No. 51

New Projection Readout

Cal-Glo Co., El Segundo, Calif., is offering a new Shelly 12-message digital readout. The Shelly Driver-Augmented Readout (Model DAR-100) is designed especially for operation with low-power computer or integrated circuit systems.

It features a miniature projection system, including an assembly of 12 lamps for displaying twelve different messages on the readout's viewing screen. The lamp assembly contains 12 silicon planar epitaxial transistors in a common-emitter configuration to drive the lamps from low-power (decimal) signal sources. The readout, which is ¾-in wide, 1⅛-in. high, and 3¾-in. long, weighs less than 3 oz. It uses standard mil and commercial T-1 lamps, 3 through 28 v, and employs a 14-contact printed-circuit-type connector with 0.125 centers.

Circle Reader Service Card No. 52

Errata

In a photograph on page 30 of the last issue of INFORMATION DISPLAY, the person identified as Sherman H. Boyd was actually Roy Kilpinnen, member of the Fifth National Symposium Publicity Committee (chaired by Wendell S. Miller).

SOCIETY FOR INFORMATION DISPLAY

SIXTH NATIONAL SYMPOSIUM

28-30 September 1965
New York City

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PAPERS CALL

The Sixth National Symposium will present papers in four half day sessions. Three of these sessions will consist of 20 minute presentations followed by a 10 minute question period. The fourth session will consist entirely of five minute presentations.

There will be no restrictions on subject matter except that it should be related to displays. Individual sessions will be organized around broad areas, tentatively consisting of:

1. Physics and chemistry and their myriad subdivisions and combinations, such as electronics, optics and photochemistry.
2. Psychology and physiology, including psychophysics, information transfer and personnel hazards.
3. Systems science and art, including display/computer/user interface, programming and specific applications.

Authors should strive for both scientific rigor and excitement, and the papers must be defensible to maintain the high standards of the Society.

The short five minute papers should be exciting, challenging, speculative, provocative or even controversial.

Persons with contributions in these areas are encouraged to submit papers for presentation at the Symposium.
Five copies of a 500 word abstract and summary, together with author's name, title, employment, affiliation, and brief biography should be submitted before 28 June 1965 to:

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Authors of papers related to work performed under government contract are reminded that it is the author's responsibility to receive appropriate release from the cognizant government agency. All sessions will be unclassified.

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at the NEW Raytheon Side-View Numerical Indicator Tubes

Because of their unusual design, the new Raytheon digital, in-line miniature indicator tubes offer several important advantages over conventional top-viewing indicators. For one thing, their unit cost is lower. They require less mounting depth, allow close horizontal spacing and display large characters for the available viewing area.

These new Raytheon Side-View Numerical Indicator Tubes also feature conventional non-segmented characters for maximum readability, low power consumption, exceptional reliability and ultra-long life. Raytheon Side-View Numerical Indicator Tubes are available with numerals 0 to 9, characters + and —. Types with custom characters can also be provided. A mating Raytheon tube socket is available at low cost.

. . . MORE NEW RAYTHEON DATA DISPLAY DEVICES

New Datastrobe Digital Readout System (at right) features multi-digit display from a single light source, shared solid-state logic and true 4-bit BCD input . . . (Left) Special cathode-ray tubes, available in many sizes, combine electrostatic and magnetic deflection for writing alpha-numeric characters while raster scanning.

RAYTHEON

For complete information on RAYTHEON DATA DISPLAY DEVICES — or for an operating demonstration — write to Raytheon Company, Components Division, Industrial Components Operation, Lexington, Mass. 02173

