Experiment 6-2: The Nodal Slide

The nodal slide is an instrument used for locating and measuring the cardinal points of a lens or a system of lenses. It allows F_1, F_2, H_1, H_2, N_1, and N_2 to be located with respect to the vertices of the lens or lens system. This is important, as the vertices are the only physical landmarks of a lens accessible for alignment and measurement. The cardinal points themselves are usually points in space or in the interior of a lens that are difficult or impossible to align to. Refer back to Figure 6.5 which shows a lens and the nomenclature used for this lab.

If the indices of object and image space are identical, the nodal points and principal points of a lens coincide (H, and N, are coincident, and H_2 and N_2 are coincident). Assume that a lens or system of lenses is illuminated with a collimated beam of light When the lens or system of lenses is rotated about the secondary nodal point N_2, the image appears stationary. Even though the lens rotates, the imaae does not. At this point, N_2 and H_2 are known to be located over the axis of rotation. Measurement of the distance between the rear vertex and the image gives the back focal distance (BFD). By next positioning the rear vertex of the lens over the axis of rotation, δ_2 is measured. At this point, the positions of H_2, N_2, and F_2 are known with respect to the rear vertex The lens is turned around end-for-end and the process repeated to find the other three cardinal points.

A drawing of the nodal slide used in this lab appears in Figure 6.7. A rotation stage slides along the optical rail on a carrier that may be locked down at any position. The rotation may also be fixed with a locking screw, located on the side of the stage. Note that the center of rotation is coincident with the marker line on the carrier. On top of the rotation stage is fixed a precision slide stage, with a lens holder on the movable part of the stage. The position of the lens on the slide is read with a vernier scale, having a resolution of 1/20 mm, or 50 microns.

This arrangement of stages allows any part of the lens to be positioned over the center of rotation of the rotary base. It is this feature of the nodal slide that allows the cardinal points of a lens to be measured, in particular the nodal points themselves, N, and N_2. Note that the vernier scale is not referenced to any particular point The readings taken will be referenced to the vertices and cardinal points of the lens under test.

The detailed use of the nodal slide is now outlined. Follow the steps given to determine the cardinal points of the lenses provided.

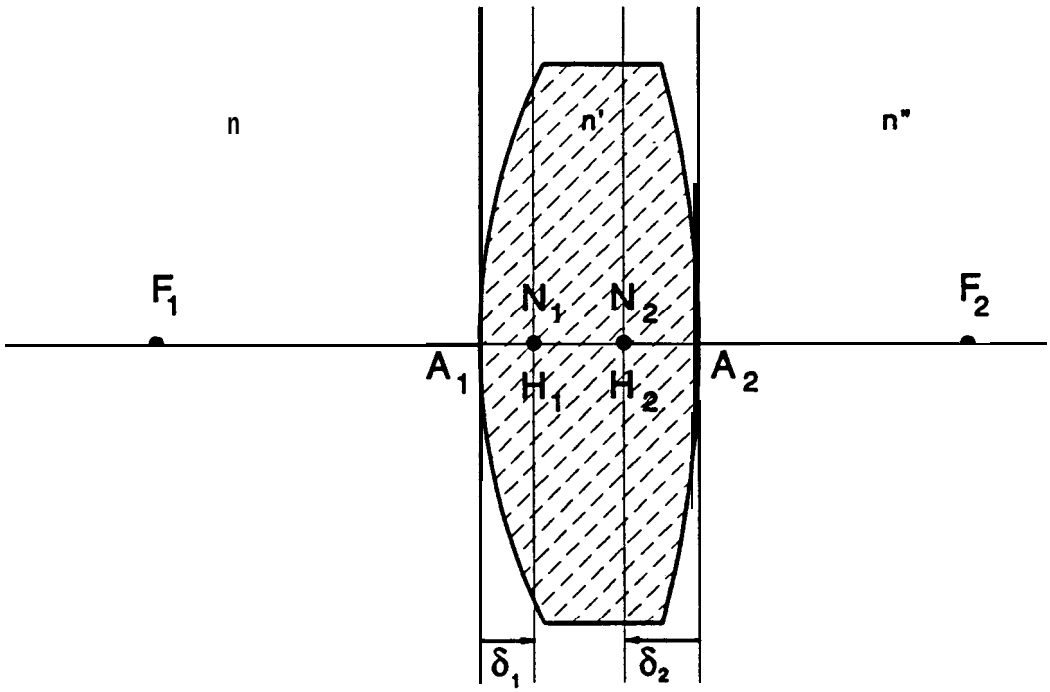

Figure 6.5. Cardinal points of a thick lens.

