XVIII. Note on the optical characters of Ludlamite

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tained by means of the needles of 0.553 millim. diameter. It is seen that it presents the same general characters as the curve P, which relates to the permanent magnetism. The portion of the curve, R_1 , R_2 , comprised between the foot of the tangent to the point of inflection and the point where this tangent cuts the horizontal asymptote of the curve is the region of *rapid magnetization*. The extent of this region, and the coordinates of the two curves corresponding to the extreme points, very well characterize, in default of the complete curves, the magnetic qualities of the steel employed.

[To be continued.]

XVIII. *Note on the Optical Characters of Ludlamite.*
By N. S. MASKELYNE, M.A., F.R.S.*

IN my contribution to Mr. Field's paper on the above mineral I gave a very brief and inexact notice of its optical characters, not having the time or the material to work them out. The preliminary experiments had been made upon fragments of rough crystal on which only the cleavage-plane could be identified, and the form of which was misleading as to the position of the face 100. I have since had the opportunity of working upon another crystal, which, though very full of divisional planes, has nevertheless enabled me to obtain the following results.

On looking through a plate of a crystal of Ludlamite parallel to a cleavage-plane in a Nöremberg's polarization-apparatus, one of the optic axes may be discerned near the edge of the field; and it is also seen that the optic axes lie in the principal section parallel to the plane of symmetry.

Accordingly two faces were ground on the last-mentioned crystal as nearly as possible parallel to the plane of symmetry. One of the planes thus ground was cemented to a plate of glass and laid upon the revolving stage of a microscope, and by the aid of a goniometer eyepiece, one wire of which was accurately adjusted parallel to the plane of polarization of the light employed, the directions were determined of the principal sections of the crystal relatively to the trace or edge of the cleavage-plane, 001. This process gave an angle of $12^\circ 22'$ for the inclinations of the two principal sections upon the trace of the face 001 and on its normal respectively, the greater angle of $102^\circ 22'$ for one of the principal sections lying on the positive†

* Supplementary notice to Mr. Field's memoir read before the Crystallogical Society on December 15, 1876. Communicated by the Author.

† In my first communication the contour of the fragment led me to the erroneous conclusion that this angle was on the negative side of the normal.

side of the normal 001. Consequently the normal of the face 100 makes an angle of $22^{\circ} 55'$ on one of the principal sections. A plate was accordingly ground from this crystal in a direction as nearly perpendicular as was attainable to this principal section; and a second plate was formed from a cleavage fragment of another crystal as nearly as possible perpendicular in direction to that of the former plate and to the plane of symmetry.

Examined in oil, the optic axes were found to make an apparent angle of $97^{\circ} 50'$ in the former plate and of 119° in the latter. The first mean line is therefore inclined on the normal of the face 100 at $22^{\circ} 55'$, and on the normal of the face 001 at an angle $77^{\circ} 38'$; and the acute angle between the optic axes within the crystal, as obtained by calculation, is $88^{\circ} 54'$.

The dispersion of the optic axes for the different colours appears to be inconsiderable. The striated structure of the crystal from which the plate was cut perpendicular to the first mean line somewhat obscured the tints close to the hyperbolas; but in both the eyes representing the optic axes a blue fringe on the convex side of the hyperbola was discernible. In the other plate this characteristic was more marked, as in it each hyperbola presented a blue fringe within the first ring on the side nearest, and a red fringe on the side opposite, to the second mean line. Consequently the mean lines for these colours can be very little dispersed; for their dispersion is not recognizable in the plates experimented on; but the optic axes for the red rays present a slightly wider divergence in respect of the first mean line than do those for blue light.

The optical character is *positive*, as shown by the dilatation of the rings in the former of the two plates when a plate of quartz, cut perpendicular to the axis, is rotated on a line perpendicular to that which joins the optic axes in a Nöremberg polarization-apparatus.

It may be worth while observing that the directions of the principal sections in a small plate can be determined with ease and with considerable accuracy by the method above described, since, if the point of maximum obscuration is difficult to be hit upon with precision, this determination can be much facilitated by a slight rotation of the analyzing prism to right or left; for then tints developed in the crystal assist in indicating a slight inclination of its principal section to the plane of polarization. Of course the relative directions of the principal sections of the crystal, and of the trace (or edge) of one of its faces perpendicular to the plane of symmetry, are readily determined either by the revolution of the crystal on the rotating stage till the trace of the plane is in contact with the wire of

the eyepiece, or by bringing the rotating wire of the eyepiece into apparent contact with the edge of the face in question.

The method is available and chiefly useful in cases where it is almost impossible, or at least requires a refined lapidary's skill to form an artificial twin according to the elegant method of Des Cloiseaux.

N.B.—As a contribution tending to complete my memoir of December 15, I add three more figures representing various forms of the crystals of Ludlamite.

January 18, 1877.

XIX. A Theorem in Continuants.

By THOMAS MUIR, M.A., F.R.S.E.*

IN the Philosophical Magazine for June 1853 (vol. v. p. 453) Professor Sylvester gave the first imperfect germ of a theory of continuants—determinants of the form

$$\begin{vmatrix} a_1 & b_1 & 0 & 0 \\ -1 & a_2 & b_2 & 0 \\ 0 & -1 & a_3 & b_3 \\ 0 & 0 & -1 & a_4 \end{vmatrix} \quad \text{or } K(a_1^{b_1} a_2^{b_2} a_3^{b_3} a_4)$$

—pointing out their connexion with continued fractions, as seen in the identity

$$a_1 + \frac{b_1}{a_2 + \frac{b_2}{a_3 + \dots + \frac{b_{n-1}}{a_n}}} = \frac{K(a_1^{b_1} a_2^{b_2} \dots a_n)}{K(a_2^{b_2} \dots a_n)};$$

and in the next volume (pp. 297–299) he established a funda-

* Communicated by the Author.