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TECHNIQUE FOR PRECISE ALIGNMENT OF SMALL DIAMETER LASERS

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Abstract

This report describes a technique for the precise alignment of small diameter lasers. This technique is applicable in the alignment of any laser, but is especially valuable if the diameter of the lasing medium is small, and/or one of the mirrors in the laser cavity is curved.

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Technique for Precise Alignment
of Small Diameter Lasers

A technique is described that simplifies the alignment of lasers that have small diameter active areas. This technique is especially useful if one of the mirrors in the laser cavity is curved, for example a small bore laser with a hemispherical cavity. Standard reflection or autocollimation alignment techniques, which employ a single CW laser or autocollimator as the alignment tool, have been found to be impractical because of the difficulty in obtaining a usable retroreflection from the final or far mirror of the laser cavity. This difficulty arises because the small diameter of the lasing medium and divergence caused by the curvature of the mirror combine to attenuate the retroreflection to a point where it is no longer visible. This problem is eliminated by the use of an autocollimator in conjunction with a CW alignment laser as shown in Figure 1.

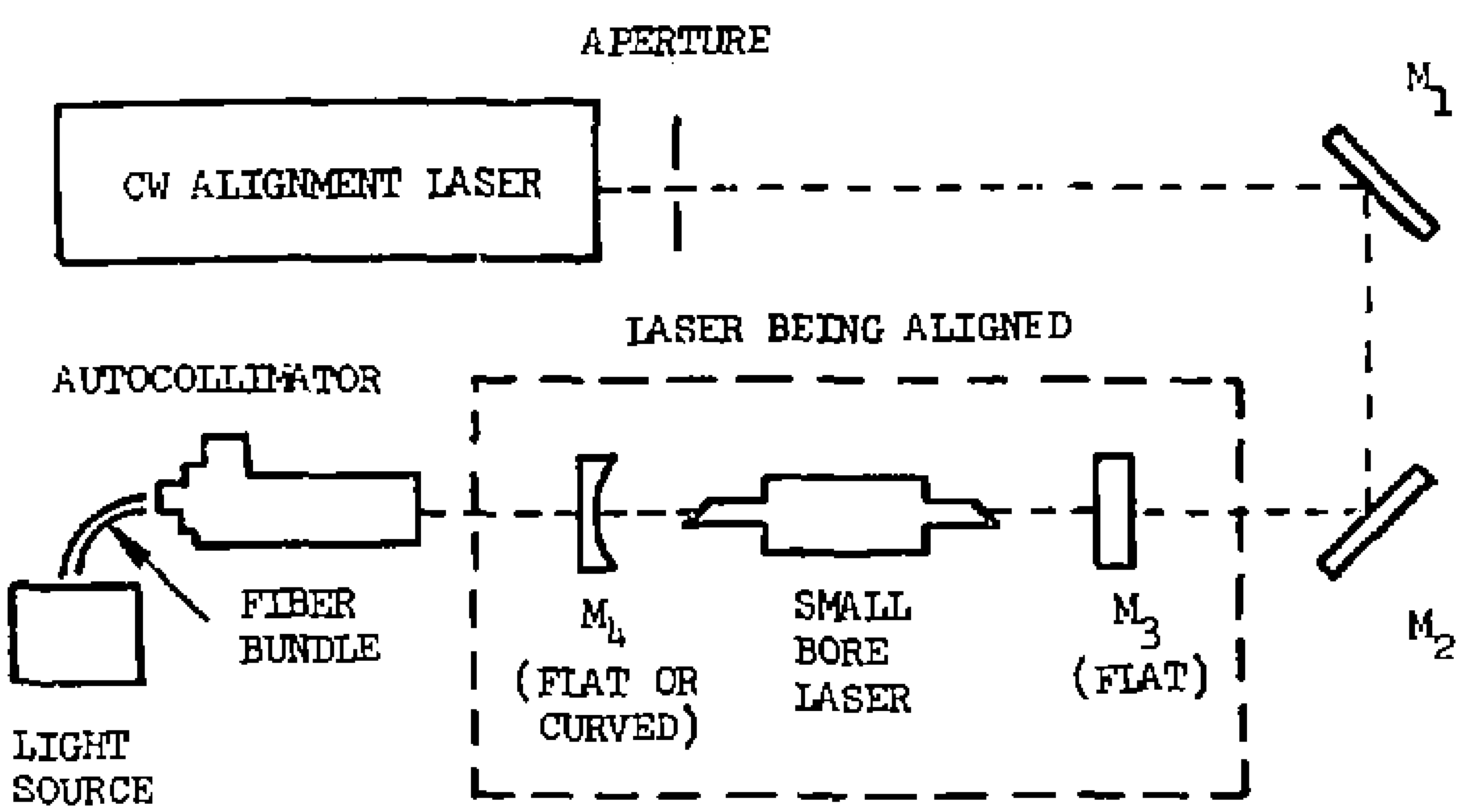

Figure 1. Alignment Set Up

The components are arranged on a suitable table in approximately the positions shown. The diameter of the aperture is selected so that the beam from the CW alignment laser transmitted through it is approximately the same diameter as that of the small bore laser being aligned. The autocollimator selected should