SPECIAL OPTICS

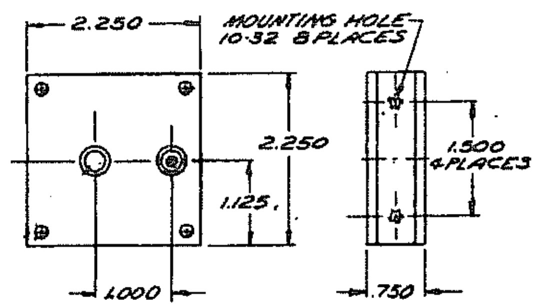
Bulletin 105-2 RISLEY PRISM BEAM STEERING ASSEMBLIES

SERIES 1000 SINGLE-AXIS LASER BEAM DEFLECTOR

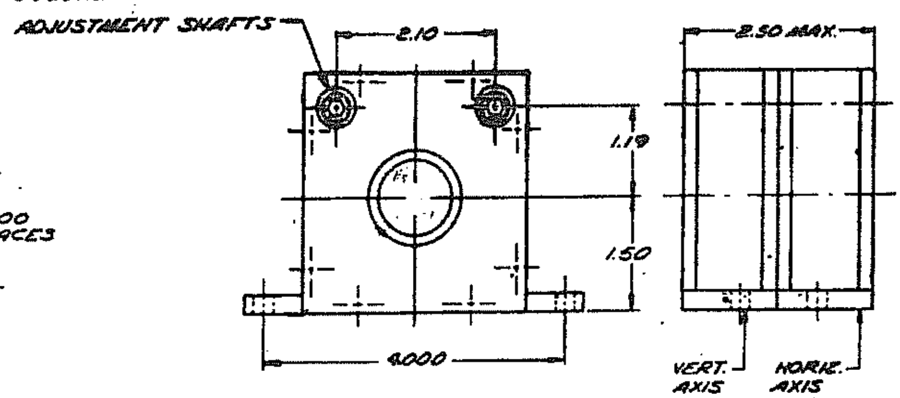
To obtain a single-axis deflection, it is necessary to simultaneously rotate the two wedges in opposite directions and through identical angles. Special Optics has developed a rotation mechanism for single-axis deflection with zero backlash that can be manuallv-or motor-driven.

Model No.	Aperture (mm)	Wedge Material	Max. Deflection at 1064 nm	Shaft Rotation for Maximum Deflection	Torque Value (ounce - inch)
12-1001	5	Quartz	13.5 min.	540°	1
12-1002	5	Quartz	2°	540°	1
12-1003	25	Quartz	13.5 min.	720°	3-5
12-1004	25	Quartz	2°	720°	3-5
12-1005	71	ZKN-7	11.3 min.	2000°	8-10

Note: The 1000 Series are stackable for independent X-Y deflection.



Models 12-1001 and 12-1002

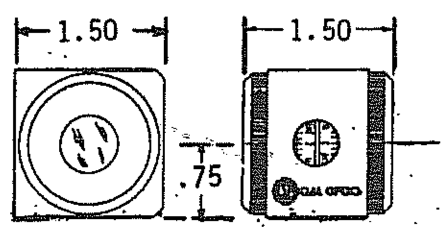


Model 12-1003 shown stacked for 2-axis deflection

SERIES 2000 MONOCHROMATIC BEAM DEFLECTOR

The 2000 series utilizes two single-element fused silica wedges mounted in a housing that allows independent, manual rotation. The transmitted wavefront deformation is $\leq \lambda/10$ over the 15 mm aperture. A set of indexed drum dials provides direct angular readout of each wedge.

Series 2000 & 3000 housing



Model No.	Maximum Deflection
12-2001	0.5°
12-2002	2.0°

MODEL 12-3015 ACHROMATIC BEAM DEFLECTOR

For applications requiring that a multi-line laser be deflected, the model 12-3015 utilizes two pairs of prisms; each pair consisting of one high dispersion glass wedge and one low dispersion glass wedge. Each pair is air-spaced to maintain a high resistance to laser damage ($\approx$ 350m watt/cm^2, 20 nsec).

Wavelength(nm)	Maximum Deflection (degrees)	%Transmittance
1064	3.000	97.5
632.8	3.000	95
532	2.986	97
514.5	2.980	95
488	2.970	92

Coincidence Error (arc sec.)

1064 and 632.8nm----- 0.2"
1064 and 532nm------- 5.0"
514.5 and 488nm----- 3.6"

Technical note on opposite si

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THEORY OF OPERATION

Since the Risley prism is utilized as a "fine tuning" or high resolution beam steering device, the refracting angle A of each individual wedge is typically less than 5^{o}. For such a thin wedge in air, the deflection of the incident laser beam is given by $d = (n-1)A$ where n is the refractive index of the prism material.

When two identical wedges are used in series and aligned parallel, the total deflection, D, is twice that of each individual wedge. For zero deflection, the wedges are aligned opposite. Risley prisms should therefore be assembled using combinations made of material from the same melt and fabricated with the same refractive angle (within several arc seconds).

As the second wedge is rotated with respect to the first, the deflection is continuously varied from minimum to maximum values. Since the deflections add vectorially, the resultant deflection of the Risley pair is defined by the relationship:

$$D = \left[2d^2\ (1 + \cos B)\right]^{1/2}$$ where B is the angle between the wedges.

Since $\left[\frac{1 + \cos B}{2}\right]^{1/2} = \cos B/2$, the expression for D becomes $D = 2d \cos (B/2)$. (1)

By introducing the ability to rotate both wedges independently with respect to the incident laser beam, one can steer the beam to any position within a solid angle of $\pi \tan D$ (in steradians).

If only one wedge of the Risley pair is rotated, the magnitude of the deflection is calculated using equation 1. Conversely, if the distance from the beam deflector to the target(Z) and the displacement in the target plane (X) are known, the angle of wedge rotation is calculated from the relationship:

$$B = 2 \cos^{-1} \left[\frac{\tan^{-1}\left(\frac{X}{Z}\right)}{2d}\right] \quad (2)$$

One disadvantage of beam steering with a Risley prism pair is that the direction vector varies along with the deflection angle. This cross-coupling problem can be solved by rotating both wedges in equal but opposite directions with a resulting single-axis deflection. Independent X and Y deflection is achievable by stacking two such counter-rotating wedges in series.

DEFLECTION NON-LINEARITY

As the relative angle between the wedge axis of a Risley prism is changed from 0^{o} to 180^{o}, the deflection varies from a maximum to minimum value, respectively. The relationship between deflection magnitude D and the relative angle B is defined as:

$$\Delta D = 2d \left[\cos\left(\frac{B + \Delta B}{2}\right) - \cos\left(\frac{B}{2}\right)\right] \quad (3)$$

The deflection per degree change in B is therefore approximately 40X greater when B is close to 180^{o} than when the wedge axes are nearly aligned parallel.

CHROMATIC NON-LINEARITY

Since the deflection of a wedge is a function of wavelength, the chromatic dispersion of a set of single-element wedges is calculated by differentiating D with respect to n.

Substituting $(n-1)\,A$ for d in equation(1)

$$D = 2(n-1)\ A \cos\ (B/2)$$

$$\Delta D = 2A \cos\ (B/2)\, \Delta n \qquad \text{and} \qquad \Delta D = \frac{D n \Delta n}{(n-1)} \quad (4)$$

For white light, let n equal the index for the sodium D line and let Δn equal the index difference between 486 and 656.3nm. Then, $\frac{\Delta n}{n-1}$ becomes the Abbe number V_d.