Development of Electron Gun "S-CXO"

Yong Geol Kwon, *Member*, Deog Ho Kim, Yang Je Lee, *Member*, Kwang Jin Yun and Young Jun Yoon

Abstract

To meet the demand of the display market for large, flat, high-resolution screen, the Super Common eXtended field Oval lens (S-CXO) has been developed with resolution improvement of 10% or more compared to a conventional electron gun. A new main lens structure is adopted, to enhance the effectiveness of aperture and the performance. The new main lens can be assembled using an existing assembly system

Key words : CDT, electron gun, effective aperture, common large-aperture

1. Introduction

As the screen size of color display tube (CDT) increases, high level of beam current is needed so as to maintain brightness. However, as the size of an electron beam spot increases, spherical aberration increases, thus deteriorating the resolution. Maintaining the required high-resolution in large screen size and deflection angle has become an important design goal.

In contrast to conventional cylindrical symmetry lens, a rotationally asymmetric main lens capable of reducing the spherical aberration was designed through computer simulation and experiments. The rotationally asymmetric main lens has a composite structure in which a center gun has an elliptic aperture while the side guns have a complex aperture (half-circular, rectangular and half-elliptical apertures). As a result, the beam spot size decreases by 13 % and the resolution is improved from 1.5M pixel to 2.3M pixel or more.

We have named the electron gun as S-CXO (Super Common eXtended field Oval lens) gun.

2. Structure of S-CXO gun

Fig. 1 shows the structure of an S-CXO gun. The main lens of the S-CXO gun is comprised of a large-aperture electrode having a G5-4 electrode and a G6 electrode, and auxiliary electrodes of plate type inserted into the large-aperture electrodes.

For uniform focusing over the screen, a multi-step focusing structure is adopted[1]. In particular, beam focusing is done using a uni-potential focusing lens including G3, G4 and G5-1 electrodes, and bi-potential focusing lens including G5-4 and G6 electrodes.

In order to correct the halo beam shape of peripheral screen, due to curvature field distribution, and negative astigmatism by non-uniform magnetic field from deflection yoke, double-dynamic quadrupole lens is adopted, which includes G5-1 and G5-2 electrodes for 1st quadrupole lens, and G5-3 and G5-4 for 2nd quadrupole lens[2-4]. One of the advantages of the S-CXO gun is in the dynamic lens system which is simply achieved by adopting circular hole electrodes and key-hole shaped electrodes.

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3. Main Lens Design

As shown in Fig. 2, an auxiliary electrode for a conventional electron gun has circular shapes, whereas the conventional auxiliary electrode positioned in the large-aperture electrode has a cup shape, so it is impossible to have non-circular shapes. Also, there are

