ADVANCED DISPLAY SYSTEMS

MR. JOSEPH HALLET
Sylvania Electronic Systems

COLOR CODED CRT CONSOLE DISPLAYS

The amount of information that can be used effectively by an operator is a key parameter in the design of any display system. Present display consoles attempt to increase the amount of information content by using coded shapes and symbols; by intensification or by flashing of important items; and by controlling the display format in such a way as to enhance the recognition of significant data. However, color, which is one of the most effective methods of coding information, has not been widely used in display consoles because of the lack of a suitable display device.

The conventional color television tube employs an internal shadow mask which severely limits resolution. While there have been some attempts to use this type of tube for information display, it has been necessary to work with much larger symbols than would normally be desired, and registration (convergence) of colors is not sufficiently precise to permit accurate mixing data in different colors. Figure 64 shows the effect of the shadow mask structure in limiting the size of symbols that can be displayed. In this illustration, the symbols have been scaled to 1/4 inch height, and it may be seen that even at this large size the quality leaves a great deal to be desired.

Many of the significant disadvantages of the shadow mask color tube arise from the need in color television to preserve the color quality of a natural-color picture. In information display, the need is quite different; color separation is needed for color coding, but color fidelity is relatively unimportant. This makes it possible to consider other color CRT techniques such as the multilayer-screen, beam-penetration color tube, which do not provide the high color fidelity needed for TV applications, but have the high resolution and color separation quality that is needed to display color-coded information in the form of lines and symbols.

It has been known for many years that a multicolor cathode ray rube could be designed using a multilayer screen. By controlling the penetration of the electron beam the color of light emission could be varied. However, until recently, the methods used to produce the multilayer screen did not produce sufficient uniformity to be acceptable for information display. A proprietary method of screen deposition developed by Sylvania has largely overcome the uniformity problem, and two-color tubes have been produced with good uniformity in sizes up to 21" in diameter.

Color selection in these tubes is accomplished by setting the acceleration voltage to a predetermined level. One level accelerates the electron beam so that it penetrates only the first phosphor layer, producing the characteristic color of that phosphor. In most tubes built by Sylvania, the less efficient phosphor is placed first so that it will not be masked by the more efficient phosphor; typically the first phosphor is red while the second (closest to the screen) is green.

The color produced is a function of the combined emission from the two phosphor layers. Thus it is possible to produce a mixed color (orange) by operating at a voltage above that required to stimulate just the red layer. At higher voltages, the green emission predominates. Thus, through control of the CRT operating conditions, two or three easily distinguishable colors may be produced to code the displayed information.

An experimental information display system employing the high resolution color CRT has been in operation at Sylvania for more than a year. Circuits have been developed that permit data to be interlaced in two or three colors at speeds high enough for flicker-free display of random access lines and symbols or tabular information. Although the present

