5.2: A Gatling-Gun Multibeam CRT

Conrad J. Odenthal
Tektronix, Inc., Beaverton, OR

Robert G. Quick
Azuray, Inc., Scotts Valley, CA

Abstract

A multi-beam CRT has been developed for use in a high-resolution, high-brightness, 19-inch display. A brazed stack electrode assembly generates a nearly circular array of eight beams from a single cathode.

Introduction

The highest resolution, commercially available, single-beam, monochrome video-display monitor is capable of displaying up to 3 million pixels on a 19-inch CRT display.[1] This monitor displays 1500 lines with 2000 pixels per line at 30 fL through a 63% neutral-density filter at a 60-Hz refresh rate.[2]

Operation of this display requires data to be fed at a 240 mega-pixel rate. Operating at speeds much beyond this rate becomes a formidable electronics challenge. In addition, adding full color to this display through the use of a liquid-crystal color shutter requires the frame rate to be three times the present rate of 60 Hz.[3,4] Brightness would also have to be increased to make up for the light lost as it passes through the shutter.[5,6] Higher cathode loading or higher screen voltage is possible, but the higher required sweep rate and higher video-drive pulse becomes extremely difficult to supply. If viewing distances closer than 18 inches are desired, then more than 1500 lines would be needed to optimize visual acuity.[7] In addition, video pulse width would need to be reduced to 1.5 nsec with rise and fall times preferably less than 0.5 nsec.[8] Higher cathode loading could only be generated with higher cutoff and higher video-pulse-drive voltages.

One way to surmount the aforementioned difficulties is to use a CRT in which multiple beams are generated, scanned, and focused as a single group. Generation and uniform deflection of a group of eight independently modulated beams, however, is in itself not an easy task, and presents some unique problems.

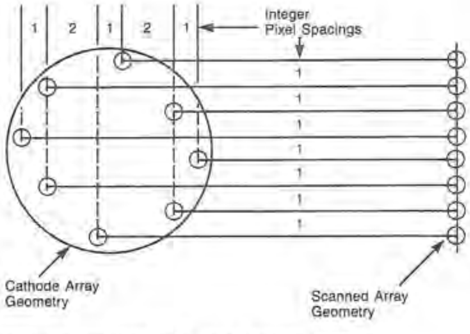

Fig. 1. Array geometry of multi-beam CRT.

Array Geometry

The array geometry shown in Fig. 1 is disposed to produce integer pixel spacing both horizontally and vertically. Thus, when the array is properly rotated, demagnified, scanned, focused, and astigmatized, vertically uniform pixel line-to-line spacing results. Concurrently, when appropriately timed video signals are added, uniform horizontally spaced pixels are also displayed over the entire screen quality area. The array size is made to the smallest practical value to minimize the amount of demagnification required to produce the desired display. For a 2000-line, 10-inch-high display, the array size has to be reduced to 0.035 in., or approximately half-size. This reduction is first generated by causing the array to be demagnified at the entrance of the helix accelerating field. A second array of crossovers is subsequently formed about 1 in. into the helix (Fig. 2). The magnetic focus coil at the back of the deflection yoke is used to image this second array onto the screen by magnifying the array by approximately two times. Production of the second crossover allows the array size to be dynamically changed as required by the scanned position of the array. In addition, this method allows the fixing of the astigmatism correction close to the demagnification lens, correcting simultaneously for most array shear distortion and beam astigmatism.

For instance, if the deflection yoke is energized to deflect the beam to the side of the display, it acts as a converging lens with an astigmatic component. To keep the array in focus at the screen, the magnetic focus-coil lens strength must be reduced, which causes the array to come into focus at the side, but with slightly less magnification than that at center screen. The drift-tube voltage must then be adjusted to move the second array of crossovers toward the screen to correct the magnification. Likewise, array rotation and astigmatism must also be dynamically adjusted along with beam position to correct for the other distortions introduced by the yoke.

Array Demagnification

From the preceding paragraphs, it should be recognized that it is desirable to keep the beam bundle as small as possible in the vicinity of the yoke deflection field to minimize yoke aberrations. This translates to keeping α_2 small (see Fig. 3), which is inversely proportional to the array magnification.