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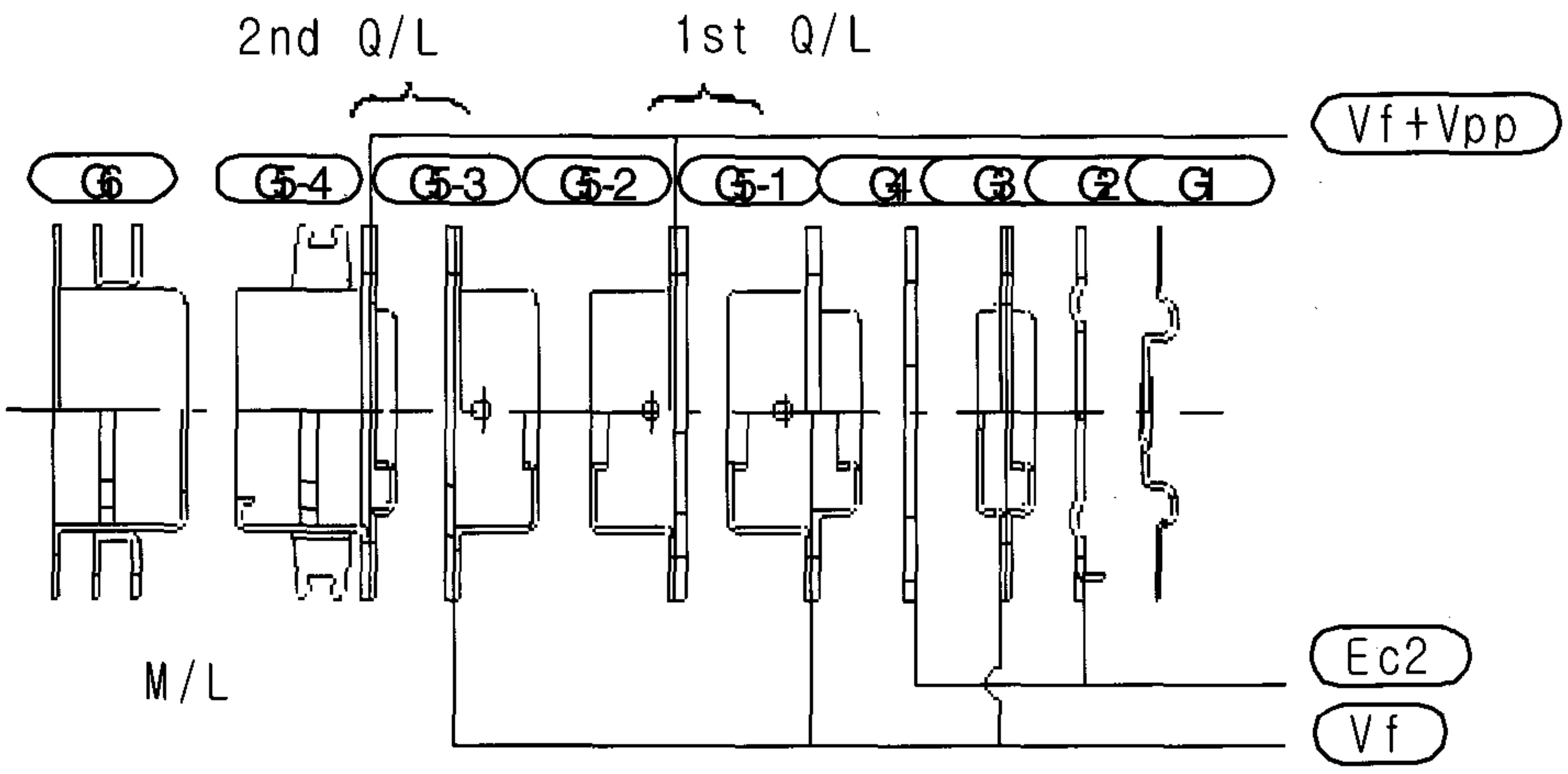

Fig. 1. Structure of S-CXO Electron Gun.