have a pinhole for the projected light pattern and either a cross hair or a ring pattern for its reticle, for example a Davidson model 657 tooling autocollimator, with a 116 high intensity light source. If one of the mirrors of the laser being aligned is curved the autocollimator is located at that end of the cavity. It is positioned as close as possible to the curved mirror, since the reflected spot intensity decreases as the distance between the autocollimator and curved mirror is increased.

The optical axes of the CW alignment laser and the small bore laser are aligned with each other by X and Y tilt adjustment of turning mirrors M_1 and M_2. By using the autocollimator to observe the light from the CW alignment laser that is transmitted through the small bore laser, it can be determined when these axes are aligned. Due to reflection of the beam from the inner walls of the small bore laser, misalignment of these optical axes will appear somewhat as shown in Figure 2a. When the two are coaxially aligned, the pattern shown in Figure 2b will be observed. At the same time M_1 and M_2 are being adjusted, the autocollimator is adjusted to keep the transmitted beam centered on its reticle. When the pattern shown in Figure 2b is observed in the center of the reticle, the optical axes of the CW alignment laser, the small bore laser, and the autocollimator are coaxially aligned.

With these axes established it is now relatively simple to align the optical axes of the two cavity end mirrors M_3 and M_4 parallel to each other. This is accomplished by individually adjusting M_3 and M_4 so that their optical axes are parallel to any of the established axes. The optical axis of M_3 (flat mirror) is aligned parallel to the axis of the CW alignment laser. This is accomplished by X and Y

