

AN INEXPENSIVE PETROGRAPHIC MICROSCOPE¹

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ABSTRACT

A number of manufacturers have recently announced development of students' microscopes selling for about \$100.00, which can be adapted for elementary petrographic work by the addition of inexpensive polaroid elements, and a simple rotating stage. The design of a stage and installation of polaroids are described.

POLARIZING ELEMENTS

Conventional petrographic microscopes differ from medical microscopes in their provision for polarizing the incident light by a more or less fixed and permanent polarizer in the substage, and for analyzing the transmitted light by means of a second polarizing element called the analyzer, which is mounted in a slide so as to be easily moved into or out of the optical path. An accessory slot at 45° to the vibration planes of the polarizer and analyzer is usually located in the body tube below the analyzer. The arrangement of fixed polarizer and movable analyzer is not the only possible scheme that permits examination of mineral grains both in plane polarized light and with crossed nicols. An alternative arrangement is a fixed analyzer in the body tube, and a removable polarizer in the substage. This arrangement is very easily added to certain student microscopes made by the Bausch and Lomb Optical Company and by the American Optical (Spencer Lens) Company, since both manufacturers provide a rotatable disc carrying several holes to control the aperture in the substage. If a diffusing screen of ground glass is present close to the plane of the stage to give illumination of large numerical aperture, it must be relocated below the polarizer.

In the Spencer No. 78 microscope, a heat-reflecting metal stop is located immediately above the built-in lamp in the substage. The instrument is purchased without the standard blue ground glass disc in the stage, and a ground glass must be cemented to the top of the heat-reflecting stop immediately above the lamp. Duco cement has proved satisfactory in the first few months' use of one of these instruments. Polaroid film is cemented over the largest and second-smallest holes in the aperture-control disc, in such an orientation that the vibration-direction is east-west, to correspond to that of the removable element (analyzer) of the conventional petrographic microscope. This can be done accurately with the aid of a conventional petrographic microscope provided with a crosshair eyepiece, as follows: the aperture disc is removed and a line is

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scratched on it to indicate the direction between the center of the disc and the center of each hole that is to be covered with polaroid. The disc is then placed on the stage of the regular polarizing microscope, and using the lowest magnification, this line is made exactly parallel to the north-south crosshair. A square of polaroid film is then laid over the hole and cemented in place in such an orientation that it appears completely dark when viewed in plane-polarized light. Minor adjustments to its orientation can be made just before the cement hardens.

The analyzer may be installed permanently in the tube, or in the ocular. It is more easily placed and adjusted in the ocular, but then interference figures can only be seen by using a hand lens ($6\times$ to $10\times$) to examine the image projected in the Ramsden disc about 5 mm. above the eyepiece, according to Klein's method.²

To permit the use of Lasaulx' method³ which requires simply the removal of the ocular, the analyzer must be installed in the tube of the microscope. In the Spencer No. 78 microscope, the lower end of the short tube that receives the eye-piece is accessible for this purpose. This tube may be unscrewed from the top of the body tube. A round polaroid disc is inserted against a shoulder in the bottom of the tube, and held in place by a narrow strip of string brass, bent to form a ring. Adjustment of this polaroid to crossed position must be done by turning it in its mount with the point of a sharp needle after reassembling the tube to the microscope. Cement can be applied to make this adjustment permanent, if desired.

