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IMAGE ROTATOR ALIGNMENT

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QUALITY DIVISION

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ABSTRACT

Pechan prisms are often utilized at the Pantex firing site to rotate a test part image for proper alignment to the streak camera slit plate. Modification of a prism mounting system provides means for the mutual adjustment of the prism axis, prism mounting axis, and streak camera optical axis. This reduces, or eliminates, image translation during rotation about the optical axis. Alignment errors, modification devices, and alignment procedures are presented for the rotatational prisms employed at the test site.

PECHAN PRISM ALIGNMENT ERRORS

Pechan prisms are used to rotate (or derotate) an optical image. The image rotates twice the angular rotation of the prism due to image invertion at various reflecting surfaces within the prism (see Fig. 1). These prisms can be used in converging or diverging light beams without causing significant image aberrations (astigmatism)(*1*). The prism axis, prism mounting axis, and the streak camera optical axis must be mutually aligned to assure that the emerging (output) optical axis will not be tilted or translated.

Fig. 2 shows the effects of prism displacement with respect to the

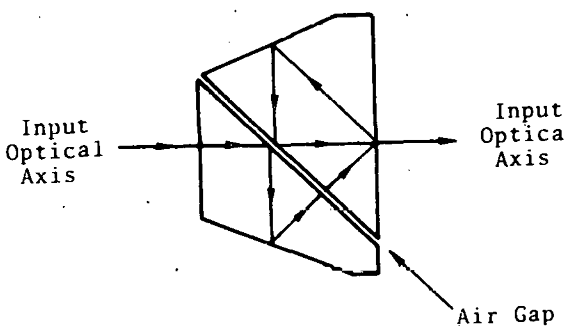

Fig. 1. Total Internal Reflections Within a Pechan Prism

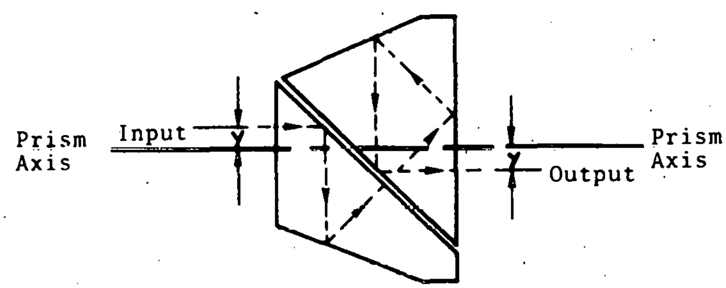

Fig. 2. Effects of Prism Displacement with Respect to the Input Optical Axis (The X axis is normal to the paper)

optical axis when the displacement is along the Y-axis. Prism translation along the X-axis (perpendicular to Y-axis) will not deviate the emerging optical axis. Angular misalignment effects can be seen in Fig. 3 where the output optical axis is deviated in position, and angle, for Y-axis errors. Similar, but more complex, deviations result from X-axis angular errors.

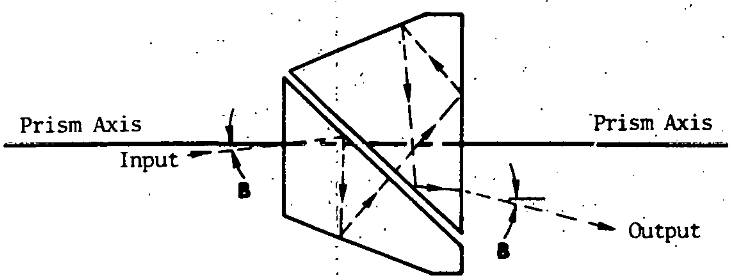

Fig. 3. Effects of Prism Tilt with Respect to the Input Optical Axis

The effects of prism alignment errors were investigated by Sullivan(2) and the resulting image shift patterns are presented in Fig. 4 for prism angular and displacement errors. Prism tilt errors produce analogous effects to the displacement errors where angular coordinates and dimensions replace their corresponding displacement errors. Fig. 4 represents a plot of image shift as the prism rotates on its mechanical mounting axis where θ corresponds to the angular orientation of the prism assembly, d_1 the displacement of mechanical to input optical axis, d_2 the displacement of mechanical to prism axis, and r the displacement of optical input to optical output axis. Prism fabrication errors, in the β-plane, are the only errors which cannot be corrected by correct orientation of the prisms (2).