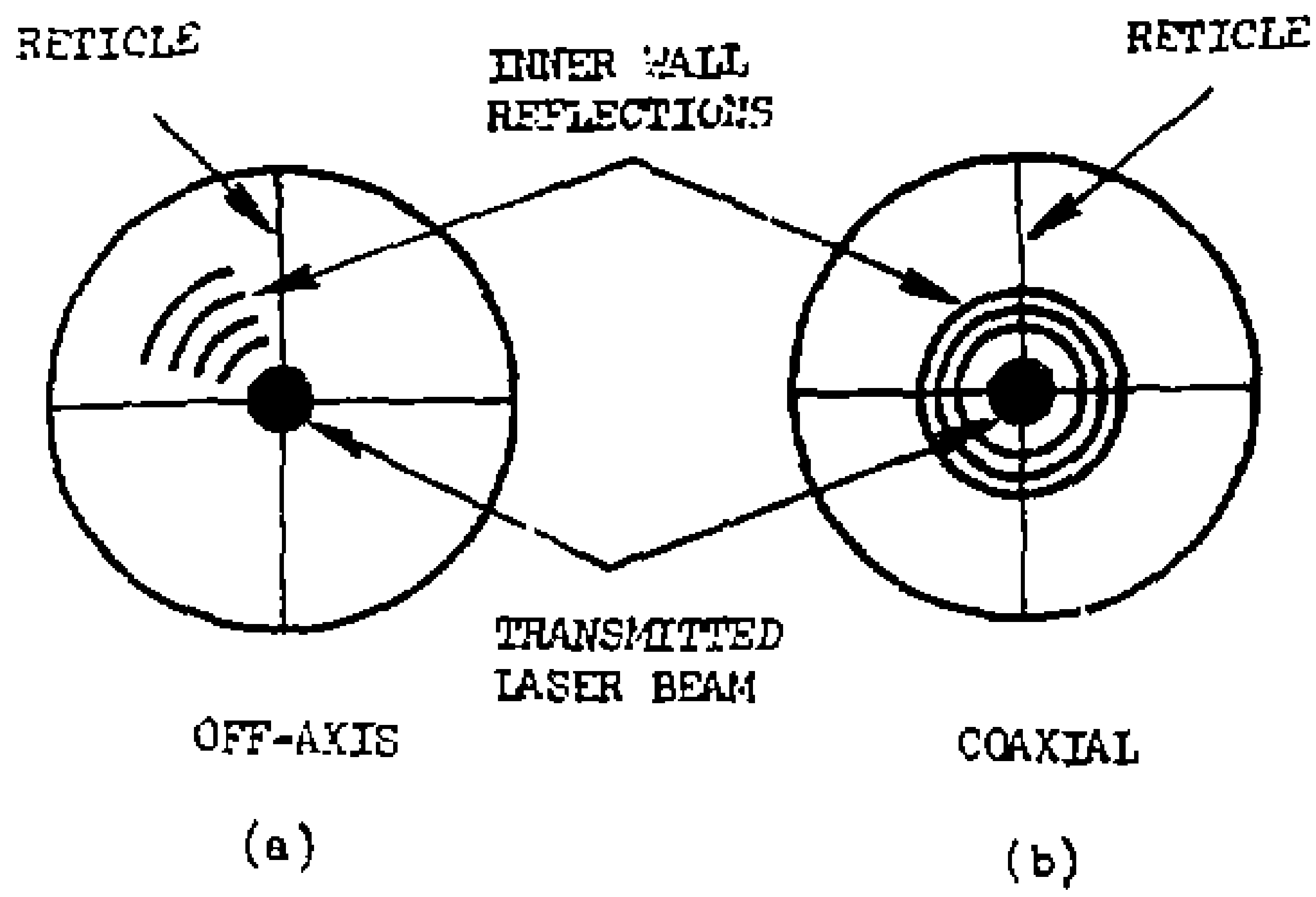

Figure 2. Pattern Observed in Autocollimator

tilt adjustment of M_2, and can be determined when the light from the CW alignment laser reflected from M_3 is centered around the aperture. Because of the divergence of the alignment laser, the diameter of the spot reflected from M_3 will be slightly larger than the aperture and will appear as shown in Figure 3.

