A.M. Morrell

The RCA COTY-29 tube system

The RCA COTY-29 tube system was announced to the industry in June 1982. The new tubes will be starting into mass production this year. They should be the most popular new tubes in sets next year.

The RCA COTY-29 development is a new generation of color picture tubes having many improvements over the present in-line self-converging tubes. It is a system wherein all factors—the yoke, the tube, and the receiver interface—have been optimized for system cost and performance. Its name, COTY-29, stands for **C**ombined **O**ptimum **T**ube and **Y**oke with a 29-mm diameter neck. This system covers all tube sizes from 13V through 25V as well as 90° and 110° deflection angles.

The features of the COTY-29 system are:

- An improved electron gun using an extended diameter lens (XL) for reduced aberration and improved focus that is substantially independent of beam spacing.
- Maintenance of the 29-mm neck diameter for optimum focus.
- Improved convergence achieved by reduced beam spacing in the new XL gun without sacrificing focus performance.
- A miniaturized yoke for lower cost and lower deflection-power requirements.
- High reliability by continued use of the 29-mm neck diameter together with standard bases and sockets.

Tube evolution

To put the COTY-29 development in proper perspective, it would be useful to review some of the major steps in the self-convergence in-line color picture tube development since its early-1970s introduction.[1] Table I shows the major steps in this evolution.

In 1972, the first in-line tubes with self-converging 90° yokes and line screens were marketed.[2] These tubes featured a unitized in-line gun using a bipotential main lens with a focus voltage of 20 percent of the anode voltage. The deflection yoke had toroidal windings for both horizontal and vertical deflection. This type of yoke was chosen since the toroidal windings could be precisely placed and, therefore, make a very consistent product. A gun with beam-to-beam spacing of 5.1 mm was chosen to assure good convergence and to provide an adequate lens diameter for the 20-percent bipotential lens.

In 1975, the 110° version of this tube was introduced into the European market.[3] The gun was similar to its 90° predecessor except for the use of slot optics to minimize deflection defocusing. The yoke retained a toroidal-toroidal winding but an additional quad winding was included to aid in convergence.

The next step was the switch from the toroidal-toroidal type yoke to one using a **S**addle horizontal coil and a **T**oroidal vertical coil (ST yoke). This change was made primarily so that the horizontal coil inductance could be increased to provide a better match to the transistor drive circuitry. At this time the beam-to-beam spacing on most tubes was increased from 5.1 mm to about 6.6 mm. This was done to increase the available space given to each of the three guns. The extra space allowed a larger lens diameter for improved focus. To take advantage of the larger lens, the focus voltage was increased to 28 percent of the anode voltage.[4] Two years later the ST yoke and wider-spaced gun design was incorporated into 110° tubes primarily for use in the European market.

In 1977, there was another development in guns aimed at further focus improvement to allow the in-line system to be more competitive in large-size tubes with 90° and 100° deflection angles. Multi-element focus designs with increased focus-voltage requirements were developed in this time period. Several different arrangements were introduced.[5,6]

After the improved gun designs were established, changes in 90° and 100° yoke designs were introduced. Prior to this time, most of the ST yokes were corrected for north/south pincushion distortion, but the east/west pincushion distortion was corrected

Abstract: *This paper describes a new color television picture tube system which has been developed by RCA at Lancaster in conjunction with Consumer Electronics and the Labs.*

Called COTY-29 (which stands for "Combined Optimum Tube and Yoke in a 29-millimeter neck"), the system features an improved gun with a new XL focus lens and a cost-reduced, minimized yoke. Reliability and performance are improved while manufacturing costs have been reduced.

This article was originally published in the *IEEE Transactions on Consumer Electronics*, Vol. CE-28, No. 3 (August 1982). It won the first-place paper award at the 1982 International Conference on Consumer Electronics.

