THE DETENT SPINDLE STAGE

General

Wilcox (1959) describes an ingeniously simple device, aptly called a spindle stage, that permits a single anisotropic crystal to be accurately oriented for measurement of its principal refractive indices α, β, γ, ε, and ω. The method involved largely eliminates errors in determining these indices caused by inexact orientation of the cyrstal. Moreover, all principal indices can be measured from the same grain. Sample size is hence reduced to a minimum. Saylor (1966) also describes spindle stage procedures such that, "trustworthy and accurate measurements can be executed by non-scientific personnel."

Like the Wilcox spindle stage, the detent stage can be used to orient crystals by means of interference figures so as to measure their principal refractive indices. Additional advantages of the detent stage, already enumerated in detail by Bloss and Light (1973), include (1) more rapid and easy change of oils, (2) quicker and more convenient setting of the spindle at readings 0°, 10°, 20°, . . . 180° on its protractor scale, and (3) more compact storage of grains after use because they are mounted on needles rather than on an entire spindle. Advantage (2) is particularly useful for obtaining data for compiling extinction curves and for use with the computer program of Bloss and Riess (1973). This latter program permits accurate values for 2 V to be obtained merely by measuring extinction positions as the grain is rotated on the spindle axis.

Mounting The Crystal

The stainless steel tubing that constitutes the spindle of the detent spindle stage has an inner diameter of 0.022 to 0.023 inches. Thus, a number 8 (Dritz brand No. 252) sewing needle, inserted point first into the tubing will enter up to its eye. (Other brands of number 8 sewing needles may be too large to enter the tubing sufficiently.) A supply of suitable sewing needles, with their eyes clipped off, and their points slightly flattened, should be kept at hand. To the flattened needle point, apply a small amount of a cement such as the glue-molasses mixture described by Wilcox (1959, p. 1276) and mount the grain to be studied, following the procedure of Wilcox, so that it lies on the central axis of the needle. Allow the cement to set for about a day. The setting process can be hastened by reducing the proportion of molasses in the glue. A jet of warm dry air from a Presto Minidrier will reduce the setting time to two hours or less. Avoid coating the grain entirely with cement because this will prevent measurement of its refractive indices.

The needle with the grain securely mounted on it can now be inserted into the spindle. At the junction where the needle telescopes into the spindle tube, a very small amount of the molasses-glue cement may be applied, if desired. This will prevent any immersion oil, if it creeps up the needle, from entering the tube. Also, if the needles fit too loosely in the tube, this cement can be allowed to dry to eliminate any possibility for the needle turning independently within the tubing.

Instead of mounting the grains on needles, one can use suitable lengths of glass capillary tubes as strongly recommended by Saylor (1966). Such capillary tubing may be heated and drawn out until its outer diameter will fit into the spindle tube, its inner diameter should be a bit smaller than the grain. Saylor discusses procedures for squaring off the end onto which the grain is to be cemented.

The Oil Cell

Two pieces of a jumbo paper clip may be expoxied onto a Ward's micro slide (27 x 46 x ca 1.2 mm) as in Figure 1A. Alternatively, a U-shaped piece of a jumbo clip can simply be laid upon the slide. A small piece of coverglass laid, but not cemented, across the clip segments (Fig. 1B) completes the oil cell. The dock-like area cut from the base of the spindle stage permits the old oil cell to be slid away and a cell with the next oil to be slid into place. If a principal index of the crystal matches this second oil, contamination by the previous oil can be reduced by sliding this second cell away, then inserting a third cell with this same oil. In effect, the second cell has been used to rinse away the first oil.