MODIFICATION AND ALIGNMENT PROCEDURES

Modification mounting devices were fabricated to allow mutual adjustment of the prism axis, prism mounting axis, and input optical axis. The modified prism mounting system is shown in Fig. 5. Pieces 1 through 5 were fabricated for a modified prototype. The plane surfaces of piece 3 were machined parallel so that the prism (mounted with its plane surface flush to piece 3) remains angularly aligned to piece 6 during rotation. Piece 6 was measured to assure correct angular alignment to piece 7, which attaches to the optical rail. The holes in pieces 4 and 5 were drilled slightly off-center to provide lateral adjustments for the prism axis and

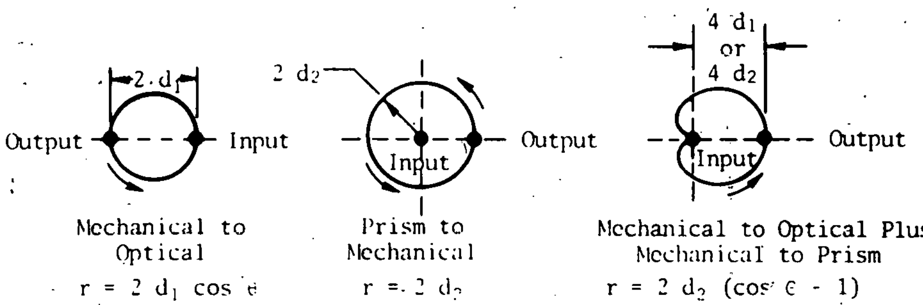

Fig. 4. Image Shift Effects of Displacement and Angular Alignment Errors

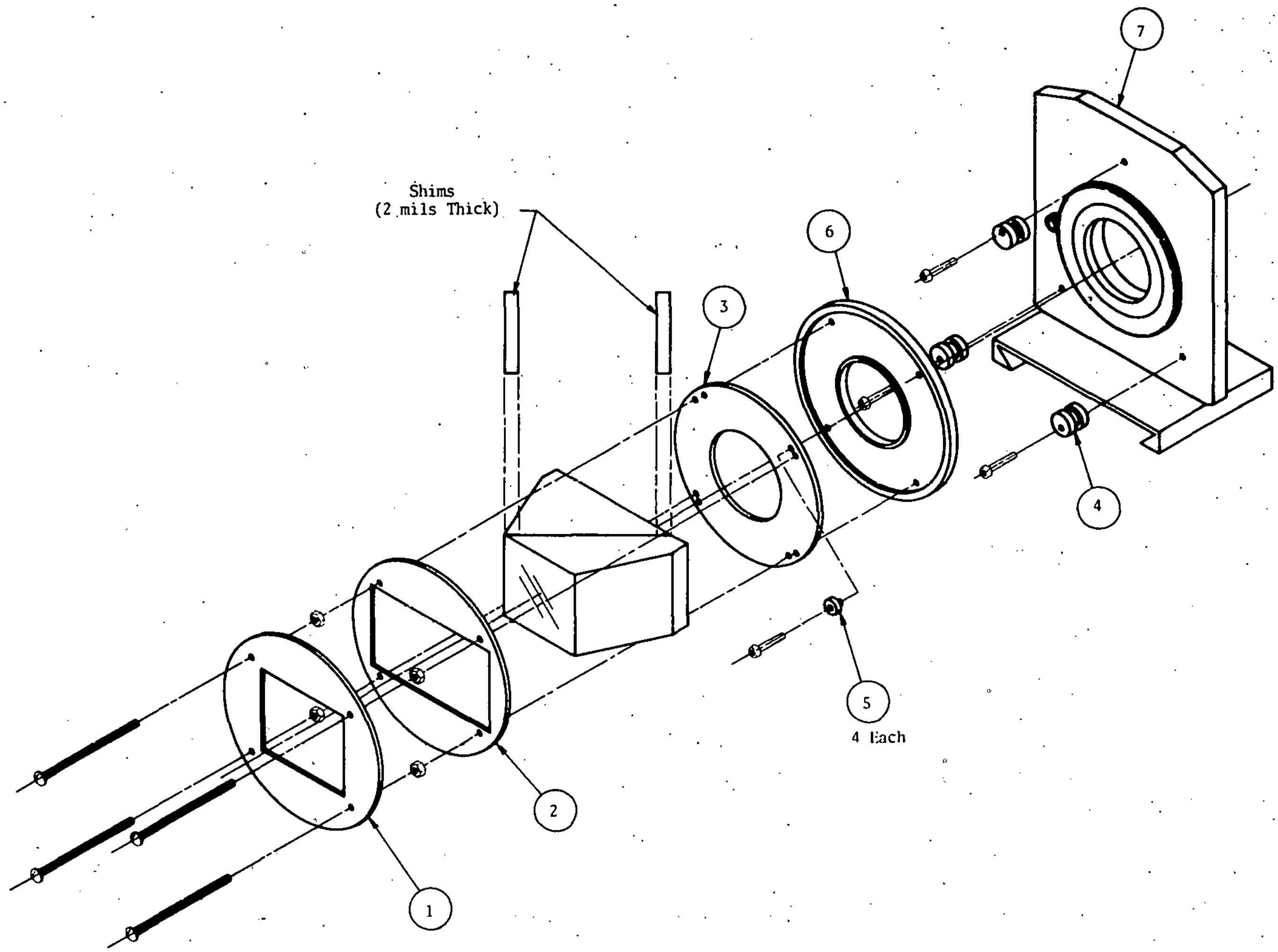

Fig. 5. Modified Mounting System for an Image Rotator

mechanical axis. The rectangular openings (in pieces 1 and 2) were fabricated with a small clearance on the prism to allow alignment of the two prism halves to a common axis.

Assembly of the mounting system began by fastening the prism to piece 3. Note that metal shims (2 each, 2 mils thick) separate the two prism halves. This provides an air gap with uniform spacing to yield internal reflection at the two uncoated prism surfaces. Special care must be taken to assure that these prism surfaces are kept clean since even a nearly invisible fingerprint on an uncoated surface can deflect light rays out of the prism system prematurely.

Piece 7 was then aligned (angular and lateral) to a laser beam and secured in place. Beam deflection was observed before, and after inserting the prism. Slight pressure was applied to pieces 1 and 2, and laser beam deflection was observed during prism rotation and compared to the patterns shown in Fig 4. Three adjustments were performed during this operation.

1. The two prism halves were aligned to a common axis.

2. Piece 3 was shifted (by means of the offset holes in piece 5) to align the prism axis to the mechanical axis (piece 6).

3. Piece 6 was shifted (by means of the offset holes in pieces 4) to align the mechanical axis to the input optical axis (the laser beam).