Final manuscript received March 23, 1983.
Reprint RE-28-4-4

Table I. *Major steps in the evolution of in-line picture tubes prior to the COTY-29.*

Year of introduction	*Deflection angle*	*Yoke type*	*Beam-to-beam spacing (mm)*	*Neck diameter (mm)*	*Gun type*
1972	90°	TT	5.1	29	20% Bipotential
1975	110°	TT plus quad.	5.1	29	20% Bipotential
1977	90°	ST	6.6	29	28% Bipotential
1977	100°	ST	6.6	29	40%/28% Tripotential
1979	110°	ST	6.6	29	28% Bipotential
1980	90°/100°	ST pin-free	6.6	29	Various
1980	90°	ST pin-free	4.8	22.5	Various

by means of circuitry. The new generation of ST yokes were designed and constructed to be pin free, thereby eliminating the cost of circuit correction. Although this provided an attractive option from the circuit standpoint, it complicated the design of both the yoke and the picture tube. To obtain east/west pin correction, the distribution of field gradients in the yoke were altered in a complex manner by means of biased windings and/or the addition of flux-shaping metal pieces. In addition to increasing yoke costs, these yokes also caused greater beam distortion due to their higher field gradients. Several different types of pin-corrected yokes were introduced; these were noninterchangeable because of the different register and coma error (difference in size of the raster of the center beam compared to the outer beams) characteristics produced on the tube.

In 1980, another tube-and-yoke design was introduced in Japan for smaller tube sizes—the neck diameter was reduced from 29 mm to 22.5 mm.[7] This change was incorporated to reduce yoke cost and deflection power. It also reduced gun size and required a reduction in beam-to-beam spacing from 6.6 to 4.8 mm. The smaller gun diameter challenged the gun designer to obtain good focus characteristics.

COTY-29 development

Against this background of design evolution, the COTY-29 system concept was developed. The designers' goal was to properly consider cost and performance of the tube, the yoke, and the circuitry. A further goal was to have a system that could apply to all tube sizes and to both 90° and 110° deflection angles. It was established that 90° deflection is optimum for small tube sizes up through 19V. With 19V as the cross-over type, 110° was selected as best for the 19V through 25V sizes.

The basic elements of the new system are a new XL gun for improved focus and a miniaturized yoke to reduce yoke cost and deflection-power requirements. The XL allows a reduction in the beam-to-beam spacing with little effect on focus performance.

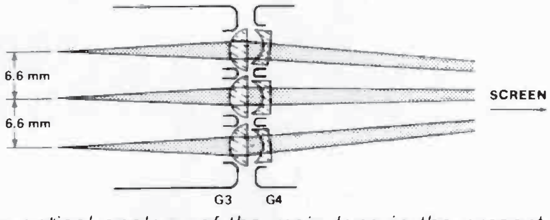

Fig. 1. *The optical analogy of the main lens in the present gun.*

This beam-spacing reduction gives better convergence and, together with a new optimum contour of the funnel, permits the miniaturization of the yoke.

The XL gun

The principle of the XL gun is best illustrated by reference to its predecessor. Previous in-line gun designs created problems because of limited available space for a low-aberration gun. Since the diameter of each of the in-line guns is limited to slightly less than one-third of the inside neck diameter, various systems have been designed to obtain the best focus within this basic limitation. Figure 1 shows the diameter limitation of most present gun designs by means of a light-optics analogy.

The XL uses a larger common lens for the major element of the main focusing lens. This is achieved as shown in the light-optics analogy of Fig. 2. An oval ridge on grid number 3 and also on grid number 4 forms a large lens encompassing all three beams. Because of its greater size, the aberrations of this lens are small by comparison to those of a conventional lens.

Figure 2 also shows that there are small lenses formed by the individual guns, but their action is small in comparison to the large common lens. This feature makes it possible to change the spacing between beams, without significantly affecting focus characteristics. The focus quality of this lens is limited primarily by the neck diameter, not the beam spacing. By taking advantage of this basic characteristic, designers have reduced the beam-to-beam spacing of the COTY-29 system from 6.6 to 5.1 mm.