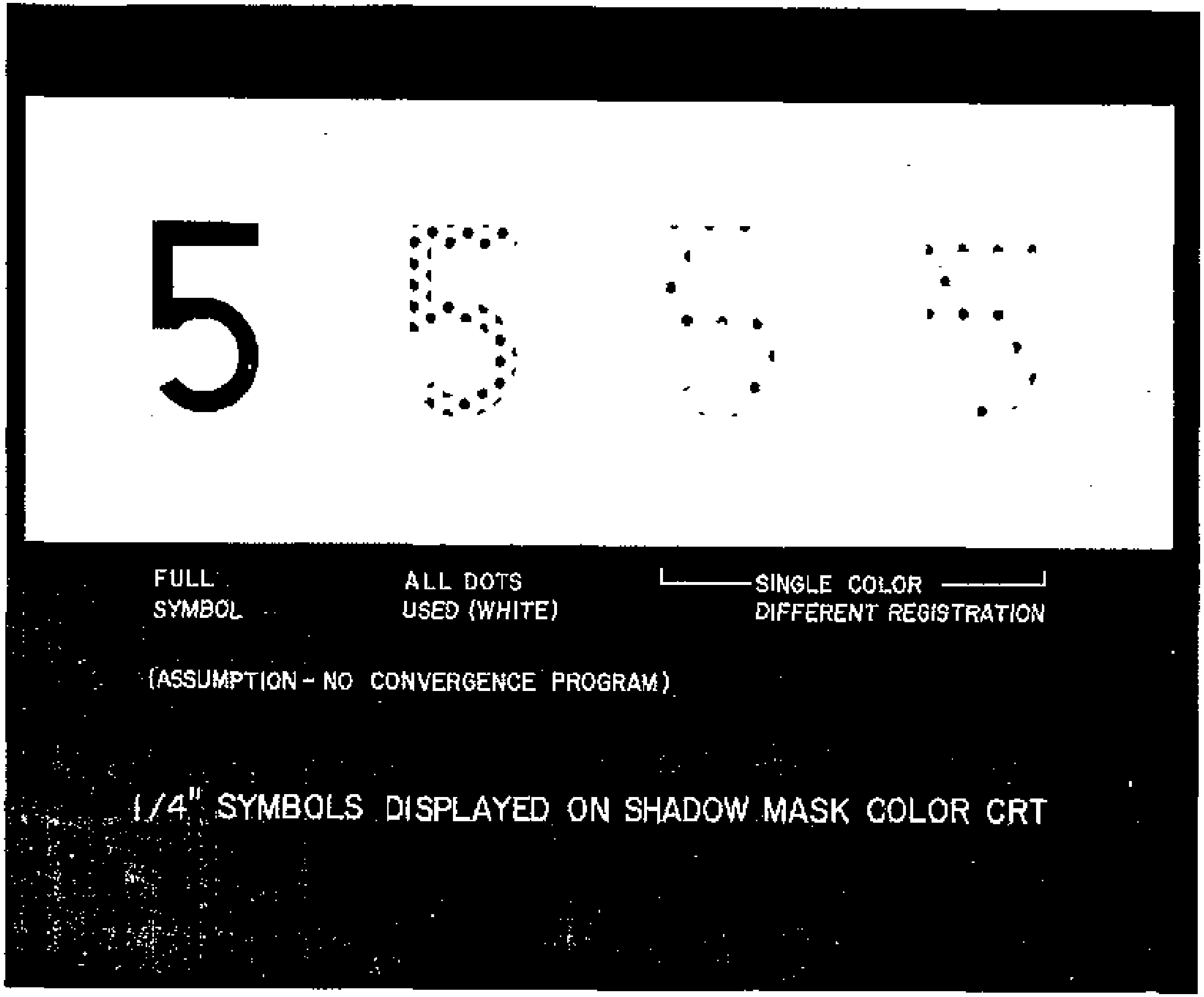

Figure 64. One-fourth Inch Symbols Displayed on Shadow-Mask Color CRT

display uses a single electron gun to minimize registration errors, it is possible to employ a dual gun (one gun for each color) which greatly simplifies the control circuitry and makes it possible to color code randomly placed symbols without affecting the writing speed or quantity of displayed data. The registration accuracy of the present system is such that intermediate colors between red and green may be produced by over-writing alternate patterns of red and green, as well as by operating the electron gun at an intermediate voltage.

The demonstrated feasibility of high resolution color display techniques should lead to much wider use of color in future displays used for control purposes, as well as for displays used primarily to present information where operator action is anticipated. Other applications are seen in composite real time situation displays of data from multiple sensors and in displays of graphs and curves where color can be used to advantage to provide visual separation of several overlapping patterns.

ELECTROLUMINESCENT DISPLAYS

Electroluminescent displays have had a controversial history. Early predictions of a flat screen television set on the living room wall raised expectations to an unreasonable level; subsequent experience with the realities of trying to apply this new display technique to an even simple problem created an over-reaction against EL in some quarters. The facts are that EL devices today will do some display jobs that cannot be done by any other technique; in other applications EL devices are subject to tradeoffs similar to other display devices and should be considered as one more competitive technique.

This attitude has often weighed against applying EL where it was really well suited. While EL cannot do every display job, it is exceptionally well suited to do certain display jobs. In fact, EL makes it possible to perform some kinds of display tasks that simply could not be done by any other presently available method. EL should be used for display where it fits—it is not necessary to wait for further growth in the technology to find many practical applications of EL today. But EL should not be force-fit to an application that can be done better by CRT or other means, simply because EL is "solid state." Let's consider some of the right and wrong ways to think about EL for information display today and for the near future.

