A New Means of Demonstrating Optic Figures

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The recent introduction of a new polarizing substance of paper thickness known as *polaroid* has made possible certain demonstrations and experiments with the microscope not possible with the ordinary nicol prism.

If one places a basal section of a uni-axial crystal upon the stage of a microscope and places immediately above it a sheet of polaroid, he can project an optic figure, without the use of the microscope, onto a paper sheet or a ground glass held above the figure. By moving the ground glass, or even piece of paper, up and down above the thin section, one can easily demonstrate that the rays of light coming through the polarizer with the condensing lens in place are moving in a radiating direction so as to form a solid cone of light with rings of color, one within the other, and spaces of darkness which make the cross. If one places a cylinder of translucent material over the section one can obtain horizontal rings of color, again demonstrating the fact that the rays of light in the optic figure have a conical shape. An even more graphic illustration of this can be arranged by the use of a block of uranium glass which becomes luminous wherever a beam of light passes through it. These luminous beams unfortunately are very faint and good demonstrations are not possible except in a very dark room. With the use of uranium glass it is even possible to see that the light is divided into four separate beams by the black crosses. With bi-axial figures demonstration becomes even more striking. When a section cut normal to the acute bisectrix of the bi-axial mineral is placed on the stage with a plate of polaroid above it, transmitted light will throw a brilliant optic figure on a piece of ground glass held above the stage. A paper cylinder shows the emergence of the optic axes along the side of the cylinder, and a block of uranium glass shows the passage of light as a luminous cone without any suggestion of bands of darkness such as those which make the crosses in the uni-axial figures.

It occurred to the writer that with blocks of glass of known thickness it would be possible to make a calibration upon the ground glass surface in such a way as to enable one to read the optical angle of bi-axial minerals in a manner very similar to the method devised by Mallard. A little experimentation, however, shows that these axes can easily be projected onto a curved surface, and the writer devised a goniometer by which the optic angles in air could be read direct.

This device is made of two semicircles, preferably of celluloid, 5 cm. in radius which are attached to a base 10 cm. long and 2 cm. wide and with a hole 1 cm. in diameter in the middle. The semicircles are joined by a semi-translucent strip 2 cm. in width, which is a protractor numbered from zero at the zenith to 90° at each horizon. This is placed over a bi-axial section which gives a good optic figure, preferably in a position such that the acute bisectrix passes through the zenith. When the section is turned to the 45° position with the isogyres passing through the eyes, then the angle E can be read in both directions from zero in case the acute bisectrix is really vertical. Of course these two angles will be the same. In case the acute bisectrix is not vertical but not too eccentric, the sum of the two angles read from zero may be taken as being closely equivalent to 2E.

The angle 2E as measured on the goniometer scale may not be equal exactly to 2E. It is assumed that the rays of light which pass through the center of the optic eyes are exactly parallel to the radii of the goniometer, but in certain cases they may not be quite parallel because the point of convergence of the condensing lens may be either slightly above or slightly below the base line of the semicircular goniometer. That error is minimized in the author's device by having it made with a radius of 5 cm., which is so large in proportion to the probable lack of coincidence between the point of condensation of the lens and the center of the protractor's circle that any difference is practically negligible. In any case it seems impossible that this difference could amount to more than 1/10 cm. in a vertical direction, which, with a radius of 5 cm. and small angles, would be entirely insignificant and only in the case of readings where 2E is more than 40° could the error amount to more than 1°.

Another model of this same device is made with a radius of 2½ cm. This has the advantage of use on the stage of a microscope without withdrawing the barrel, but it has the disadvantage that the error discussed above becomes relatively much more serious, especially for minerals with high values for 2E.

The use of the goniometer here described is made possible only by the invention of polaroid, because with the ordinary nicol prism it would be impossible to bring the base of the goniometer any where near the point of convergence of the condensing lens. Aside from the use of this simple goniometer, polaroid seems to the writer to be of great help in demonstrating the nature of optic figures as seen under a polarizing microscope.