This reduction in beam-to-beam spacing was selected because it improved the convergence. Most convergence errors are roughly proportional to beam spacing. The reduction in beam spacing by 23 percent will, therefore, result in approximately the same

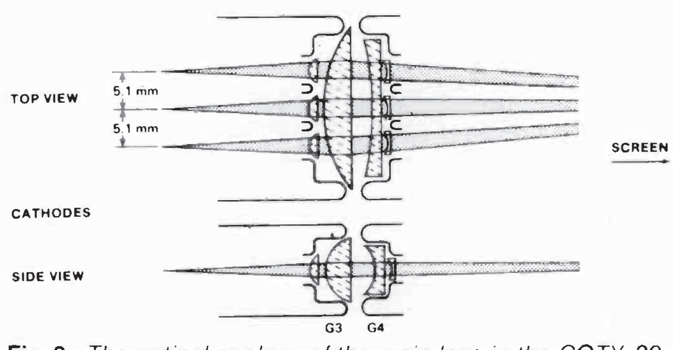

Fig. 2. *The optical analogy of the main lens in the COTY-29 XL gun.*

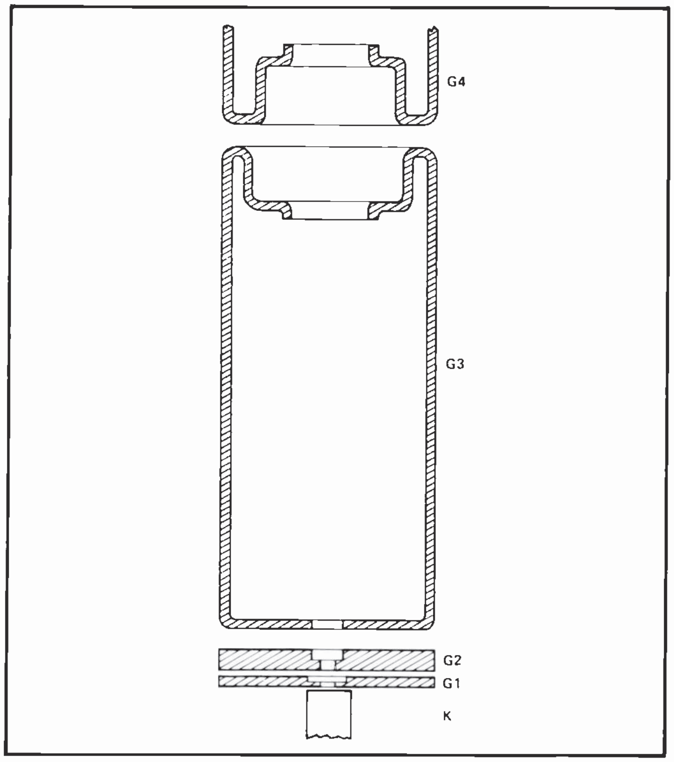

Fig. 3. *The XL HiPI gun.*

degree of improvement in convergence. In addition, the coma error is reduced greatly by the smaller spacing. Experimental data shows that the correction for coma, by means of field formers on top of the gun, is reduced by a factor of two. This reduction is useful in providing a greater allowable tolerance for tube-and-yoke variations.