The properties of an EL display device are unlike those of any other type of display. There are good and bad points:

EL is flat—power is concentrated where it is needed—the displayed patterns are precisely controlled in shape, size and position—information is visible from all angles—failure occurs through gradual decreasing brightness rather than by burn-out.

EL requires a special power supply—control circuits operate at high voltages—standard accessories and circuits have not been available—there is virtually no phosphor persistence—brightness is not high compared to most incandescent and cathode ray devices.

EL displays are digital devices—interfaces can be purely digital thus simplifying maintenance—the displayed patterns can be made to be exact counterparts of functions which exist in a system to depict signal flow or to show diagnostic test patterns—multiple elements allow simultaneous excitation—EL is solid state—this is not just a cliche—complete instruments and displays can be fabricated today that use no vacuum devices and no moving parts, yet fully duplicate the function of existing electromechanical displays.

EL is fast—visible displays can be changed as quickly as the data can be made to change.

These properties of EL displays can be applied in many useful ways today, and many more applications are on the horizon as improvements are made in control circuits and in EL device performance.

The Apollo Command and Lunar Modules and the Manned Orbiting Laboratory make extensive use of electroluminescent displays for numerical and status information. These applications include clocks and timers, fuel gauges and computer readouts. In addition, the instrument panels in these vehicles employ integral EL lighting to illuminate scales and legends. Some of the factors which influenced the choice of EL for these vehicles were:

(a) Light is produced only where it is needed; thus power requirements are minimized.

(b) EL devices operate for long periods of time without catastrophic failure; the typical gradual reduction in light output as the devices age can be offset if necessary by compensation in the power supply, although the duration of the missions for these spacecraft has so far made such provisions unnecessary.

(c) The thin panel form factor of the EL devices makes it possible to package complete instruments in small cases, contributing to lower overall weight, and helping to make optimum use of available panel space.

(d) The special AC power required to operate EL devices can be obtained from inverters which are generally required to operate other equipment in the vehicle.

Figure 65 is a photograph of a completely solid state instrument using an EL display which has passed all of the environmental testing required to qualify for manned space flight.

Recent developments for the Air Force have proven the suitability of EL for instruments to be used in conventional aircraft, even under the high ambient illumination that is encountered in the cockpit. (Ref: Development of High Contract Electroluminescent Displays AFFDL-TR-66-183.) Continued development of high contrast electroluminescent devices will permit these displays to operate at reduced ratings in a normal environment, further increasing useful life which already well exceeds 5000 hours continuous operation.

One of the problems in applying EL devices has been the lack of suitable low cost control devices. Each user has been forced to design his own control circuits from scratch, thus increasing design and materials cost to a point where EL has frequently been unable to compete with other less capable display techniques which have nevertheless been more highly developed as display products. Many systems require a display of tabular data which can be viewed simultaneously by a number of different people. A number of techniques have been applied to satisfy this problem including closed circuit TV, projection from hard copy and direct view display from large electronically controlled display boards using gas glow tubes, projection or electromechanical readouts. In the past, each method has shown certain disadvantages depending upon such factors as the installation requirements, maintenance, visibility and cost.

The large tabular display board using electroluminescent readout devices has potential advantages in all respects provided that such a system can be installed at a reasonable cost. In particular, the wide viewing angle and low maintenance requirements offered by EL displays are particularly attractive. Further, the EL status board can be readily packaged in such a manner as to survive the most stringent operating environmental conditions, making it a suitable approach for tactical equipment. Figure 66 shows a basic EL readout module which has been used in several system designs.

Cost has been a significant factor in eliminating EL displays from consideration in many previous systems. This situation stemmed from the lack of a suitable set of general purpose control components. Each system had to be custom-designed from the component level on up.