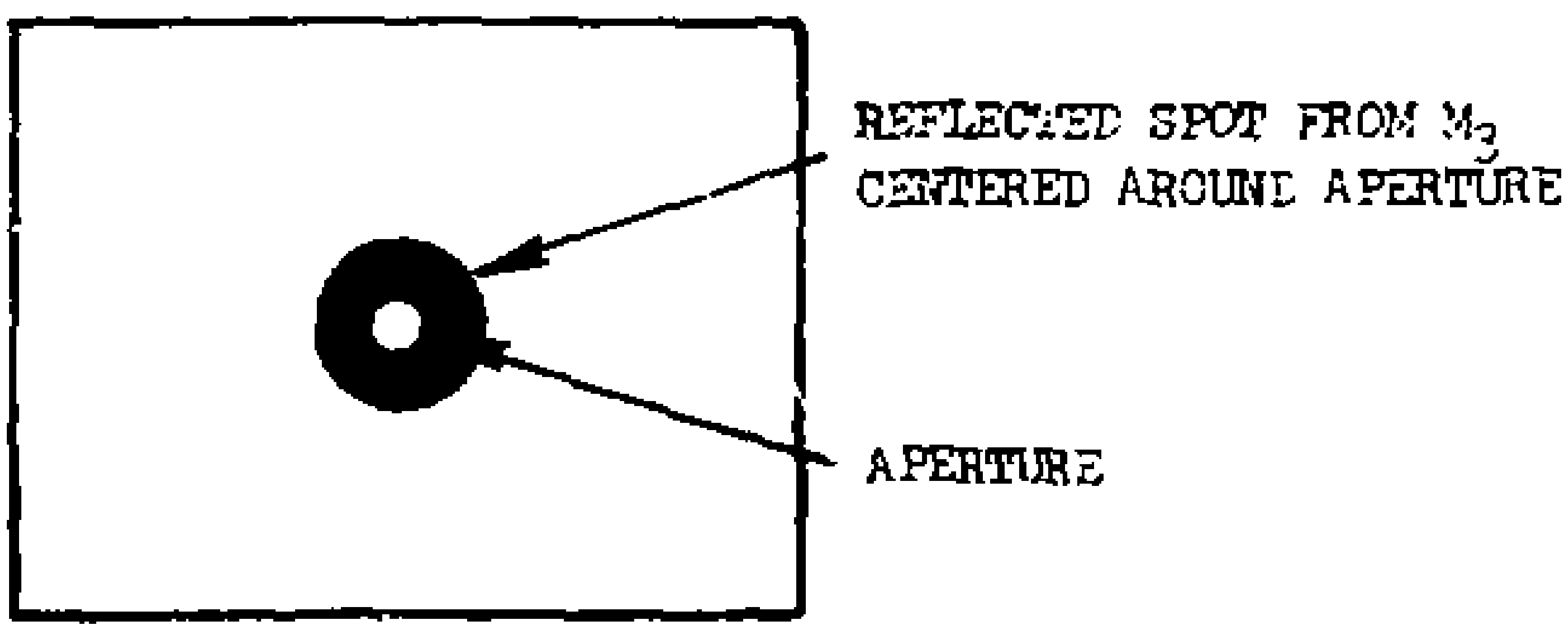

Figure 3. M_3 Alignment

The CW alignment laser is now turned off and the optical axis of M_4 (flat or curved mirror) is aligned parallel to the axis of the autocollimator. This is accomplished by X and Y tilt adjustment of M_4 and can be determined when the pinhole light pattern projected from the autocollimator and reflected from M_4 is centered in its reticle. If M_4 is a flat mirror the reflected light will appear as a small spot the same size as the pattern projected by the autocollimator as shown in Figure 4a. If M_4 is curved, the reflected spot will appear larger in diameter than the projected spot and appear as shown in Figure 4b. The diameter of the reflected spot is determined by the radius of the curved mirror, but centering is accomplished in the same manner as for a flat mirror. At this point, the optical axes of mirrors M_3 and M_4 are aligned parallel to each other, and to the optical axes previously established.