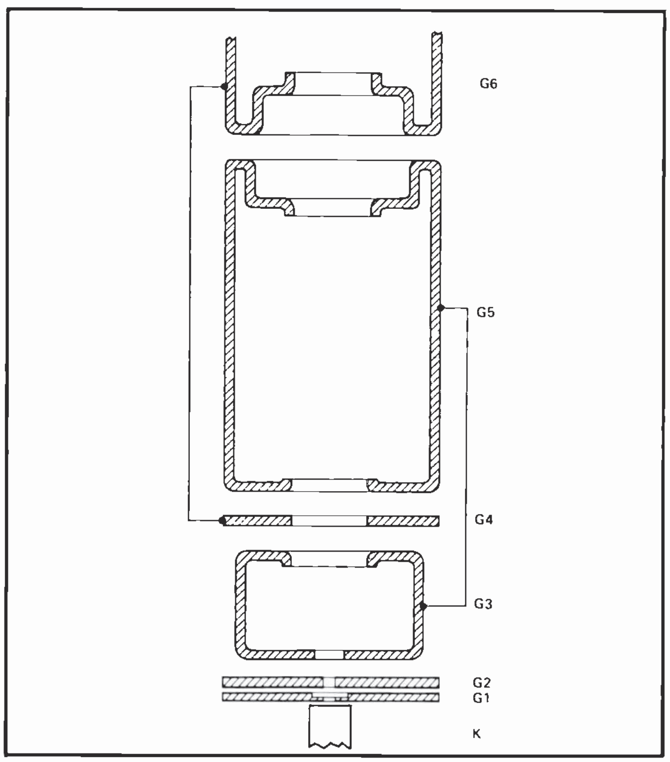

Fig. 5. *The XL DB gun.*

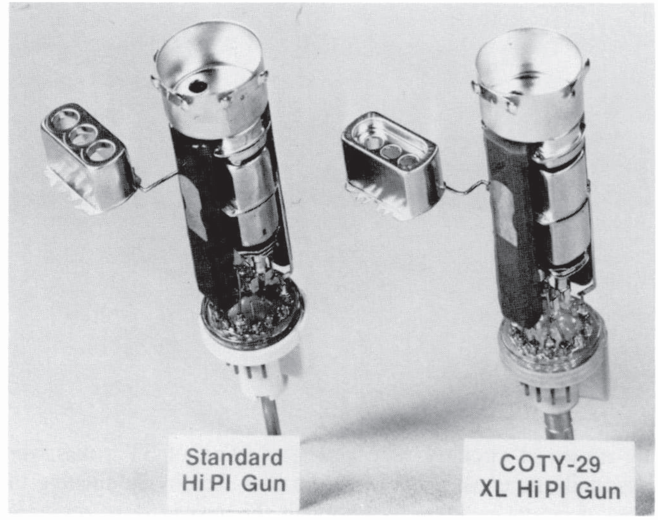

Fig. 4. *The XL HiPI gun (right) and the standard gun.*

The reduction in beam-to-beam spacing, although it improves convergence, results in slightly reduced screen tolerances. The effect of the earth's magnetic field on screen register is inversely proportional to beam spacing. Internal magnetic shields, commonly used in present-day tubes, minimize this problem. Previous use of this spacing has shown that, from a practical point of view, this decrease in screen tolerance is quite small.

For 90° tubes, the XL feature is used in a high-focus-voltage bipotential precision in-line (HiPI) type gun. Figure 3 shows this construction. The focus voltage is approximately 26 percent. Figure 4 is a photograph of the XL HiPI gun compared to its predecessor. An extra grid number 3 has been attached to each gun in the photograph to show the difference in construction.

For 110° COTY-29 tubes, the XL feature is used in a double bipotential gun. Figure 5 shows this DB construction with the XL formed between grid number 5 and grid number 6. In this case, the focus voltage is approximately 31 percent of the anode voltage. The reason the DB design was chosen for 110° deflection types was to obtain the smallest beam diameter in the deflection yoke. Since all self-converging yokes cause deflection defocusing, the smaller beam size of the DB gun reduces this