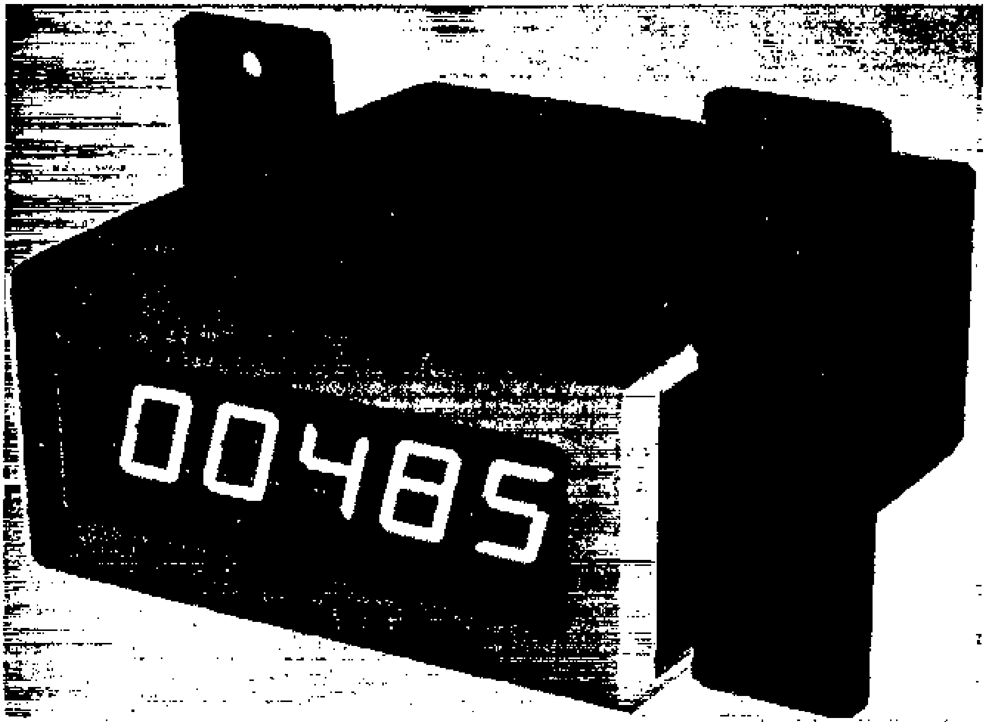

Figure 65. Solid-State Instrument Using an EL Display

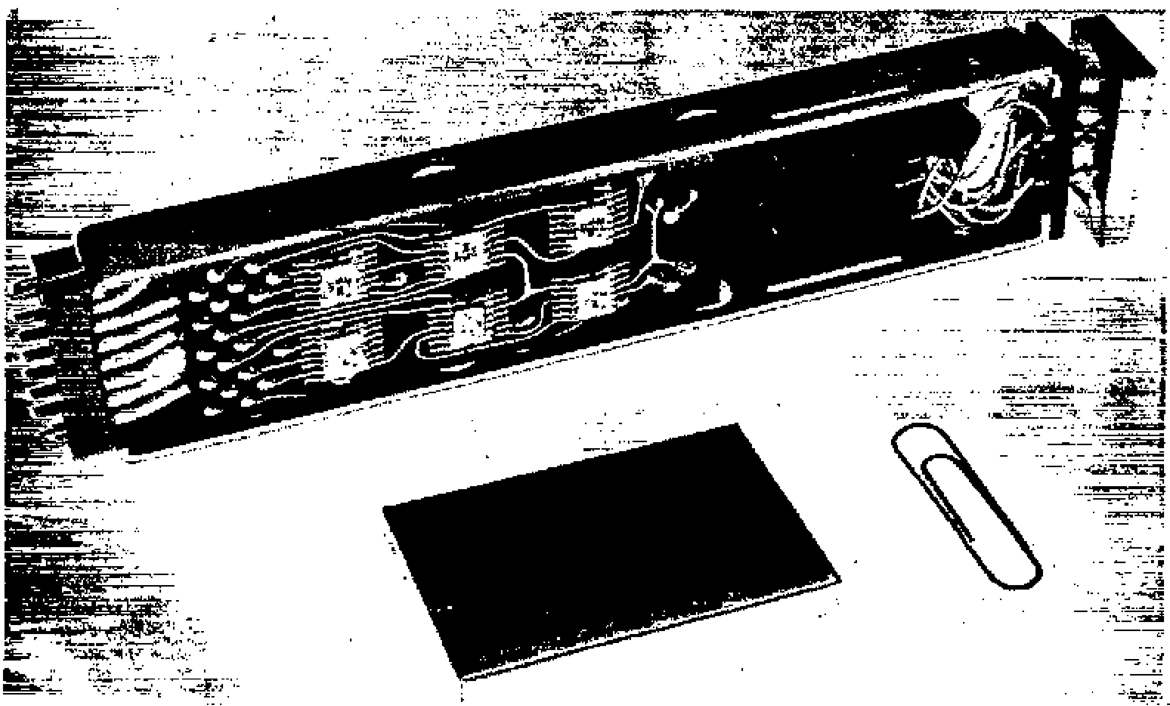

Figure 66. Basic EL Readout Module

In the near future, low cost driver devices, translators and memory circuits will be available to operate EL numeric displays. These circuits will be compatible with contemporary integrated circuits and will make it possible for the system designer to include EL displays without having to revert to specialized design of circuits. Thus the cost of design as well as the cost of components will be materially reduced.

Another class of EL device can be used to display random patterns such as maps, grid lines and target trails, as well as randomly placed alphanumeric data. These devices consist of large matrix arrays of discrete electroluminescent lamps which can be selectively turned on or off to form the desired patterns. Two types of panel structure are being actively developed by Sylvania. One employs an array of specially designed semiconductor circuits mounted behind each element of the display. This structure has excellent performance characteristics since the EL lamps are operated at normal ratings and the circuits can be addressed in under five microseconds to turn an element on or off. Figure 67 shows a type of structure that incorporates these circuits. Various other configurations are under study.

A second type of panel structure is the EL crossed grid panel. Each element in the display falls at the intersection of row and column electrodes. Voltage pulses of 10 to 30 microseconds duration applied to the proper tow and column electrodes will cause the selected dot to light. Since phosphor persistence is low, it is necessary to refresh the crossed grid display in somewhat the same manner as a conventional CRT display, with a corresponding reduction in brightness. However, this type of display should be suitable for use in low ambient illumination in equipment where space is limited. Displays of this type have been fabricated up to 16 by 16 inches, and building-block modules have been fabricated which would be suitable for larger arrays up to several feet in extent. Figure 68 shows a composite display taken from an 8 x 8 inch square building block module. The structure has 16 elements per inch. This display was developed for the Air Force Rome Air Development Center (Ref: RADC-TDR-64-362.)

Both types of discrete element display structures are being refined to improve performance and minimize the cost per element. Both types are finding potential applications in specialized equipment where advantages of thin construction and precise registration of displayed information are important.