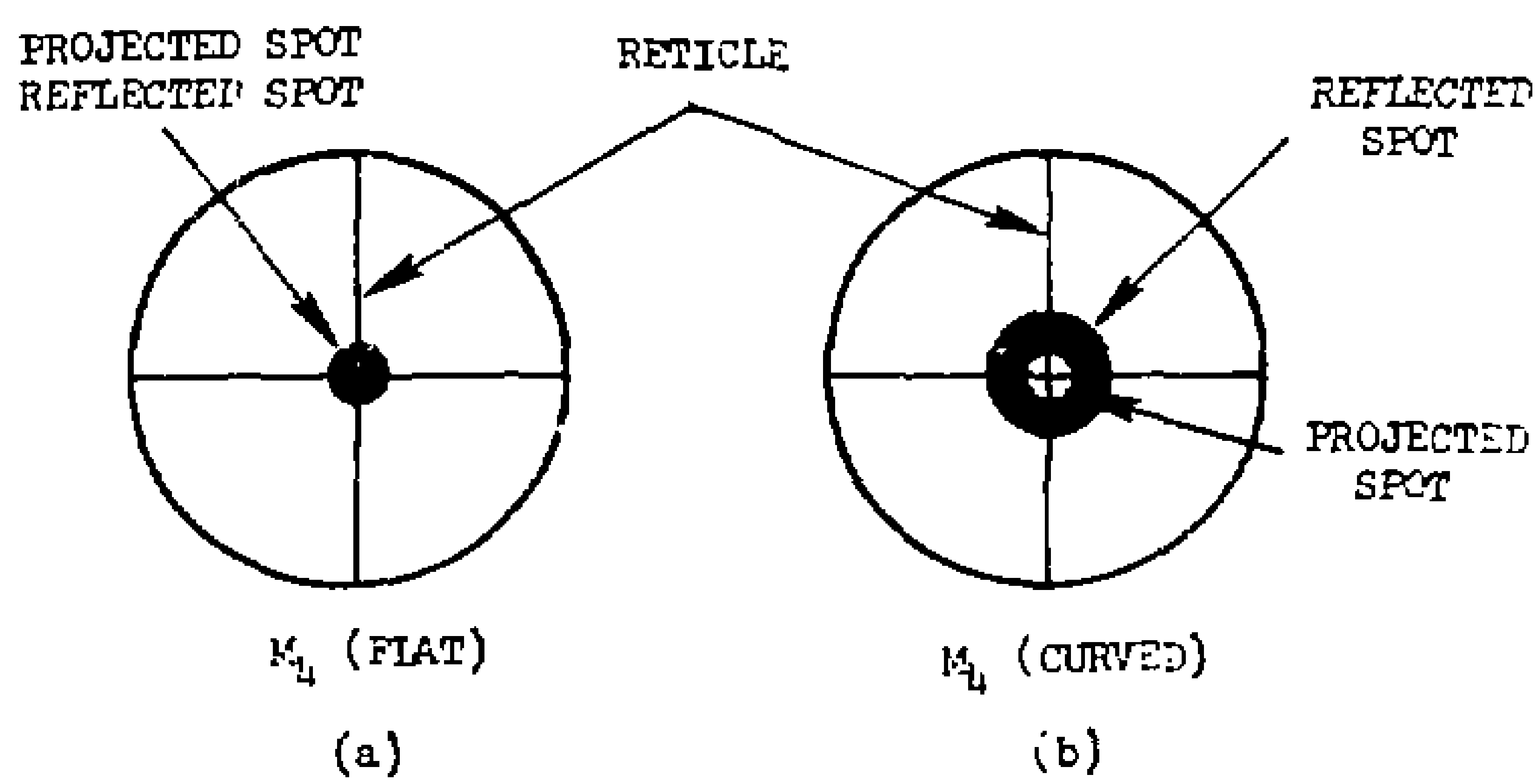

Figure 4. M_4 Alignment

To check the preciseness of alignment of mirrors M_3 and M_4, the CW alignment laser is turned on and the pattern shown in Figure 2b is observed. Any inaccuracy in the alignment of M_3 and M_4 will show up as a set of interference fringes superimposed upon this pattern. These fringes are caused by reflections of the transmitted beam between mirrors M_3 and M_4, and will appear somewhat as shown in Figure 5a. Fringes that are wider and further apart, as shown in Figure 5b indicate more accurate alignment of M_3 and M_4.