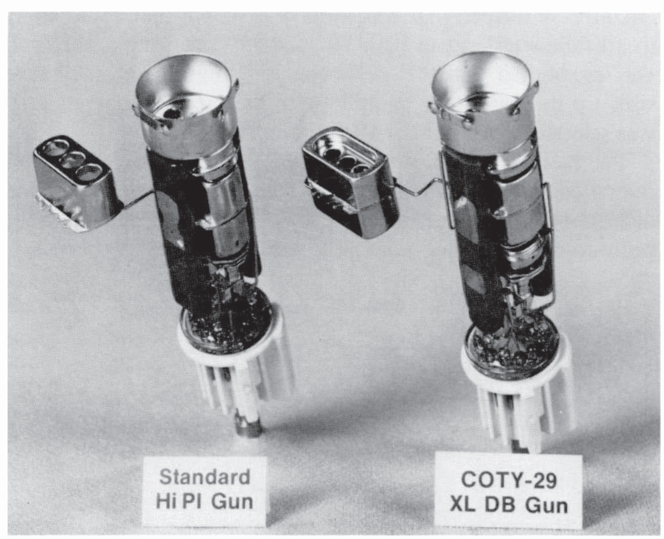

Fig. 6. *The XL DB gun (right) and the standard gun.*

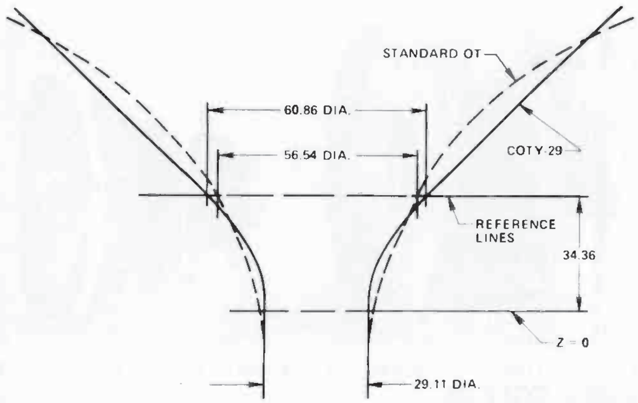

Fig. 7. *The 90° COTY-29 funnel in comparison to the present open-throat funnel in the yoke region.*

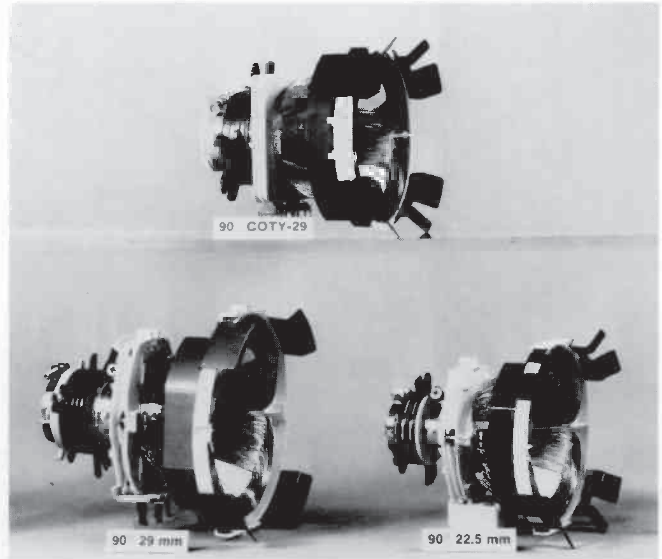

Fig. 8. *Three different 90° yokes, COTY-29, the standard 29-mm neck, and the 22.5-mm neck type.*

effect with the 110° deflection angle. Figure 6 is a photograph of the XL DB gun compared to a standard HiPI gun. In this photograph, an extra grid number 5 is shown in contrast to the conventional gun.

Both the XL HiPI and the XL DB guns employ slot optics in the beam-forming region. The reason for slot optics is to produce a different beam focal length for horizontal deflection than for vertical deflection. This differential focal length partially compensates for the differential effect of the self-converging yoke's pincushion-shaped horizontal deflection field and its barrel-shaped vertical deflection field. This concept was employed in the form of elliptical apertures in grid number 1 and grid number 2 in the early 110° in-line gun.[3] Since that time, various improved combinations of nonround apertures have been employed in these grids.[8]

A vertical slot on the grid number 2 side of grid number 1, combined with a round aperture on the cathode side, was selected for both of the XL gun designs. The parameters of this beam-forming region of the gun have been optimized to provide best focus over the entire screen. The use of slot optics in the lower portion of the gun in combination with the XL, and the adjustments that can be made between the two, provide better options for maximizing performance than were available in previous gun designs.