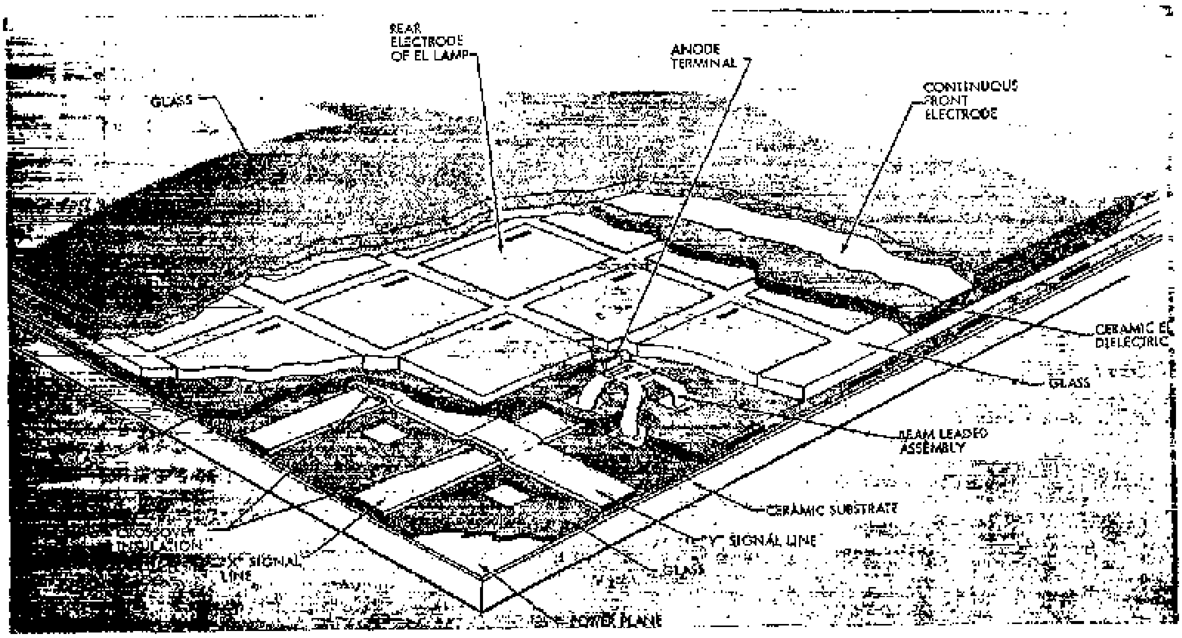

Figure 67. Proposed Monolithic Assembly for EL Panel and Control Circuitry

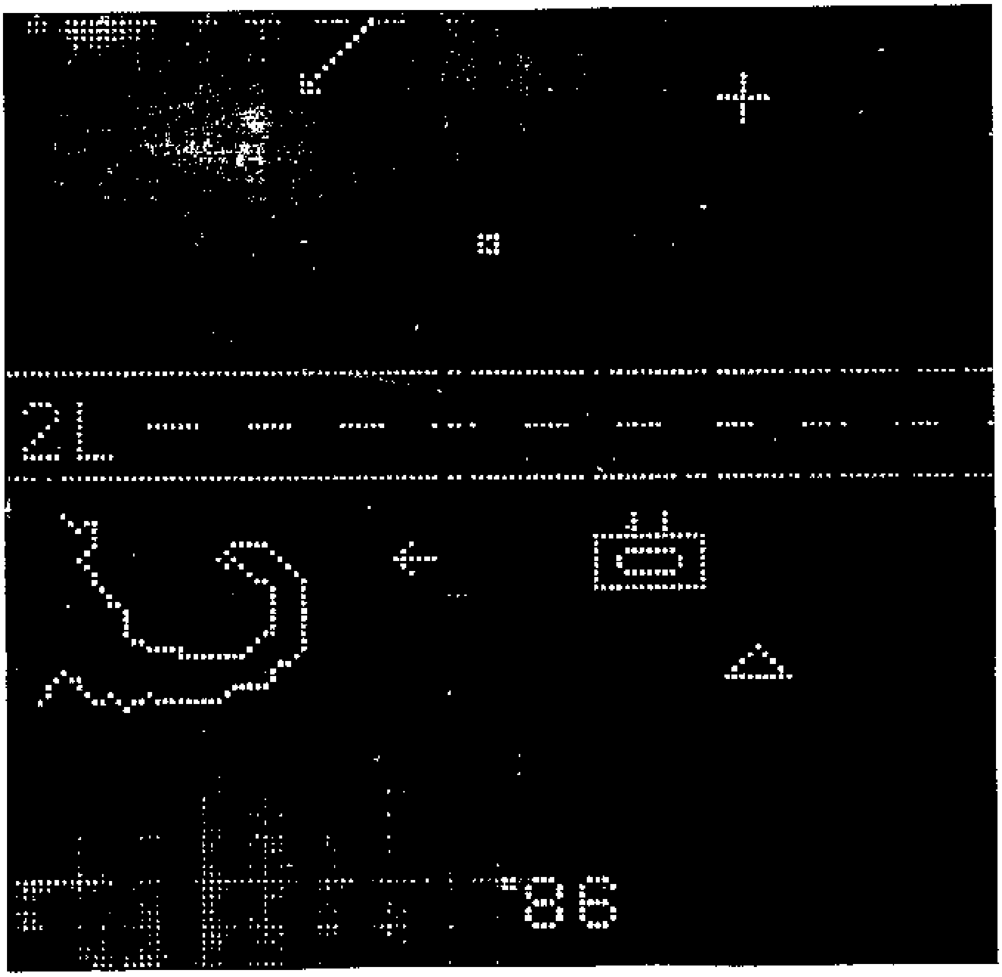

Figure 68. Composite Display from 8x8 Inch Square Building Block Module