Furthermore, since it is desirable to have the largest possible value of array magnification or, conversely, if the array size at the cathode is larger than the desired array size at the screen, array demagnification should be minimized. Since a limiting aperture is used to limit the beam bundles, larger demagnification results in beam-current and, therefore, brightness limitations at the screen. Thus, it is highly desirable to generate the smallest practical array at the cathode end of the CRT. Figure 4 shows how the

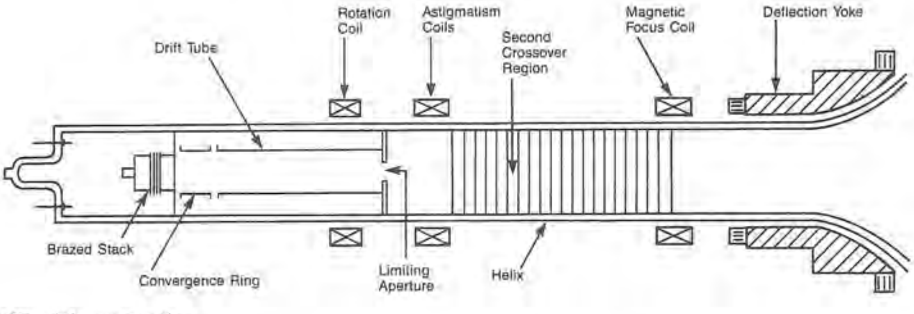

Fig. 2. Multi-beam CRT with magnetics.

ISSN0097-0966X/86/0000-053-$1.00 + .00 © 1986 SID

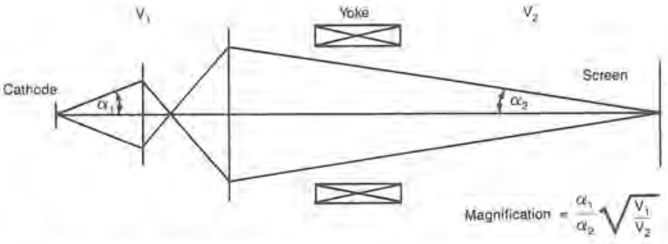

Fig. 3. Array magnification.

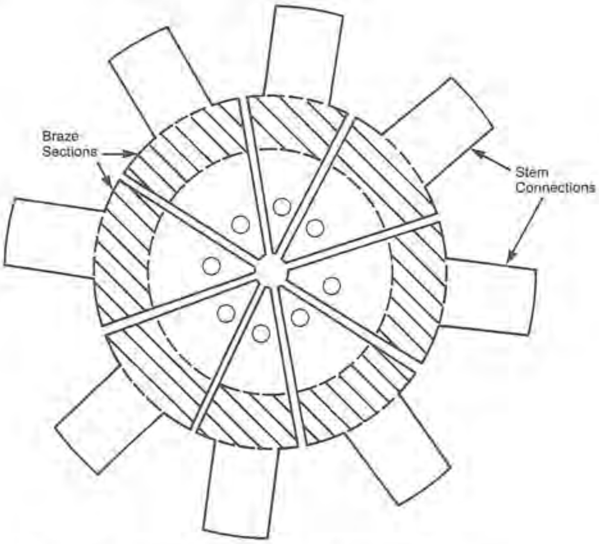

Fig. 4. G1 (8 separately controlled sections).

array geometry is superimposed onto eight independently controlled grids, G1, for individual beam-brightness control.

Stack Construction

Figure 5 is a cutaway view of an assembled stack that produces eight individually modulated electron beams. Ceramic washers space electrodes, which are sandwiched between two ceramic support cylinders. The lower cylinder supports a shaved cathode assembly, while the upper cylinder joins the G-5 aperture and drift-tube assembly to the collimation assembly. Eight G1s are operated negative with respect to the cathode and produce a standard triode operation. G2 is common to all eight beams as are G3, G4, and G5. G2 is used to adjust the eight beam-cutoff values, while 3, 4, and 5 are used to collimate and converge the beams through the G5 apertures. The convergence ring in the drift-tube stack is used to converge all eight beams through the limiting aperture just before entering the helix (Fig. 2).