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ID Advertisers

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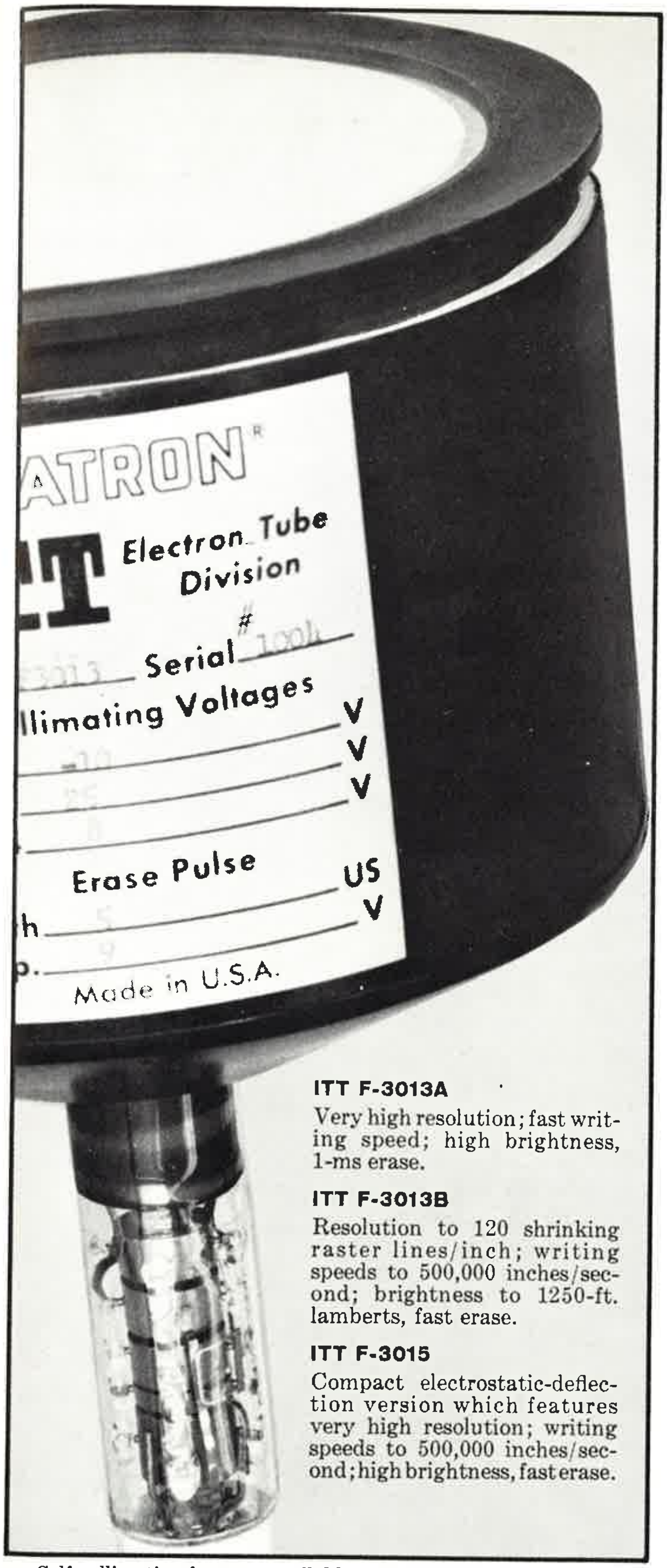

ITT F-3013A
Very high resolution; fast writing speed; high brightness, 1-ms erase.

ITT F-3013B
Resolution to 120 shrinking raster lines/inch; writing speeds to 500,000 inches/second; brightness to 1250-ft. lamberts, fast erase.

ITT F-3015
Compact electrostatic-deflection version which features very high resolution; writing speeds to 500,000 inches/second; high brightness, fast erase.

Self-collimating features available with all of the above tubes.

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Three compact new 5-inch storage tubes by ITT combine exceptionally large viewing area with greatly reduced overall length. They are designed for ruggedness, will withstand 10G vibration. A high-resolution, on-axis writing gun greatly reduces the distortion in the scanned pattern and simplifies equipment packaging.

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

Options available cover a variety of application, and there are input interfaces for digital computers, telephone subsets, and other digital sources. Let our systems applications engineers explain how the 210 adapts to **your** needs. Write or call today for an appointment.

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