The XL, by its inherent larger size, reduces aberrations. To maintain the maximum advantage of this concept, the maintenance of the overall gun diameter was very desirable. Therefore, the neck diameter was kept at 29 mm. By maintaining this size, the use of standard stems, base configurations, and sockets was achieved. These proven features are valuable in the terms of reliability and freedom from high-voltage instability problems.

The focus performance of COTY-29 guns that have the XL is clearly superior to conventional designs. Data shows that highlight spot size is substantially reduced, and in addition, this new gun design gives even further reduction in flare. Comparisons with guns having main lenses with smaller diameters due to reduced neck size are even more significant. As mentioned previously, a unique feature of the XL gun is the gun designer's option of varying the parameters of the XL in conjunction with variations in the slot optics of the beam-forming region. With these two independent variables, the focus at the screen center and at the edge can be adjusted for best overall focus. Compensation for the defocusing action of the yoke is, therefore, significantly improved. The focus quality of the XL gun can be shown in comparison to a conventional gun by reducing the anode voltage of the XL gun. Comparable focus can be obtained with the XL gun operating at significantly lower voltage than that of the conventional design.

The COTY-29 yoke

As previously mentioned, the reduced beam-to-beam spacing and the optimization of the funnel contour in the yoke area have permitted the reduction in the size of the deflection yoke. In Fig. 7, the new funnel contour for the 90° tube is compared to that of the older open-throat design. This contour and the matching interior contour of the funnel were developed by computer computation and experimental data to closely match the beam path.

In Fig. 8, the 90° COTY-29 yoke is compared to a typical pin-free 29-mm yoke and to a yoke designed for a tube with a 22.5-mm diameter neck. The front cross-arm design is maintained to give east/west pincushion correction.

The reduction in size of the yoke permits lower material content; therefore, a lower cost. The deflection power requirement is also reduced in this design and is comparable to that of yokes designed for the tube with a 22.5-mm diameter neck.

The 110° COTY-29 yoke is also reduced in size because of smaller beam-to-beam spacing and a new funnel contour. Figure 9 shows this contour in comparison to the older open-throat design. It can be seen that it presents a slightly sharper curvature that is in accordance with the smaller yoke. Figure 10 shows the new yoke compared with its predecessor as used commercially on European tube types.

It has been concluded that the cost and performance disadvantages of a completely pin-free 110° design are a greater drawback than the cost of circuit correction. Therefore, east/west pin correction was not incorporated in the 110° yoke.

With both the 90° and 110° yokes, the reduced size has allowed the tube neck length to be reduced. This results in a 10-mm reduction in overall tube length compared to prior types.

Table II summarizes the power requirements of the COTY-29 yokes compared to their predecessors, when the tubes are operated at the same anode voltage.

Pull-out booklet here →

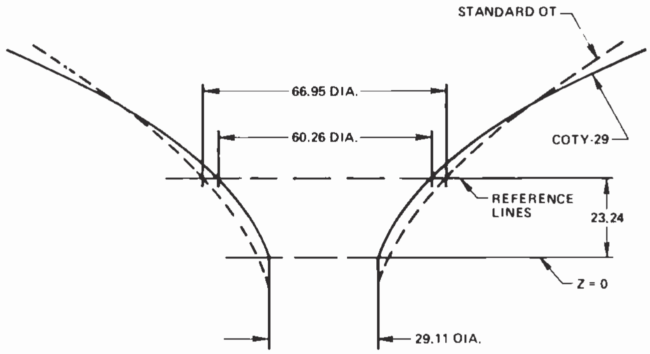

Fig. 9. *The 110° COTY-29 funnel in comparison to the present open-throat funnel in the yoke region.*