Results

Since G1 is operated negative with respect to the cathode, keeping the cathode surface evenly spaced around the peripheral location of the G1 holes is extremely important if good cutoff and drive characteristics are to be maintained. Figure 6 shows the relationship between spot cutoff and grid-to-cathode spacing. In actual practice, it was found that the cutoff variation is more a function of cathode tilt than individual G1 or G2 spacing variations.

Figure 7 depicts the grid drive and cutoff characteristics of the eight individual beams as a function of grid voltage and beam current for a particular tube. The cutoff range from 14 to 19.5 V is typical and indicates that the actual grid-to-cathode spacing probably varies about 1.3 mils. The slope of the drive characteristic is also affected by the cutoff voltage and is portrayed in Figure 8 as a function of beam-to-beam brightness variation. At 8-V drive, the maximum beam-to-beam brightness variation is roughly 12.5%. This variation requires circuit compensation to produce a uniform display. Figure 9 (a) is a photograph of the display at the center of the screen (text), and Figure 9 (b) is a photograph of the display at the upper left corner of the screen (diagram).

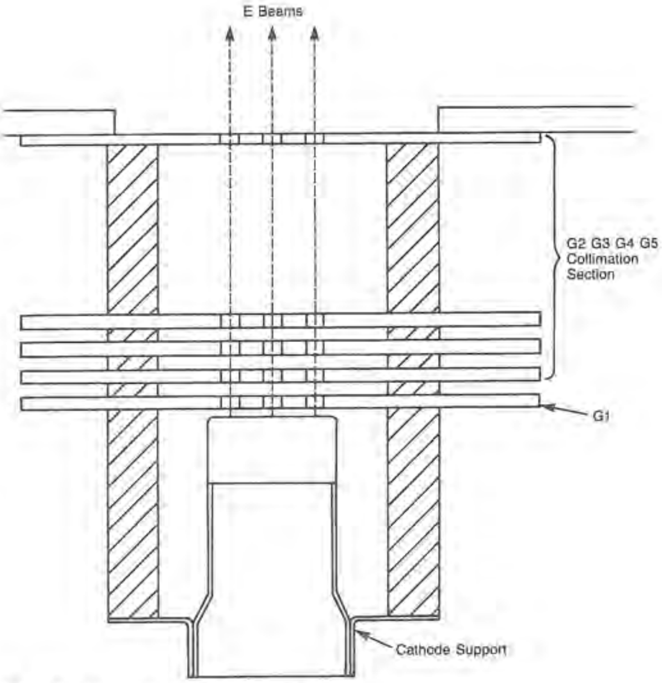

Fig. 5. Brazed stack assembly.

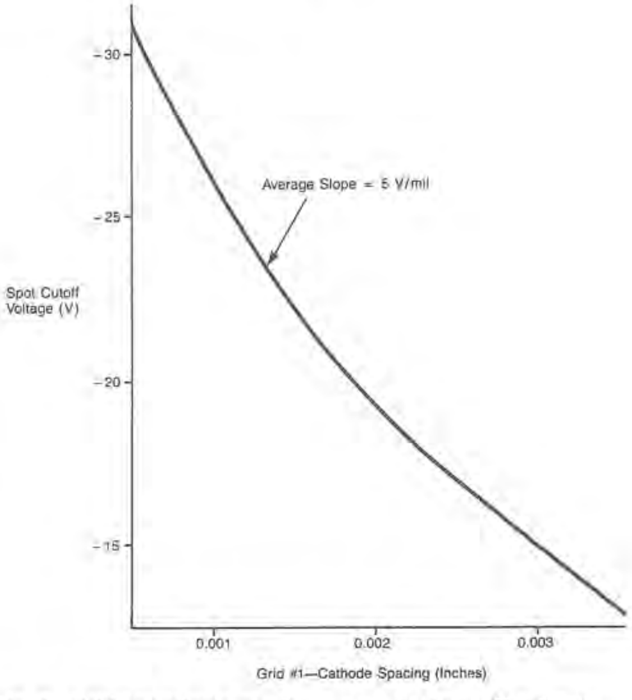

Fig. 6. Grid-to-cathode spacing versus spot-cutoff voltage.