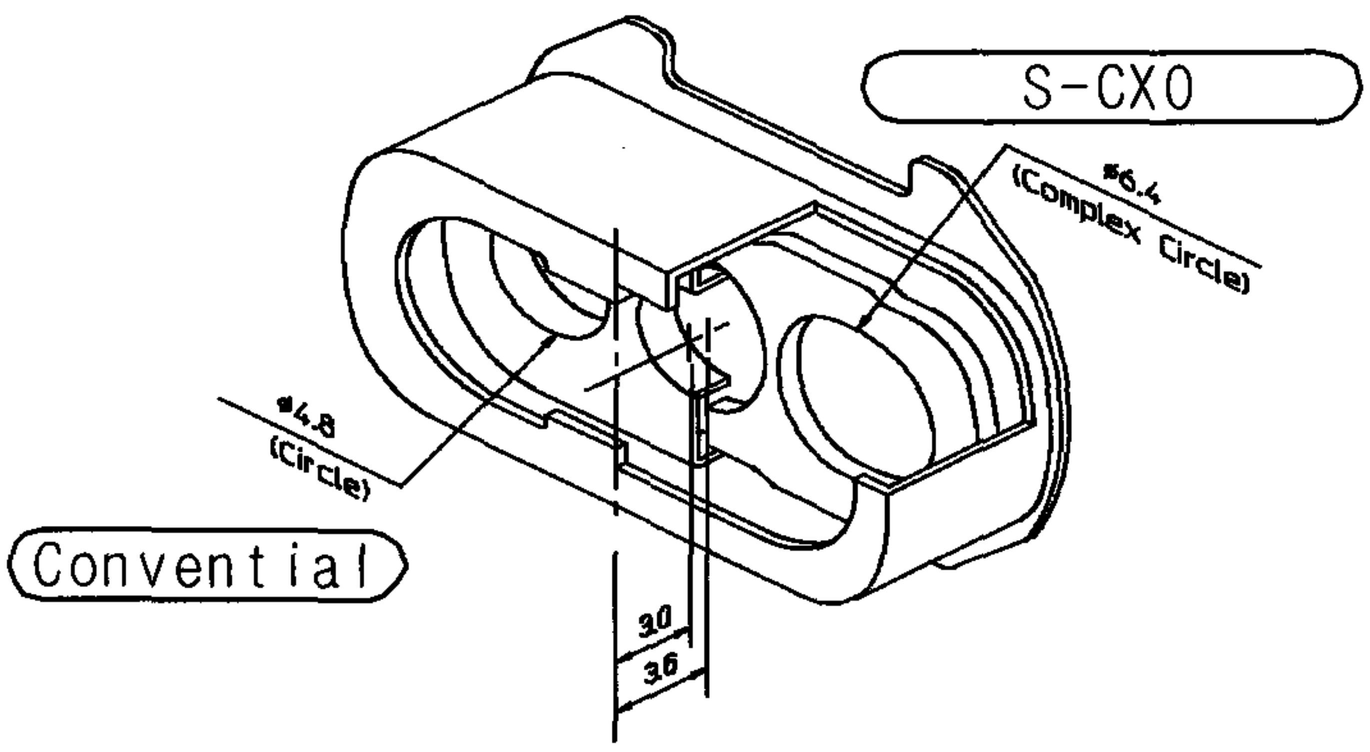

Fig. 2. Comparison of auxiliary electrode shape.