The three axes were aligned for a minimum possible beam deflection during prism rotation. This procedure was most easily accomplished by securing piece 7 so that the optical axis (laser beam) was vertical. Therefore, the various parts would not shift, by their weight, during adjustments. When satisfactory alignment was achieved, all pieces were secured by their respective fasteners and the prism assembly was tested optically for image resolution.

Finally, stabilizing blocks were bonded to the plane surfaces of pieces 1 and 2 to prevent lateral shifting of the prism halves during normal use and handling. Black electrical tape was applied to the prism sides as a seal to prevent dust or debris from entering the air gap.

CONCLUSIONS

Image shift was reduced from 10 milliradians to 2 milliradians by the modification devices discussed. This was measured as the included angle of image shift (see Fig. 4) with respect to the position of an objective lens placed between the image rotator and an object being focused. Performance of the modified assembly was determined satisfactory for the following reasons:

1. A deflection of ± 1 milliradian of the output optical axis is sufficiently accurate for the current laser alignment systems employed at the test site. This assures that the test part is perpendicular to the optical axis for optimum focus of the test parts outer boundaries.

2. Final alignment procedures require only small image rotations and the resulting image shift is a small fraction of a slit width.

3. Image resolution is not degraded by the modification devices.

4. The modified assembly is adequately stable for normal use and handling.

5. The cost of the modification is much less than a new design of the complete prism mounting system.

Two different models of image rotators are in use at the test site. The principles discussed in this report can be applied to either model, since their original mounting systems are similar. The remaining image rotators are currently being modified and are expected to perform as well as the prototype.

REFERENCES

1. Technical Staff (Melles Griot), "Prism Potpourri," Electro-Optical Systems Design, March, 1976, p. 28.

2. D. L. Sullivan, "Alignment of Rotational Prisms," Applied Optics, Vol. 11, No. 9, September 1972, p. 2028.