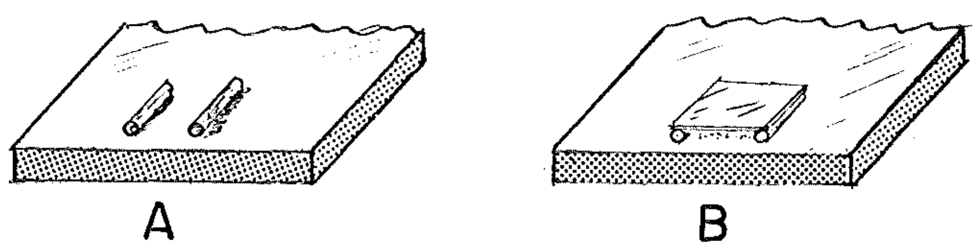

Figure 1. Portion of glass slide that inserts into detent stage. (a) Paperclip wires shown glued onto slide. (b) Cover glass bridged across paperclip wires to complete the oil cell.

The Protractor Scale

The detent-defined angle readings on the inside surface of the protractor scale will generally be true. The readings on the opposite surface, which are accompanied by the words "DETENT SPINDLE STAGE," are merely for convenience of knowing what the detent position is even when the detent side of the protractor scale faces away from the observer.

A very useful feature of this spindle stage is the presence of detents which cause the spindle to click into place at the spindle settings 10^o, 20^o, 30^o, . . . 170^o with fainter clicks at 5^o, 15^o, . . . 175^o. To increase the sharpness of the click, use small pliers to press together slightly the "shepherd's crook end" of the spindle arm (Fig. 2). To reduce click sharpness

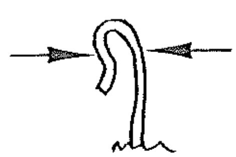

Figure 2. The arrows indicate how slight pressure should be applied to shepherd's crook end of spindle to increase sharpness of click into detent positions. If click is too sharp, slightly pry the end open.

so that the setting 10^o, 20^o, 30^o . . . 170^o are easily distinguishable from settings 5^o, 15^o, . . . 175^o, pry the shepherd's crook-end ever so slightly apart. On the early production models, flowage of metal during the bending process may have produced small displacements of the 0^o and/or 180^o detent stops from true. To remedy this, a segment of a needle has been inserted into the shepherd's crook end of the spindle arm so that the base plate of the spindle stage acts as a positive stop for the 0° and 180° positions, from which they may sometimes differ by 1° or more. It will be particularly important to use these positive stops when determining the reference azimuth as discussed by Bloss and Riess (1973).

Attaching The Spindle Stage To The Microscope Stage

The detent stage may be inserted into a mechanical stage already attached to the microscope stage. The translational motion of this mechanical stage can then be utilized to align the grain under the cross-hair intersection. Alternatively, the base of the spindle stage may be cemented to the microscope stage with the molasses-glue cement, which is water soluble. In such event, care should be exercised to insure, using a well centered objective, that a needle-mounted grain (after insertion of the needle into the spindle tube) will be centered under the cross-hairs.

Under either method of fixing the spindle stage to the microscope stage, care should be taken when rotating the spindle arm from one detent position to another. It is good practice to lightly press a finger on the spindle stage's base whenever the spindle arm is being moved to another setting. Otherwise, the spindle stage may flip out of the mechanical stage. One such occurrence is generally sufficient to educate the operator to the value of the above precaution. A bit of scotch tape, affixed partly on the glass side and partly on the arm of the mechanical stage that presses against the glass slide it is holding, is good insurance against such catastrophes.

Use Of The Detent Spindle Stage

The paper by Wilcox (1959) discusses the use of a spindle stage for orienting anisotropic crystals by means of their interference figures. Bloss and Light (1973) discuss some of the advantages of the detent spindle stage. Bloss and Riess (1973) discuss a computer program which calculates 2 *V* and locates the principal vibration axes *X*, *Y* and *Z* by analysis of orthoscopic extinction data. This computer method permits 2 *V* to be calculated and refractive indices to be measured from crystals too small to yield adequate interference figures.

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Any suggestions for the improvement of the detent spindle stage will be welcomed by its supplier: Technical Enterprises, Inc., P. O. Box 2604, Cambria Station, Christiansburg, Virginia 24073.