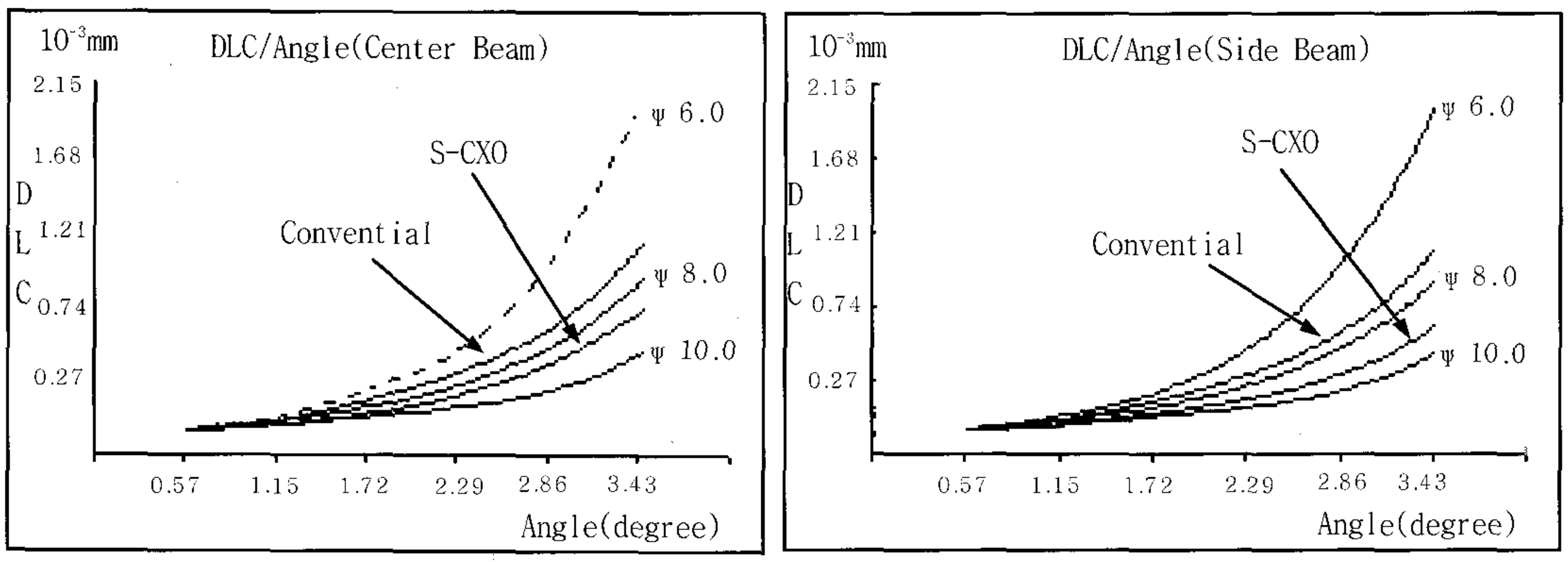

Fig. 3. Calculation of effective aperture using simulation program.

limitations to the holes size and separation between considering required mechanical strength and manufacturing difficulties of the electrodes.

Thus, for high absolute resolution, the designing of the S-CXO gun was started with plate type electrodes having enlarged the effective aperture. In addition, for optimum focus, many simulation and experiments were tried using different hole sizes and separations between them.

In order to enlarge the diameters of the center hole and side hole, the separation is increased within the what range to satisfy STatic Convergence(STC), STC variance, and other focus characteristics, relative to the conventional separation. As a result, the hole size is increased from ₵4.8 to ₵6.4. Also, in order to improve assembly accuracy and coma aberration, which occurs in the side beams, a complex aperture structure is

Table 1. Comparison of effective apertures at center and side beams between the S-CXO gun and the conventional electron gun.

Type	Center Beam		Side Beam	
	Horizontal	Vertical	Horizontal	Vertical
S-CXO	8.84 mm	8.27 mm	9.48 mm	8.49 mm
Conventional	8.14 mm	6.87 mm	7.72 mm	7.39 mm

Table 2. Comparison of beam spot size. (SS200, Beam profile-5 %, 91 kHz/ 85 Hz)

Position	S-CXO	Conventional	Improvement
Center	0.66 mm	0.74 mm	10.8 %
Corner	0.78 mm	0.91 mm	14.2 %

