Developments in Simplified Direct View Storage

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Introduction

The simplified direct view bistable storage tube continues to satisfy the need for new low cost high performance alpha-numeric and graphic displays. Recent CRT developments involve the use of a novel flood gun design and the incorporation of matched light filters to boost both the CRT luminance and display contrast. The result is a significant improvement in viewability in stringent environments.

General Characteristics of the CRT

Display Size: The particular CRT of interest, designed for desk top displays, has an 11" diagonal screen (Figure 1).

Information Density: A feature of direct view bistable screen storage is that resolution is limited only by the screen and the writing beam properties. These are designed near the detection limit of the unassisted eye. The final resolution is set consistent with the application.

Information Rate: Typically a bit of information can be stored in 5 μseconds. Because it is bistable, the screen retains the image without fading.

Interactive Power: A non-storing display can be superimposed over a stored display by setting the writing beam at a low value. Also, by simultaneously scanning the screen and interrogating the target lead, a non-destructive electrical readout of the display can be accomplished.

Display Quality: Our experience shows that luminance and contrast of 6 fL and 6:1 are acceptable in most applications. View ability is enhanced due to the fact that these are constant values. The bistable screen display is inherently uniform, flicker-free and stable.

Theory of Operation

The storage tube is operated in a bistable mode. The screen has two voltage states: a low, ~30 volt, ready to write state and a higher, ~175 volt, fully written state (Figure 2). These voltages are developed and held by electrons emitted from the flood gun cathode which is at zero volts. The two voltage states are dependent upon the structure of the screen where collection efficiency plays a predominant role. A high resolution, mono-accelerating writing gun is used to charge the screen to the written state. The flood guns serve as viewing guns, causing the phosphor to luminesce where the electrons land. The low voltage, unwritten areas receive few flood electrons. The result is a high resolution, high contrast, bistable display.

Increased Luminance

The stored luminance is proportional to the current density from the flood guns as well as the landing energy. The relationship is as follows:

$WB \cong kjV$

WB luminance in foot lamberts
j current density in mA/cm^2
V voltage

Measurements have been made which show the nature of this relationship (Figure 3). A typical value of the proportionality constant k is 1 $fL/mW/cm^2$.

Recent developments have led to significantly increased luminance via increased current density. The technique used was to increase the energy of the flood electrons to 400-500 volts as they leave the gun. This reduces space charge spreading of the electron bundle and results in an efficient design at high current density (Figure 4). As in earlier devices, a number of flood guns are grouped inside the ceramic CRT envelope. In the new design, however, luminance levels of 20-30 fL are easily achieved.

Improved Contrast

The CRT has an inherent high contrast, crisp, flicker-free display. However, high ambient light levels can present a problem. To handle that condition, several filters have been developed for the display. The technique used has been to select a green filter which matches the green output of the display (Figure 5). In this manner, broad spectrum ambient light is attenuated twice while display light is only slightly reduced. Cost is a real factor in filtering techniques and the choices reflect this. Where only light filtering and implosion protection are needed, 1/8" green plexiglass can be used. Where RFI shielding for hard copy is needed, a laminated glass filter with antiglare coatings was developed (Figure 5).

Combined Effects

The combination of a brighter CRT and appropriate filter allows the display to be more easily viewed in bright, say 100 fc, environments. A side by side comparison of a 6 fL CRT and a filtered 20 fL CRT depicts these improvements (Figure 6). Measurements of these displays indicate that both a 50% increase in the phosphor generated light and a X10 reduction in background luminance are realized.

Work by G. M. Sach at Hughes (Proceedings of the S.I.D. Vol. 11/4, 1970, pp 177-186) confirms the view ability conclusions if resolution is considered. His data indicates that 3-4 line pairs/mm will be resolvable. The CRT's were set at approximately this resolution during our observations.

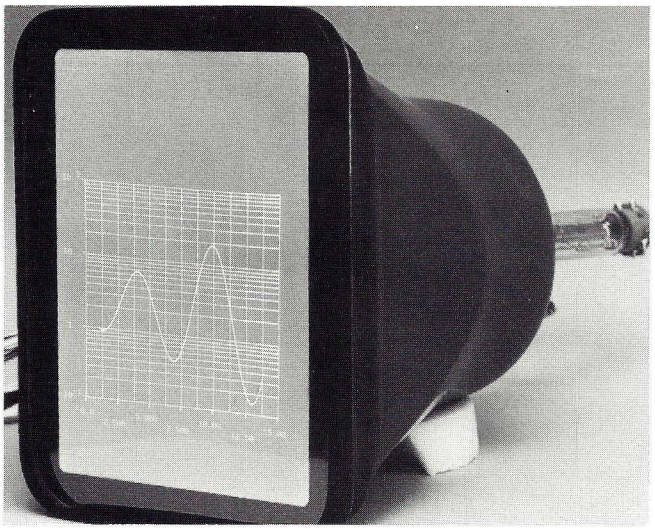

Figure 1. Eleven-inch Bistable Storage CRT.