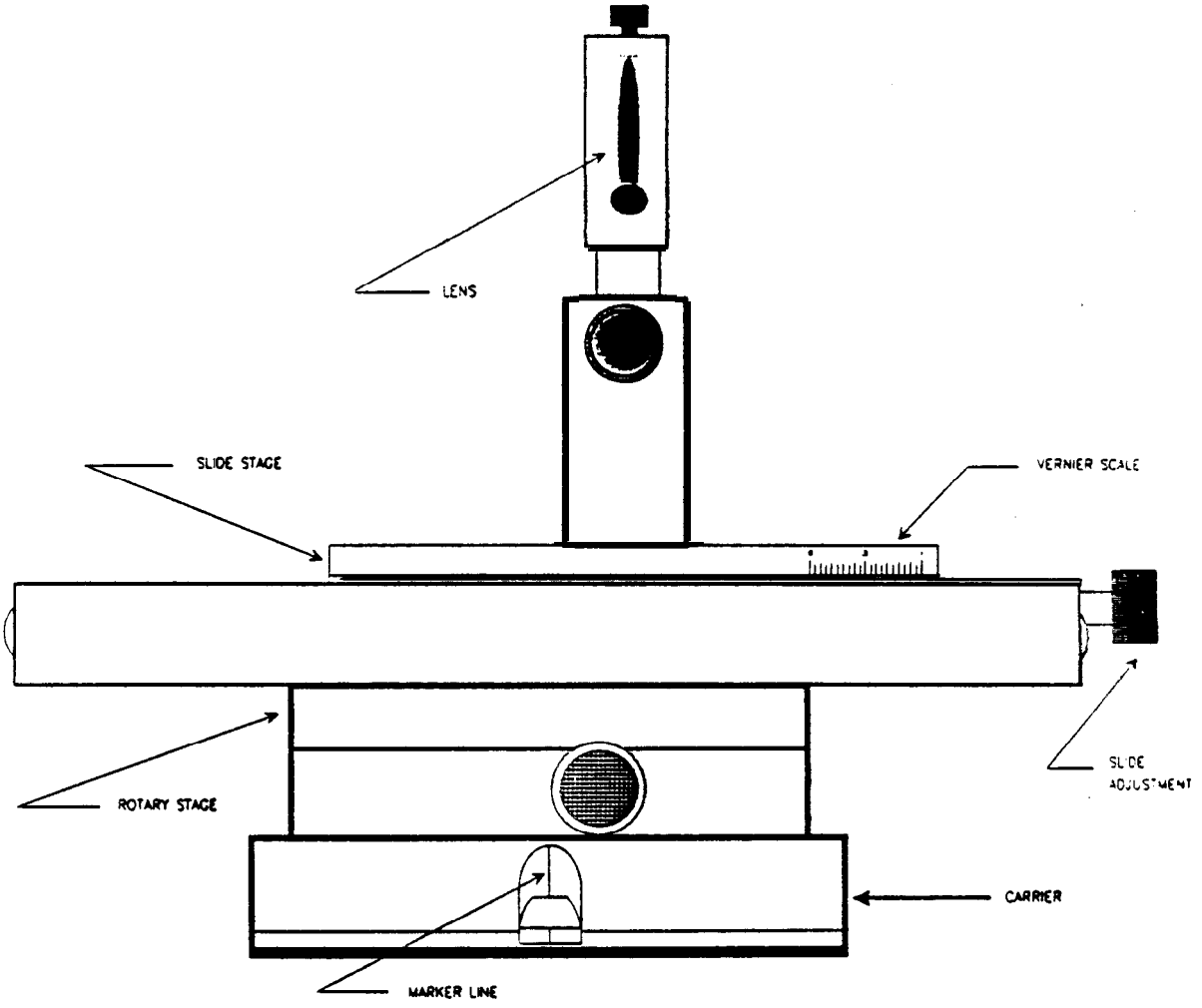

Figure 6.7. Nodal slide-mechanical layout.

