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Application of a Single Board CCD Camera on a Pentax PCS-215 Theodolite

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ABSTRACT: A small CCD camera has been mounted behind the eyepiece of a Pentax PCS-215 Electronic Total Station. The telescope image as well as the reticle can be conveniently viewed on a monitor and recorded on tape if necessary. The magnification is 25× and the field of view is $10' \times 8'$ measured on the monitor. The horizontal and vertical resolutions are $3''.5$ and $4''.5$, respectively.

1. INTRODUCTION

A Pentax PCS-215 Electronic Total Station will be used to align the Optical Path Length Equalizer (OPLE) rails. This is a delicate job where any aid that potentially improves the accuracy of the alignment is appreciated. The PCS-215 is a high quality theodolite equipped with a built-in distance measuring unit and an on-board computer. In order to make the alignment less painful, we decided to mount a small CCD camera behind the eyepiece which will allow us to look through the telescope by using a video monitor.

2. DESIGN CONSIDERATIONS

It is vital in our application that the reticle in the focal plane of the telescope be clearly visible on the monitor screen and that the resolution on the screen not be much worse than the resolution of the telescope itself ($3''$). It was also very important to make minimal impact on the PCS-215 by installing the CCD camera and to avoid any mechanical and optical degradation of its performance.

We have acquired a high resolution B/W (570 TV lines, $1/3''$ interline transfer CCD) single board CCD camera from Edmund Scientific (P53,309) for a very affordable price ($270.00). The 32 mm × 32 mm board contains all the necessary electronics and has only four wires to connect: the power 9V (150 mA)/GND and the standard NTSC video output/GND. A lens was not included.

In principle we could have used the theodolite's own eyepiece to project the image onto the CCD. However, it turned out that in that case the magnification would have been very high, and the characteristic length of the optical system would have been very long since the

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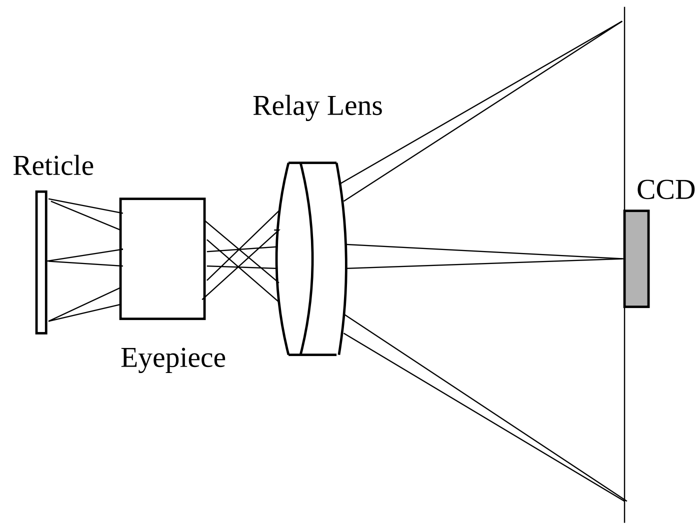

FIGURE 1. Reimaging the telescope image and the reticle onto a CCD by a relay lens.

maximum distance of the eyepiece from the focal plane of the telescope was factory limited. We did not want to alter the original design or take apart the instrument. Therefore, we decided to apply a relay lens between the eyepiece and the CCD (Figure 1).

3. OPTICAL DESIGN CONSIDERATIONS

In order to see the reticle on the screen with high contrast, the projected width of reticle lines must be sampled by two pixels on the CCD. The active area of the CCD is 4.8×3.6 mm and contains 768×494 pixels. Thus the pixel size is $6.3\times7.3\,\mu$m . We learned from the distributor that the angular width of the reticle lines projected back to the target is $2''\!.5$. The magnification of the telescope is $30\times$, therefore, the angular width of the reticle lines looking from the relay lens is $30\times2''\!.5 = 75''$. The necessary focal length of the relay lens is found from

$$f \times \frac{75}{206265} = 2 \times 7.3\,\mu\mathrm{m}$$

which yields f=40 mm. To be on the safe side, we selected an ø15 mm achromat lens (Edmund Scientific P8053) with a focal length of 50 mm. The diameter of the lens is unimportant from an optical point of view because the exit pupil diameter of the telescope is only ø1.5 mm and the relay lens is close to the plane of the exit pupil. The field of view with this lens is about $10'\!.5 \times 8'\!.2$, which translates to $3.2\,\mathrm{cm} \times 2.4\,\mathrm{cm}$ at 10 m.

A small enclosure was manufactured in the departmental shop to hold the camera, relay lens and electrical connectors. The enclosure can be screwed onto the telescope by replacing a ring around the eyepiece which protects the reticle adjusting screws. The whole assembly is small and lightweight, but it does make the telescope out of balance. Although the altitude clamp apparently can hold the position, the extra load may result in slow drifting from a position. Therefore, it was necessary to install a counter balance.

4. CONCLUSION

We have successfully installed a single board CCD camera onto the PCS-215 Electronic Total Station. The magnification is $25\times$ and the field is $11' \times 8'.3$ measured on a 9-in monitor screen. The resolution was also measured and found to be better than $3''.5$ horizontally and $4''.5$ vertically.