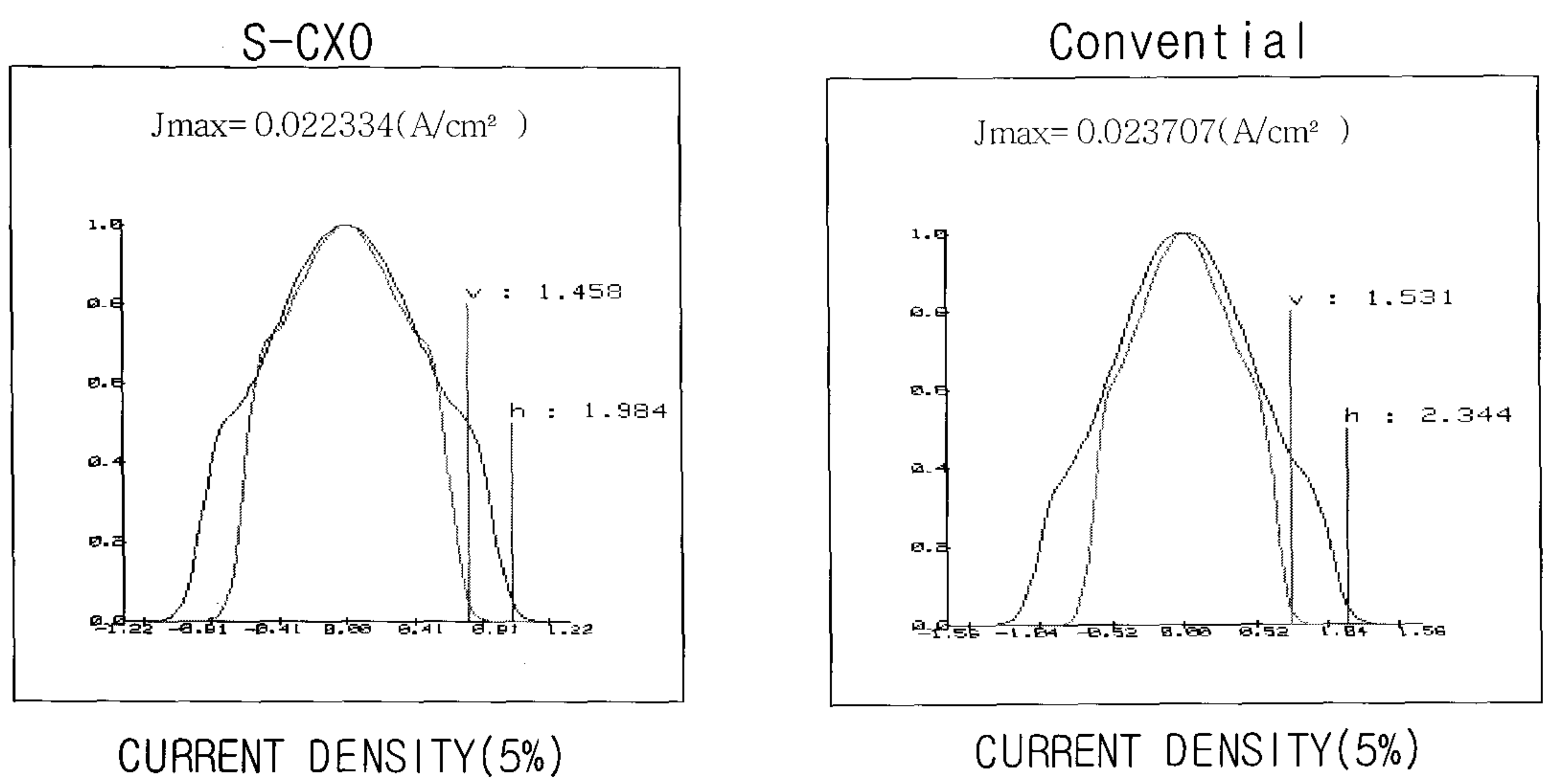

Fig. 4. Comparison of current density distribution.

adopted, in which the auxiliary electrodes including the electrodes G5 and G6 are designed to have the same shape. This way the coma aberration of the side beams is reduced.

As shown in Fig. 3, which shows a simulation using the computer simulation program[5], the main lens of conventional electron gun has an effective aperture of 7.5 mm, while the main lens of the S-CXO has a larger effective aperture of 8.8 mm in a CRT having a ₵29.1-neck, without the need for an additional element such as resistors.

4. Triode Design

To improve a conventional triode, the current density profile of a beam incident onto the conventional main lens is obtained using the computer simulation program. The result is shown in Fig. 4. As shown in Fig. 4, the conventional beam profile has a bell-shaped steep peak having a maximum width of 2.6 mm and a maximum height of 1.8 mm [6-7].

Through the computer simulation, we found that the resolution characteristics are excellent when the current density profile of the main lens shows uniform distribution with a small and rectangular peak. For a maximum width of 2.2 mm and maximum height of 1.6 mm providing the optimum current density profile, the hole size of the conventional G1 electrode is reduced from ₵0.4 to ₵0.36.

5. Beam Spot Size of S-CXO gun

As can be seen from Table 2, the S-CXO gun can improve the resolution by 10.8 % at the center screen and 14.2 % at peripheral screen, respectively, compared to the conventional electron gun. Also, a variation of the spot sizes at the low-current and high-current areas can be reduced by increasing the effective aperture and optimizing the triode structure (see Fig. 5).

