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Laser Wavelength Selector and Output Coupler

An optical system eliminates the displacement that occurs when wavelengths are selected in a multiple wavelength laser which utilizes intracavity wavelength selection by the first-order Littrow reflection of a plane grating. In such systems, some radiation inevitably leaves the cavity through the zeroth order (specular) reflection of the grating. A simple, efficient output coupling can correct the problem by varying the direction of the output beam as different wavelengths are selected by grating rotation.

A plane mirror, or a plane-mirror extension, intersects the plane of the grating (Fig. 1). Rotation for wavelength selection takes place about the line of intersection. The included angle need not be 90°; in fact, the most useful configurations result for other angles. The ray path may form a delta, a Z, or a U.

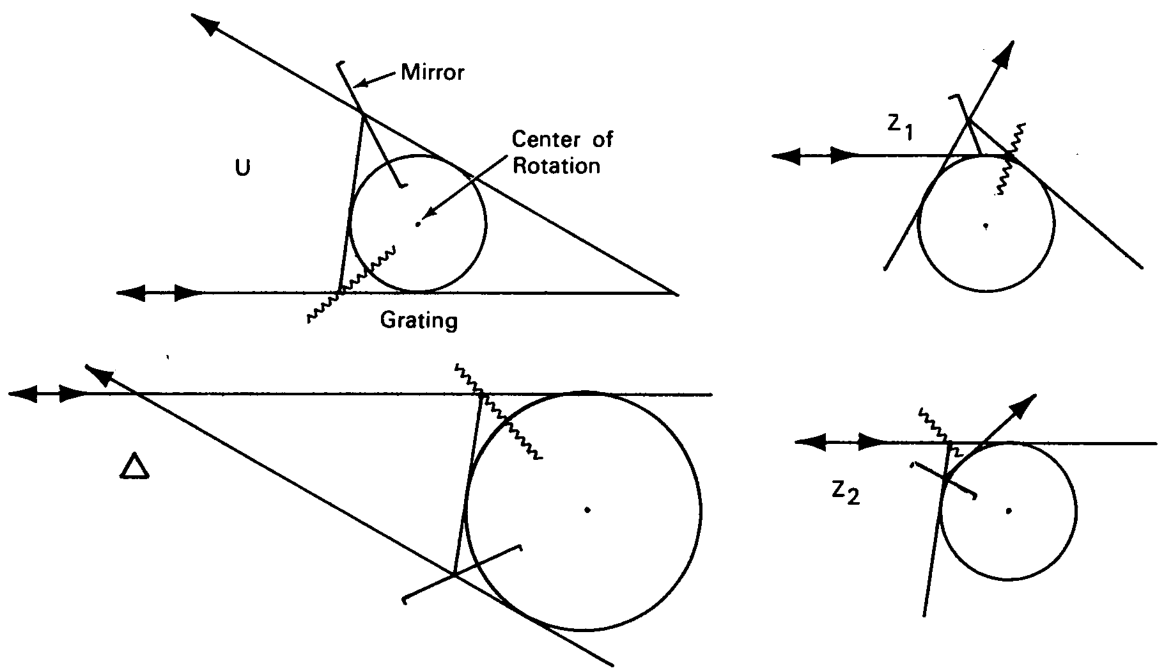

Figure 1. Four Ray Paths

In the Z configuration, one external plane mirror makes the output beam collinear with the laser axis. Two laser cavities can then be coupled at a selectable, varying wavelength. If another coupling scheme is already in use, an external plane mirror perpendicular to the output beam can return the zeroth order loss to the cavity.

(continued overleaf)

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Both input and output rays lie equidistant from the rotation axis. A given input ray and its two reflections lie tangent to the same circle, but different input rays lie tangent to different circles. Figure 2 shows one such construction. This system relies on mirror properties combined with the mirror-like grating response of the zeroth order.

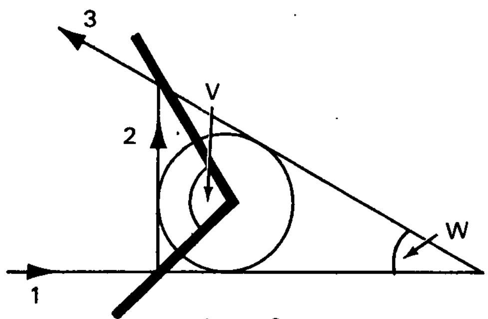

Figure 2.

The technique was used to select and couple out a range of single wavelengths in a CO_2 laser. The system was pre-aligned with a visible laser. In a test using a helium-neon alignment laser, the carefully aligned CO_2 selector was rotated through an angle exceeding 10°. The output spot moved less than 1 mm at a distance of 7 m — 2500 times less than the uncorrected motion of the grating's zeroth order.

This optical system is simple and inexpensive to construct, and is easy to align. The optics are either fixed in space or rigidly attached to the rotating grating, and any optical wavelength can be used.

Applications include higher dispersion of unwanted wavelengths, for communications; efficient output coupling of a wide range of single wavelengths in the CO_2 laser; continuous wavelength tuning of organic dye lasers, while constant output beam position is maintained; and extracting the output of a variable angle-of-incidence reflectance spectrophotometer (sample replaces grating).

References:

1. Hard, Thomas M.: IEEE J. Quantum Electron., vol. QE-5, 1969, p. 321 (summary of paper presented at IEEE Conference on Laser Engineering Applications).
2. Hard, Thomas M.: Laser Wavelength Selection and Output Coupling by a Grating. Appl. Optics, vol. 9, Aug. 1970.

Note:

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