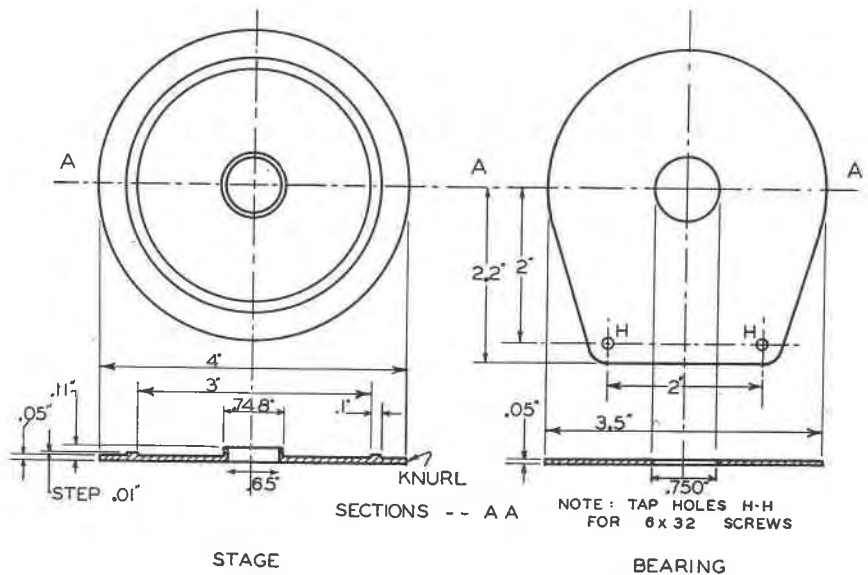
ROTATING STAGE

Figure 1 is a working drawing of the rotating stage made in a University machine shop. It is turned from brass stock $\frac{1}{8}$ inch thick. The edge may be knurled as indicated, or not. The bearing for this stage is made from thinner stock and fitted to the sleeve-bearing carefully so as to have the minimum lateral play consistent with easy turning. It is drilled and tapped for screws *considerably smaller* than the holes provided by the manufacturer for stage clips; the axis of rotation is centered for the highest power objective just before the screws are finally tightened. The hole in the stage of the microscope was originally to be the bearing, but it is too far from the optical axis of the microscope to permit work with the medium-high power (8-mm., $20\times$) objective. Trial showed that the ground glass is too far from the surface of the rotating stage to cover the angular aperture of the commoner high-power (4-mm., $45\times$)⁴ objec-

² Johannsen, *Manual of Petrographic Methods*, 1918, p. 450.

³ *Ibid.*, p. 449.

⁴ The 4-mm., $44\times$ objective with N.A. = 0.66 is satisfactory, however, and can be recommended although its higher magnification requires appreciably more care in the fabrication of the bearing for the rotating stage.



tive, and there seems to be no convenient way to bring it nearer the objective while still keeping it below the removable polarizer.

ACCESSORY SLOT

The manufacturer offered to provide an accessory slot above the objective-changer at nominal cost, and if all accessory plates are to be used, this offer would be accepted. It may be pointed out that such a slot is not an absolute necessity. Quarter-wave and first-order-red plates may be made by splitting a piece of muscovite, or indeed by mounting a piece (or pieces) of cellophane between thin glass plates. These accessories may be used either in the slot or below the medium-power objective, or one of them may be mounted permanently with a polaroid over one of the holes in the aperture-control disc. The cost of a standard quartz wedge and other accessories is comparable to that of the whole microscope, and can be avoided by the above expedient.

DISCUSSION

Trial showed that strain-free objectives are necessary for satisfactory production of interference figures. Choosing thin grains with high interference colors to obtain N_x and N_z , and thick grains with low interference colors for N_θ and N_y , the use of interference figures is not absolutely necessary for index determinations by the powder immersion method.

Accessory slot and plates may then be dispensed with. Specifying 8-mm., 20 \times , 0.50 N.A. and 25-mm., 5.1 \times , 0.17 N.A. strainfree objectives, in a double revolving nosepiece, and 10 \times ocular as equipment, making the rotating stage and bearing according to the figure, and installing polaroid film polarizer and analyzer ourselves, the cost of six of these microscopes has been kept below \$120.00 each.

An alternative to having one polarizing element completely removable is to have it rotatable from crossed to parallel position. After turning a mineral grain to extinction with the movable element in crossed position, it would be rotated to the parallel position, enabling refractive index observations to be made on one transmitted ray at a time. An annoying feature of this arrangement is the interference colors developed in mineral grains that are not at the "extinction" position.

This microscope is advertised by the manufacturer as of particularly rugged construction, to withstand the use and abuse of students at almost any level. Ruggedness naturally contributes to its usefulness for instruction at the lowest level of elementary courses in mineralogy and chemistry. Modern trends in mineralogy demand such instruction at the earliest possible stage, and student interest in the use of microscopic methods is immediate. Superior ruggedness and low price also open up possibilities of entirely new uses. These characteristics permit the direct introduction of microscopic work with geologic field studies. Most field geologists would hesitate to take a regular petrographic microscope with them for a summer's field work, even though they would find many uses for it in evenings and on rainy days, if it were available. They would not hesitate to take a rugged microscope that costs little more than a good camera or other indispensable field equipment. This microscope might encourage application of optical methods by advanced amateurs, perhaps through cooperation of museums and mineral clubs. Other special uses for this polarizing microscope do not need to be listed for readers of this Journal. There is plainly a wide application for such equipment if it proves as practical in years of use as the first model has already proved in months.