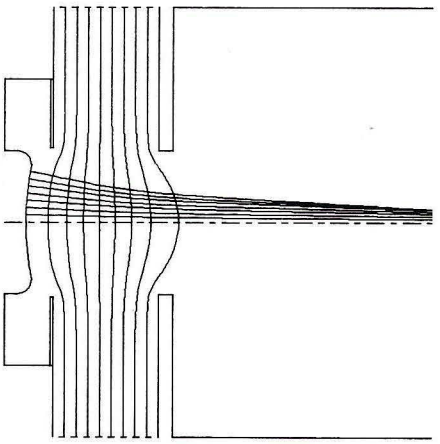

Figure 4. Electron Trajectories from High Current Flood Gun.

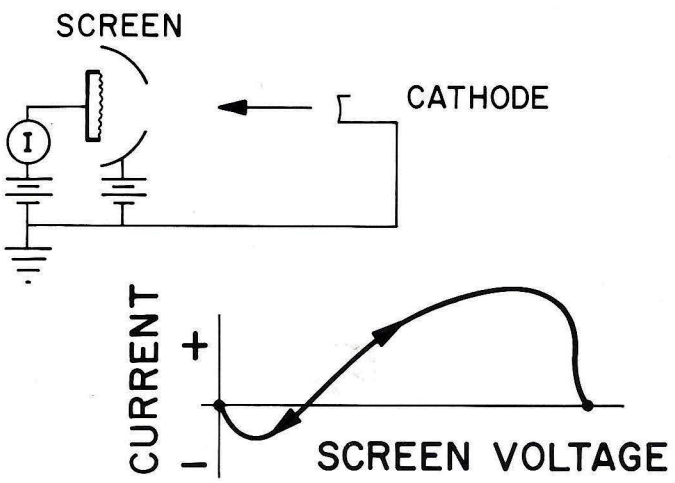

Figure 2. Model of Bistability

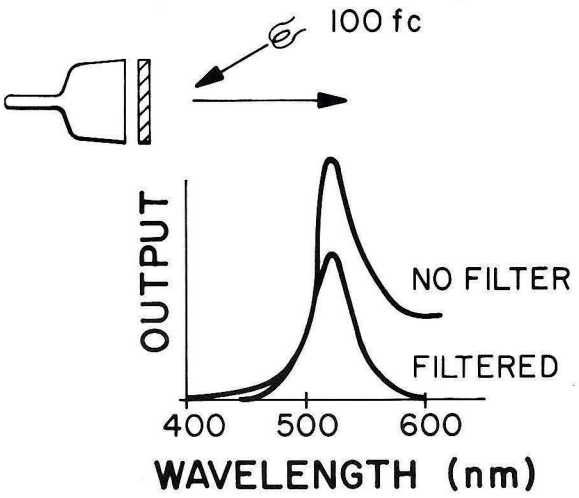

Figure 5. Effect of Filtering a 20 fL CRT in 100 fc Ambient.

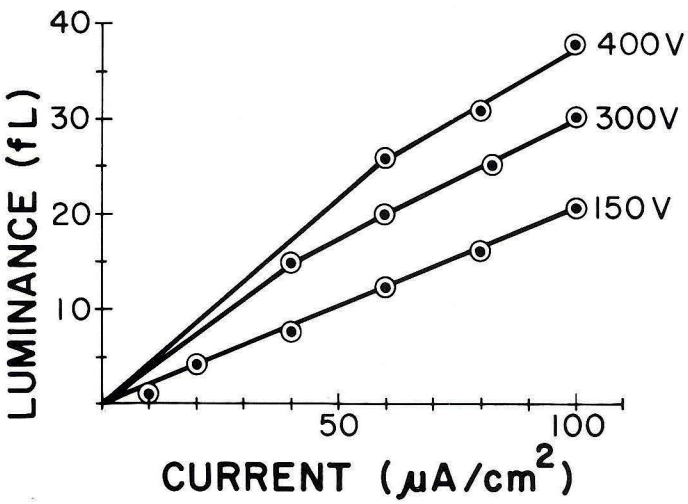

Figure 3. Luminance Relationships.

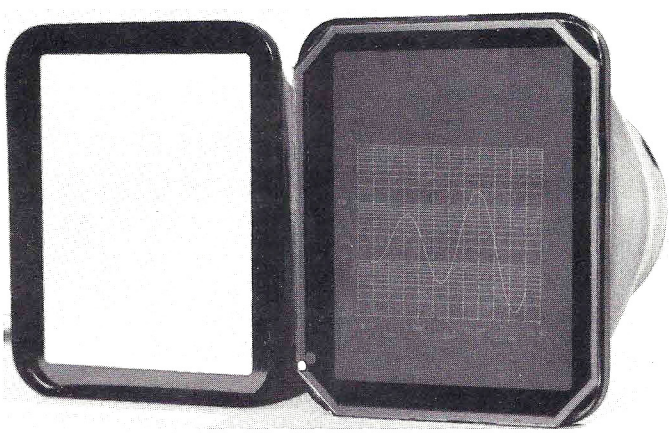

Figure 6. 6 fL CRT and 20 fL Filtered CRT in 100 fc Ambient.