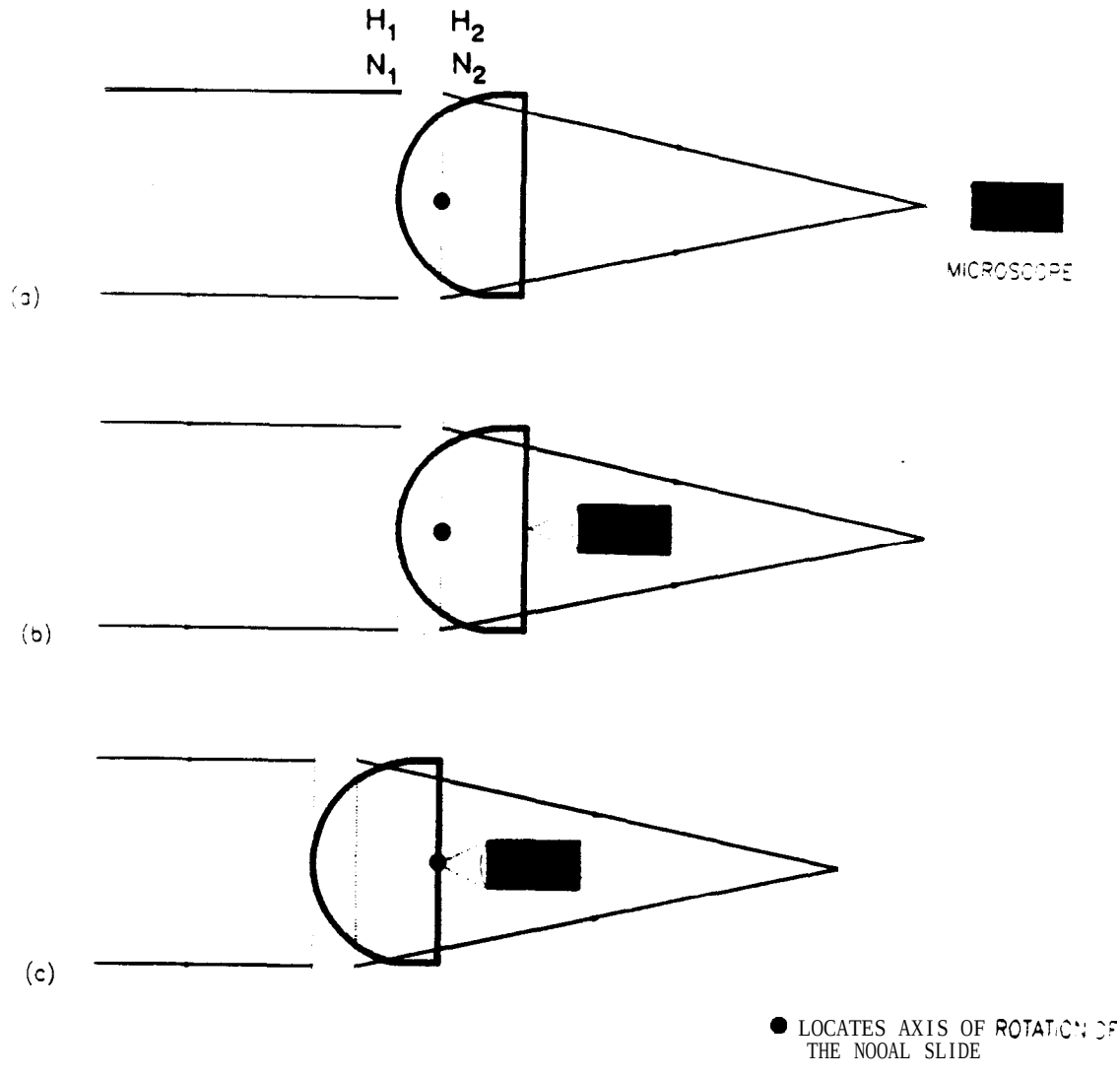

Figure 6.8. Use of the nodal slide.

