THE DESIGN OF THE SHIFTING SECTION OF AN
INTENSIFIER SILICON TARGET PICK-UP TUBE

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Abstract

The principle for designing the shifting image section of an intensifier silicon target pick-up tube is given. An electrostatic electron-optical system with a photocathode having an effective diameter of 40 mm and a system magnification of 0.65 has been designed. Experiments show that when the electron image of the photocathode is transferred to the silicon target, the geometric distortion is 2%, and the field curvature is 2 mm. The astigmatism is less than 0.32 mm at 80 percent of the viewing field and the resolution is over 50 lp/mm. It shows that the design of the electron-optical system is good and reasonable.

I. Introduction

With the development of low-light vision technologies, in the 1970's, the high sensitive intensifier silicon target device appeared and soon attracted the attention of scientific research institutes, military and commercial departments. This tube is called EBS or ISV[1] in America and SEM[2] in Japan. The first tube produced had a diameter of one inch. Our aim has been to make one and a half inch ISV with excellent image quality. The sensitivity of this kind of tube is closely connected with the design of the shifting image section of tube. Fig.1 shows a schematic diagram of the 1½" intensifier silicon target pick-up tube (i.e., the effective diameter of the photocathode is about 40 mm). The shifting image section is in front of the silicon target pick-up tube, so the incident low-light does not directly strike the silicon target to produce hole-electron pairs, but it strikes at the photocathode of S20 which can emit photoelectrons. In the shifting image section they are accelerated to a high potential of 12 kV and bombard the silicon target with very high energy. Because energy of the

Fig. 1 Schematic diagram of the 1½" intensifier silicon target pick-up tube
bombarding electrons is multiplied at the silicon target, the hole-electron pairs are also multiplied. This kind of tube is able to yield very high electron gain.

In order to develop high quality low-light TV and enhance the resolving power, we have undertaken the design of this 1₂₅₆" pick-up tube. Tab. 1 gives a comparison between the typical data reported by Westinghouse Company and those of our designed SIT. It shows that the designed SIT has a higher sensitivity and a higher limiting resolution. The detectability of the designed tube is better than that of the 1" SIT together with a single stage image intensifier[1]. Thus it is quite meaningful for us setting out to design a shifting image section of high quality.

Tab. 1 A comparison of the major specification of WL31792 and the designed SIT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Effective diameter of the photocathode</th>
<th>Diameter of the silicon target</th>
<th>Accelerating potential</th>
<th>The limiting resolution</th>
<th>The overall sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
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<td>mm</td>
<td>kV</td>
<td>TVL</td>
<td>μA/Im</td>
</tr>
<tr>
<td>Tube type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WL31792*</td>
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<td>18</td>
<td>10</td>
<td>700</td>
<td>250000</td>
</tr>
<tr>
<td>Designed tube</td>
<td>40</td>
<td>25</td>
<td>12</td>
<td>800</td>
<td>720000</td>
</tr>
</tbody>
</table>

* Typical data reported by Westinghouse Company in the U. S.

II. Calculation and Results

The electron optical system of the shifting image section consists of a spherical photocathode, a bending hook-electrode of the same potential as that of the photocathode, and a cone anode. It is a diode with fixed focusing system as shown in Fig. 2. Using DJS-6 electronic computer, we have calculated the electrostatic field and the electron trajectories in the shifting image region and determined the position of the imaging plane \( L_0 \), the central magnification \( M_0 \) and the off-axis image characteristics, such as the distortion \( \beta \), the field curvature \( F \) (the meridian field curvature \( F_m \), the sagittal field curvature \( F_s \)), the astigmatism \( \eta \) and so on[4].

According to Fig. 2 we have calculated a plot of the normalized image plane position \( L_0/D \) vs. the normalized distance between the photocathode and the anode \( P/D \) with the normalized radius of the anode hole and the magnification as parameters. As seen in Fig. 3, \( D \) is the diameter of the photocathode. It shows that \( L_0 \) and \( M_0 \) increase as \( P \) or \( r_a \) increases.

Fig. 2 The electron optical system of the shifting image section