References

1. News Update, "Three Million Pixel Display Monitor," *Electronic Imaging*, p. 20, December 1984.

2. C. Odenthal, "A 19" Very High Resolution Display CRT," *SID Dig. Tech. Papers*, pp. 258–261, 1984.

3. T. Buzak, "Design Criteria of LC/CRT Color Displays," *Electrochemical Soc., Extended Abstracts*, no. 447, vol. 83-2, pp. 712–713, October 1983.

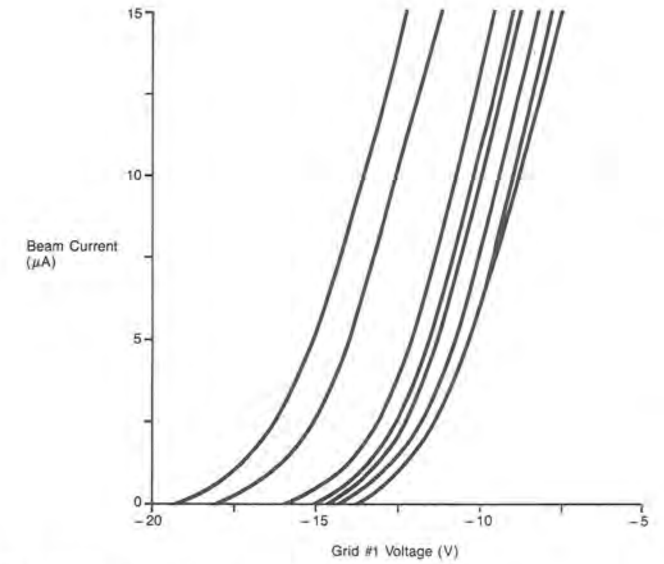

Fig. 7. Triode characteristics.

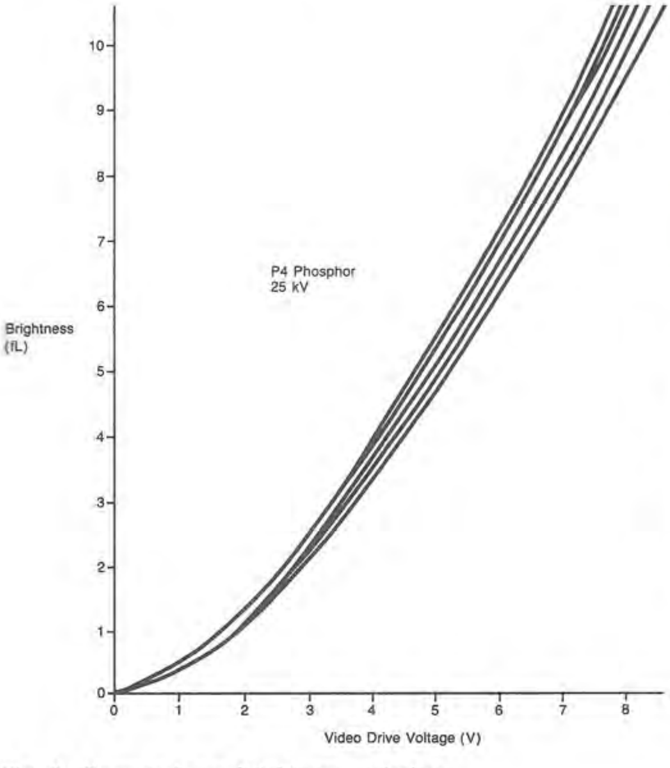

Fig. 8. Beam-to-beam brightness variation.