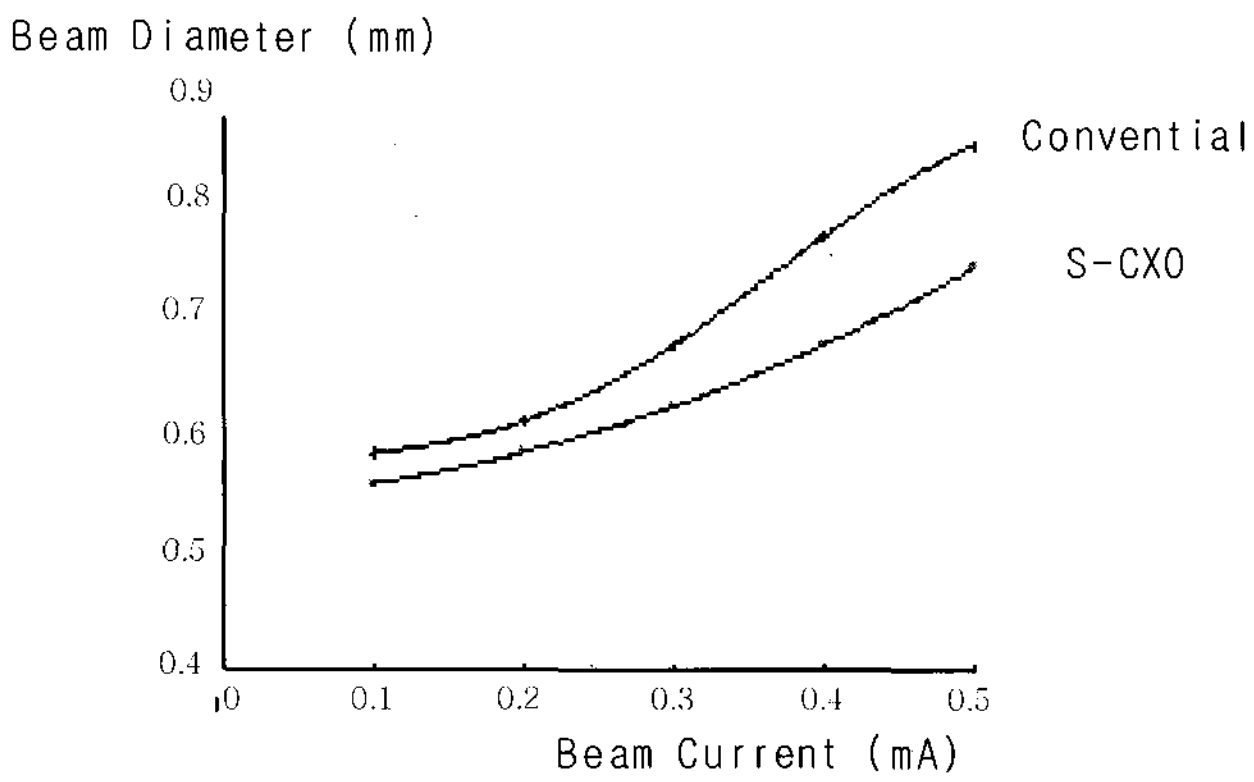

Fig. 5. Variation of spot size with respect to beam current.

6. Conclusions

An S-CXO lens for high-resolution in a large-screen color display tube (CDT) of more than 19-inch or 21-inch has been developed. A multi-step focusing lens is adopted to provide more uniform resolution. Also, a triode capable of optimizing the incident beam area for a main lens is designed using a computer simulation program, with a resolution of 2.3 M Pixel or more.

Furthermore, although the S-CXO gun adopts a mechanism which is different from a conventional electron gun, the S-CXO gun can be assembled using a conventional assembly system. Also, the focusing ability can be increased by significantly reducing the spherical aberration of the main lens without the need to separate the process. By forming a family of electron guns which can be applied to various CDTs with a minor modification, the S-CXO electron guns are more competitive in terms of price and manufacturability.

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