(1) FORM AN IMAGE WITH THE LENS

Mount a lens in the holder on top of the nodal slide. Position the light source so the diffuse pinhole aperture is on the optical axis of the lens. Lock down the position of the source. Position the microscope at the opposite end of the rail and lock it down on one of the rail markings. Form an image of the source in the microscope by moving the entire nodal slide along the optical rail. Adjust the height of the microsopce until the image is in the center of the crosshairs. Lock down the position of the nodal slide along the rail. Record the location of the microscope.

(2) POSITION H_2 AND N_2 OVER THE AXIS OF ROTATION

While looking through the microscope at the focused image, rotate the nodal slide 1 0-20 degrees in either direction. Notice that at this point the image will also rotate. Move the slide stage in one direction, refocus the image by moving the entire nodal slide, and again rotate the nodal slide. tf the image rotation appears less, repeat thii process until the image appears stationary with rotation of the nodal slide. If the image rotation appeared greater after the first attempt, move the slide in the other direction and repeat the process until the image appears stationary. At this point, H_2 and N_2 are over the axis of rotation of the nodal slide. Figure 6.8 (a) shows the situation. Record the reading of the vernier scale on the nodal slide.

(3) MEASURE ME BACK FOCAL LENGTH (BFL)

Move the microscope forward until it is focused on the rear vertex of the lens (closest to the image). A small amount of dust on the lens surface makes this easy to do. Record the location of the microscope. Calculate the back focal length (BFL) as the difference in locations of the microscope in steps (1) and (3).

(4) POSITION THE LENS VERTEX OVER THE AXIS OF ROTATION

Rotate the nodal slide. Observe the image of the lens surface. Move the slide stage a small distance, refocus the microscope on the vertex, and rotate the nodal slide. Observe the image of the lens surface. If the image rotates, continue this process until the image appears stationary. At this point the lens vertex is over the axis of rotation of the nodal slide. Figure 6.8 (c) shows the situation. Record the reading of the vernier scale on the nodal slide. Calculate the distance δ_2 as the difference in vernier scale readinas (4)-(2):

$$\delta_2 = (4)-(2)$$

ROTATE THE NODAL SLIDE 180° TO MEASURE THE OTHER SIDE OF THE LENS.

DO NOT ROTATE JUST THE LENS OR ITS HOLDER.

(5) POSITION H, AND N_1 OVER THE AXIS OF ROTATION

Repeat the procedure in step (2) above to position H and N over the axis of rotation of the nodal slide. Record the reading of the vernier scale on the nodal slide. Calculate H_1H_2 as the absolute value of the difference in readings in steps (2) and (5):

$$H_1H_2 = | (2)-(5) |$$

Record the location of the microscope.

(6) MEASURE THE FRONT FOCAL LENGTH (FFL)

Move the microscope until it is focused on the back surface of the lens (actually the front vertex now that the lens has been rotated 180°). Record the location of the microscope. Calculate the front focal length (FFL) as the difference in locations of the microscope in steps (5) and (6).

(7) POSITION THE LENS VERTEX OVER THE AXIS OF ROTATION

Repeat the procedure in step (4) above to position the lens vertex over the axis of rotation of the nodal slide. Record the reading of the vernier scale on the nodal slide. Calculate δ_1 as the difference in readings in steps (5) and (7):

$$\delta_1 = (5)-(7)$$

(8) In addition, you also have enough data to calculate the thickness of the lens. Calculate t, the lens thickness, as the absolute difference in readings of the nodal slide vernier scale in steps (4) and (7):

$$t = | (4)-(7) |$$

CALCULATE AND REPORT THE LOCATION OF THE CARDINAL POINTS IN RELATION TO THE VERTICES OF THE LENS.