NOTES AND NEWS

DOUBLE VARIATION APPARATUS

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Inasmuch as the Emmons[1] Double Variation Apparatus is now coming on the market,[2] a brief description of the Lindley microscope-refractometer[3] is perhaps in order, as during these stringent times money for both instruments may not be forthcoming. The German outfit, entirely different from the Smith-von Schlichten[4] in method, consists of three parts to be attached to the ordinary polarizing microscope. These are a refractometer stage, a special objective, and (for adjusting the apparatus) an autocollimating Ramsden ocular.

The stage resembles the Fedorow universal stage in many respects, but of the five movements possible with the standard Fedorow stage, only four are present on the microscope-refractometer, A_1 of Berek[5] being absent. The stage platform of the latter instrument has an east-west horizontal-axis rotating movement, corresponding to A_4, and there is a large arc with vernier on the left for reading the angle of inclination to the nearest minute. Inset in the stage platform is a circle with a disc of ordinary glass in the center; this circle may be rotated on an axis perpendicular to the stage platform, corresponding to A_3. On the edge of this circle and nearly parallel it (the angle of divergence is about 10°) is mounted a pin which may be rotated on its axis and which terminates near the center of the top of the glass disc. This is analogous to A_2, but has the equivalent of a 360° rotation. A mineral grain is glued to the end of this pin.

In case the grain is so mounted that the pin makes a moderately large angle with all three optic symmetry axes, it is probable that each of these in succession can be brought parallel the axis of the microscope tube; otherwise at least two optic

[1] Emmons, R. C., *Amer. Mineral.*, **XIII**, pp. 504–15, 1928; **XIV**, pp. 414–26 and 441–61, 1929.

[2] Bausch and Lomb Optical Co., Rochester, N. Y.

[3] Scheumann, K. H., Zwei Hilfsapparaturen für das petrographische Mikroskop; I. Mikroskoprefraktometer nach Lindley: *Min. u. petrog. Mitt.* (*Z. für Krist.*, usw., Abt. B), Bd. **41,** Heft 1, pp. 58–63, 1931. Manufactured by R. Fuess, Berlin-Steglitz (Hugo Meyer & Co., 245 W. 55th St., New York).

[4] *Amer. Mineral.*, **VI,** p. 38, 1921.

[5] Berek, M., Mikroskopische Mineralbestimmung mit Hilfe der Universaldrehtischmethoden, p. 10, 1924. This is *axis 5* of Winchell, A. N., *Elements of Optical Mineralogy*, Pt. I, p. 224, **1928,** since the latter has exactly reversed Berek's order of numbering. Berek's system of numbers should be adhered to, since it has priority, and since letters are not suitable for international use (cf. Reinhard, *op. cit.* in footnote 7, p. 31), and in some cases (e.g., Winchell) are cumbersome, as are Emmons' (*op. cit.*, p. 445) names. The new axis on the latter's modified universal stage should be designated A'_2 to harmonize with Berek.

symmetry axes should be accessible (i.e., in the case where the pin roughly parallels an optic symmetry axis). With the microscope stage and microscope-refractometer platform horizontal, rotating the pin until an optic symmetry plane is vertical and then turning the inset-circle until this plane is north-south brings it into a position such that on inclining the stage platform an optic symmetry axis in this optic symmetry plane is brought parallel to the axis of the microscope tube. Of course both optic symmetry axes in this optic symmetry plane cannot be brought into this position unless before inclining the stage platform each is considerably off vertical. The method of orienting the grain is analogous to that used with the Fedorow stage, but instead of the A_1–A_2–A_4 combination of the latter, one uses what is equivalent to an A_2–A_3–A_4 combination.

By means of an upper and a lower prism of a system of four prisms, the upper two of which are rotatable and the lower two of which may be shoved laterally (east-west), the path of the light may be changed from the ordinary one to one of grazing incidence with the glass disc.

The objective, which corresponds to a No. 3 in power, ends in an immersion lens shaped like the frustum of a cone. Moreover it carries part of its lens system on a slider, so that by removing this the microscope becomes a telescope. A similarly-constructed objective which however lacks the immersion lens may be used for special purposes.