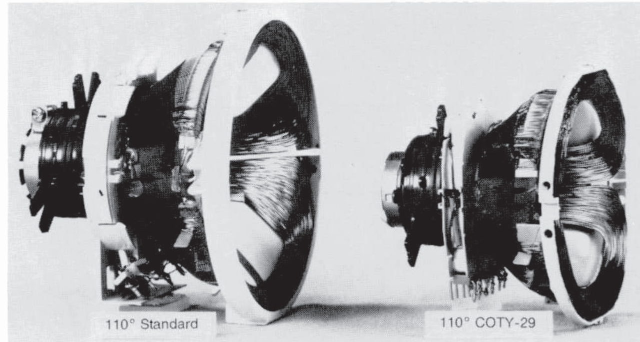

Fig. 10. *The 110° yokes—a standard European one (left), and the COTY-29.*

Table II. *Deflection power requirements at 25 kV.*

Yoke type	*Deflection angle*	*Horizontal stored energy* $1/2\ I_p^2L$ *(mJ)*	*Vertical power* I_p^2R *(W)*
COTY-29, pin-free	90°	1.8	2.0
Conventional, pin-free	90°	2.2	2.8
Conventional, pin-free	100°	3.5	4.4
COTY-29	110°	3.8	3.4
Conventional	110°	4.1	3.4

Summary

The goals of the COTY-29 design were overall cost and performance improvements. It is believed that these goals have been met by the design of a cost-effective tube that maintains those features proven for manufacturability and reliability. The yoke has been designed with lower material cost and hence, inherent lower cost; the yoke also has reduced deflection-power requirements. The circuitry enjoys the advantage of lower deflection power and, if desired, lower anode voltage. The performance gain is better focus and convergence. It is felt, therefore, that a substantial technical gain has been achieved in the COTY-29 system.

Acknowledgments

The author would like to acknowledge the extensive engineering work done within all departments of the Video Component and Display Division in Lancaster, Pennsylvania. In addition, substantial contributions were made by the RCA Laboratories in Princeton, New Jersey, in both gun and yoke designs that were essential to the project. The Consumer Electronics Division in Indianapolis, Indiana was responsible for yoke development and provided guidance on systems costs.

References

1. A.M. Morrell, "Color Picture Tube Design Trends," *Proceedings of the Society for Information Display*, Vol. 22, No. 1, SID International Symposium (1981).
2. R.L. Barbin and R.H. Hughes, "New RCA Color Picture Tube System for Portable Receivers," IEEE Spring Conference on Consumer Electronics, Chicago, Illinois (1972).
3. A.M. Morrell, "Design Principles of the RCA Large-Screen 110° Precision In-Line Color Picture Tube," 1975 IEEE Chicago Fall Conference on Consumer Electronics, Chicago, Illinois.
4. R.H. Hughes and H.Y. Chen, "A Novel High Voltage Bipotential CRT Gun Design," 1978 IEEE Chicago Fall Conference on Consumer Electronics, Chicago, Illinois.
5. A.P. Blacker, I.M. Wilson, and J.W. Schwartz, "A New Form of Extended Field Lens for Use in Color Television Picture Tube Guns," IEEE Chicago Spring Conference on Consumer Electronics (June 1976).
6. Shoichi Washino, Yoshiji Ueyama, and Shinya Takenobu, "Development of a New Electron Gun for Color Picture Tubes," 1979 IEEE Chicago Spring Conference on Consumer Electronics.
7. Eizaburo Hamano, Hisafumi Okada, and Shimpei Koshigoe, "Mini-Neck Color Picture Tube," *Toshiba Review No. 126* (March/April 1980).
8. H.Y. Chen and R.H. Hughes, "A High Performance Color CRT Gun with An Asymmetrical Beam Forming Region," 1980 IEEE Chicago Spring Conference on Consumer Electronics, Chicago, Illinois.

Al Morrell is Manager of Product Development at the Video Component and Display Division, Lancaster, Pennsylvania. He received the BSEE from Iowa State University in 1950 and joined the Electron Tube Division of RCA the same year. He has specialized in color picture tube development and has been associated with most phases of tube development for the last 33 years. He has published numerous technical papers and is co-author of *Color Television Picture Tubes*, a book published by Academic Press in 1974. His work at RCA has been recognized by two David Sarnoff Awards given in 1964 and in 1976. In 1979, he was awarded the IEEE Vladimir K. Zworykin Award.

Contact him at:
Video Component and Display Division
Lancaster, Pa.
TACNET: 227-2184