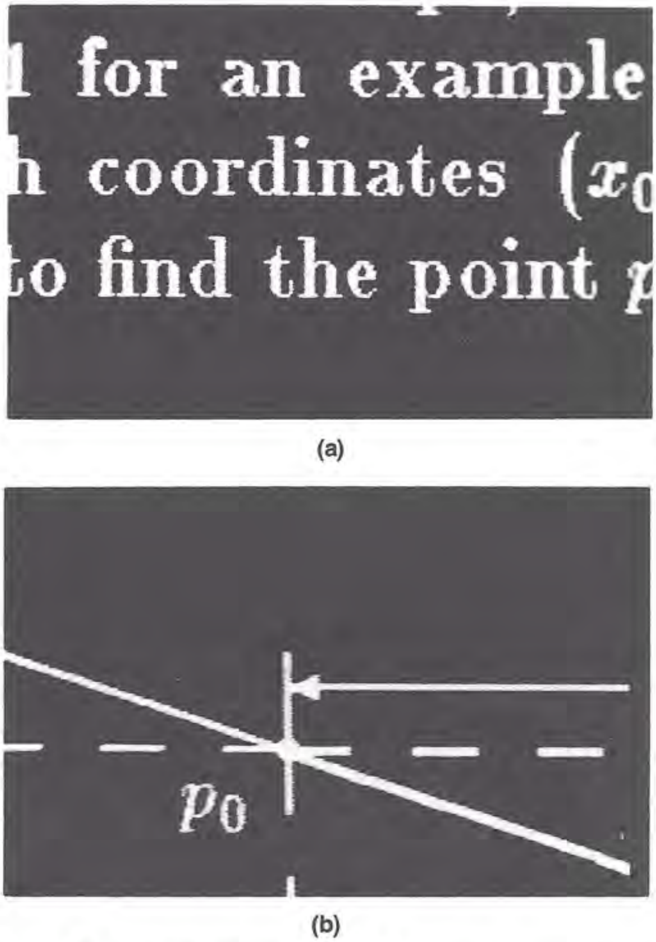

Fig. 9. Photographs showing CRT performance.

4. Rolf Vatne, Philip A. Johnson, Jr., and Philip J. Bos, *SID Dig. Tech. Papers*, pp. 28–29, 1983.

5. Petersen, "CRT Phosphor Selection for LC/CRT Displays," *Electrochemical Soc., Extended Abstracts*, no. 446, vol. 83-2, pp. 710–711, October 1983.

6. Philip J. Bos, Philip A. Johnson, Jr., and K. Rickey Koehler/Beran, *SID Dig. Tech. Papers*, pp. 30–31, 1983.

7. Sol Sherr, *Electronic Displays*, Wiley, p. 23, 1979.

8. V.K. Zworkin and G.A. Norton, *Television*, Wiley, 1954.

9. Beck and Piggin, "Multiple Beam Cathode Ray Tube Design Overview," *1985 International Display Research Conference Record*, pp. 186–191, 1985.

10. Piggin, Segredd, O'Hanlon, and Staples, "Integrated Electron Sources for Multi-Beam CRTs," *1985 International Display Research Conferences Record*, pp. 192–196, 1985.

11. D.L. Say, "A Multi-Beam CRT," *Information Display*, 11, pp. 29–34, May 1970.

12. D.S. Hill, "Multi-Beam Cathode Ray Tube Displays," *SID Dig. Tech. Papers*, pp. 74–75, 1972.

13. Depp and Piggin, *Multi-Beam Electron Beam Cathode Ray Tube*, U.S. Patent No. 4,361,781, Nov. 30, 1982.

14. R.G. Quick and F.J. Marshall, "Multibeam CRT for high-speed information recording," SID Int'l. Sym. *Dig. Tech. Papers*, pp. 122–123, 1981.

15. R.G. Quick and F.J. Marshall, "A Micro-Array Multibeam Gun for Hard-Copy Printout Cathode Ray Tubes," *Proc. First European Display Res. Conf.*, EuroDisplay, pp. 173–175, 1981.

16. R.G. Quick, "Multibeam CRT for Direct View Display of Photographic Quality Medical Images," *SPIE Conf. Proc.*, Feb. 3–7, paper 536-05, 1985.