A dark room is not essential, though for accurate work dim conditions are necessary. The mineral grain mounted on its pin is embedded in a drop of liquid which is held by adhesion to the immersion lens and the glass disc. The index of refraction of the liquid may be varied readily by adding another miscible liquid, by warming,[6] or by changing the light from the monochromator. When the indices of the liquid and of the mineral (in some definite orientation) just match, as shown by the Becke method, one of the two lower prisms of the stage is shoved in, the slider removed from the objective, and the stage tilted until the border between the bright and dark fields cuts the cross-hair intersection. From the angle reading the value of n for the liquid is determined from a simple graph ($n=1/\sin \alpha$) which covers the range from 1.32 to 2.10. By changing the positions of the side prisms, and employing a disc of special glass, it is claimed that values as high as $n=5.0$ may be read. The drop of liquid, bounded above by the plane surface of the immersion lens and below by the plane surface of the glass disc, may be considered to be a prism, the angles between the faces of which may be varied at will, but of course the light-path is always perpendicular to the surface of the immersion lens. Curves drawn indicate that with indices up to 2.6 the readings (carried to the nearest minute) are accurate to from about 3 units in the fourth decimal place to one in the third, depending on the value of n (in general lesser accuracy with larger n).

Shortly before the writer left Berlin last February Dr. Lindley kindly obtained a sample of the apparatus which was in process of manufacture and although this hasty set-up was not in all respects satisfactory, the possibilities of the instrument were demonstrated. By removing the ocular good interference figures were observable. These might be of aid in quickly orienting the specimen.

[6] Dr. Lindley is perfecting a simple electric heating element which should be available shortly.

Comparing the two sets of apparatus, that by Emmons and that by Lindley, it is clear that each in light of the other has certain advantages and disadvantages. Only the Emmons apparatus in combination with the modified Fedorow universal stage is here considered, as with the ordinary stage this method is greatly limited. The more important advantages of the Emmons method consist in the provision to *rapidly cool* the specimen, even somewhat below the normal laboratory temperature; the very exact temperature control; and moreover, because of the numerous possible movements of the modified universal stage, the ability not only to turn a grain so that its principal optical directions lie parallel to the vibration directions of the nicols, but even to rotate the oriented grain in these two planes. From the point of view of the teacher who wishes to train his students with a certain theory and technique, the writer agrees with Reinhard[7] that crystal study on the universal stage is of great value in leading to a clear conception of crystal optics.

On the other hand with the Lindley apparatus much higher indices can be measured; also it is expected that much higher temperatures can be obtained, which among other obvious advantages permit the use of high-index melts which at lower temperatures solidify to non-isotropic media. Moreover, one is not limited to certain definite embedding fluids, but may use almost any miscible mixture prepared on the stage to suit the particular grain being studied; even if the fluids used have considerably different boiling points, this is of little importance since almost the very instant the grain is matched the index of the liquid is measured.

Until one has had an opportunity to work at leisure with both instruments, it will be impossible to be certain that it is not desirable to have both. The advantage of the greater simplicity of the Lindley apparatus may be offset by its not being so universally applicable as the Emmons modified stage. This would certainly be true were it less accurate; the relative accuracy of the two instruments is at present unknown to the writer. Emmons[8] estimates an accuracy of $\pm.0002$ at best, and more commonly $\pm.0005$. The difficulty of learning the technique of preventing a mineral grain from sliding around on a tilting universal stage may be no greater than keeping it glued to the pin. The mineralogist is generally not interested in obtaining the dispersion curves for a specimen, but wishes to determine α, β, and γ accurately for sodium light. These values are read from dispersion curves in the Emmons method. Whether the Lindley apparatus would lead to these results direct with no loss in accuracy and at a saving of time as compared to the method of the preparation of dispersion curves (perhaps substituting dilution of the n-fluid for change in temperature) is unknown, but in case it would, possibly a cheaper source of illumination could be substituted for the arc and monochromator.

ADDITIONAL COMMENTS ON THE DOUBLE VARIATION APPARATUS

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Professor Fisher very kindly sent me a copy of the manuscript of his accompanying description of the Scheumann-Lindley microscope refractometer. Through his

[7] Reinhard, M., *Universal Drehtischmethoden*, p. 5, Basel, **1931.** In this connection the model of a universal stage as figured on page 14 (with index ellipsoids as shown, or with rubber balls on which skiodromes are painted) is of great value.

[8] Letter dated August 14, 1931.