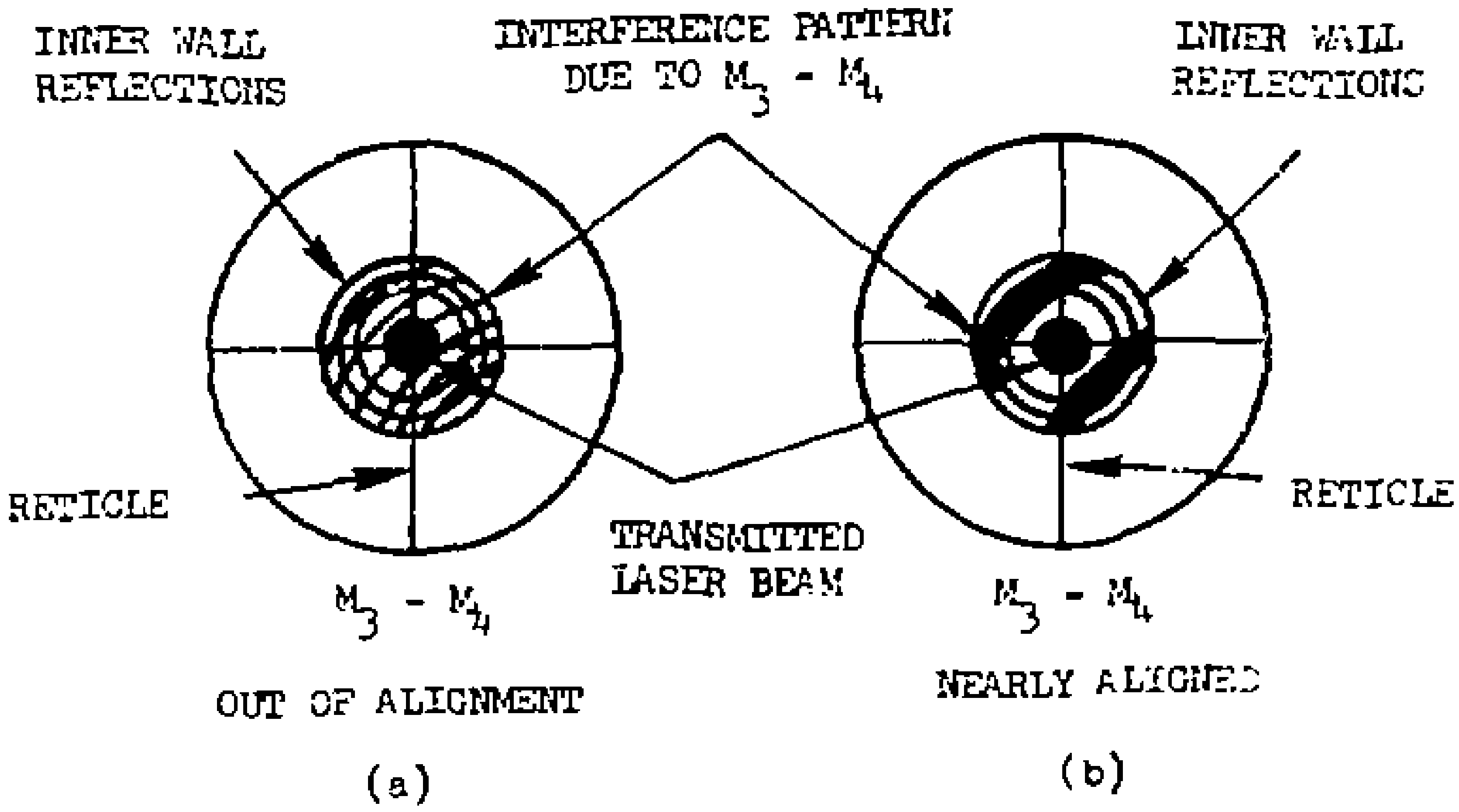

Figure 5. Interference Fringes Due to M_3-M_4 Misalignment

This alignment procedure is completed by slight adjustment of either M_3 or M_4. As M_3 and M_4 become more nearly aligned, the observed fringes become wider and further apart until a single fringe, either light or dark, fills the field of view of the autocollimator. Any further adjustment of M_3 or M_4 will show up only as a rapid change in intensity of the transmitted CW alignment laser beam from light to dark or dark to light.

The laser being aligned can now be activated or turned on. If the other components in the laser system, such as power supply, lasing material, reflectivity of mirrors M_3 and M_4, etc. have been properly selected, lasing will occur. A suitable energy detecting device, such as a photodiode, photomultiplier, silicon photodetector, calorimeter, etc., can now be placed in the system at the output end of the laser. Mirrors M_3 and M_4 are finely adjusted or "tweaked" for maximum laser output.