number of octants which could be examined was six; so that the question of the hemihedrism could be more thoroughly tested than it was by Hessenberg, who was only able to examine four. The forms {1 1 0}, {2 1 1} were well developed in adjacent octants, and are therefore holohedral. The forms {4 1 1}, {6 1 1}, {7 1 1}, {10 1 1}, and {2 3 3} were found in alternate octants only, and are consequently hemihedral. The faces of {3 2 1} were for the most part badly developed, and did not permit of any certain conclusion being drawn. Hessenberg found a plane of the form in each of two adjacent octants which excludes a hemihedrism with inclined faces. I believe it, from my observations, to be holohedral. A further examination of such crystals as are to be found in the various collections might possibly set the question of the hemihedrism of the mineral at rest, and would certainly be interesting.

XI. *Crystallography of the Nitrosoterpenes of* Dr. Tilden. *By* N. S. Maskelyne, *F.R.S.*

[Plate IV. figs. 1–6.]

The varieties of nitrosoterpenes obtained in crystals by Dr. Tilden belong to two crystalline types. The first includes the substances formed (*a*) from ordinary turpentine, (*b*) from French turpentine, (*c*) from juniper turpentine. To the second type belong the substances obtained from the oils of orange, of bergamot, and of caraway. The crystals of both types belong to the monosymmetric system.

I. *First group.*—The crystals of nitrosoterpene produced in different ways from the American oil of turpentine have already been described in connexion with Dr. Tilden's notice of the substances in the Journal of the Chemical Society, June 1875. They were of two kinds, differing in habit—the one being twinned on the plane 0 0 1, and the other not evincing any twin habit. The crystals obtained from French oil of turpentine and from juniper oil are very dissimilar in appearance to those made from the American oil; but a goniometrical study of them proves that they belong to the same crystalline type with those previously investigated. The crystals of the latter kinds furnished me by Dr. Tilden presented considerable difficulty under measurement, since certain of the faces are rounded ; and from their being very minute and inclined at small normal angles on each other, it is often difficult to discriminate the faces lying in a particular zone, as the greater number of the determinations have to be made with faces which offer no images or such as are very confused, and which can be measured only by the method of maximum illumination.

The figures 1 and 2 represent the same forms as those already given in the Journal of the Chemical Society. Fig. 3 exhibits the forms which exist on the crystals obtained from the French and the juniper oils, together with some other forms, of which the existence on some of the crystals is probable, though no reliable measurements could be obtained from them. The crystals rapidly lose by exposure such lustre as they have when fresh—apparently in consequence of evaporation taking place at ordinary temperatures, as evinced by a faint odour perceptible even while a little crystal is exposed on the goniometer.

The measurements obtained from crystals of the different sorts are arranged in columns,—the first column consisting of the calculated angles as given in the earlier communication to the Chemical Society; column II. containing the angles obtained by measurement of the crystals thus described, which were obtained from American and ordinary oil of turpentine. Columns III. and IV. give the averages of the angles (omitting the extremes) as obtained by measurements from the crystals made from French and from juniper turpentines respectively; while column V. gives the angles calculated on average data, obtained from what seemed to be the better measurements, yielded by the two latter varieties of the crystal. The forms on these "French" and "juniper" nitrosoterpenes were by no means uniformly the same. Some of the crystals were very complicated, exhibiting numerous forms of which even the zone-positions could be only approximately ascertained; others were much simpler, the faces of the forms {1 1 1}, {2 0 1}, {1 1 0}, in one case {0 3 1} apparently, with traces of {0 0 1} forming the combination. On others the form u or {3 1 2} seemed the most important face. The faces of the form {1 1 0} are in the latter varieties always corrugated by a series of planes inclined at from 1° to 3° on each other, approximately in the zone

[1 1 0, 0 0 1]. The following letters represent the faces and forms of the crystals:—

a, {1 0 0}; *m*, (1 1 0); *b*, {0 1 0}; m', $(\bar{1}\,1\,0)$; $\overline{m}'$, $(\bar{1}\,1\,0)$; *k*, {1 0 1}; *δ*, {2 0 1}; *c*, {0 0 1}; *h*, {0 1 1}; *n*, {0 3 1}; *p*, {1 1 1}; *t*, {1 1 2}; *y*, {3 3 2}; *u*, {3 1 2}; *ρ*, {5 1 2}; *λ*, $\{\bar{3}\,5\,1\}$.

	I. Calculation.	II. American.	III. French.	IV. Juniper.	V. Calculation.
	° ′	° ′	° ′	° ′	° ′
a m	53 4	53 4	......	....	52 50
m b	36 56	36 56	......	....	37 10
m m'	73 52	73 52	74 19	75° to 75° 19′	74 20
$m\,\overline{m}'$	106 8	......	105 55	105 18	105 40
a c	70 17½	70 19	......	....	70 23
a k	43 44½	......	......	....	43 38
a δ	......	......	......	....	29 52
c a'	109 42½	109 40	......	....	......
m c	78 18	......	78 18	78° 12½′ ∣ 21½′	78 18
c m'	101 42	......	101 42	101 47½	101 42
m p	37 26	......	37 25	37 55	37 22
p c	40 52	......	40 38	40 45	40 56
m y	......	......	30 8	29 31	30 3
m δ	......	.....	58 35	58 27	58 25
m' δ	......	......	120 45	....	121 35
δ u	......	......	17 4	....	16 39
m' p	86 20	......	86° to 87° 15′	87 9	86 51½
m' u	......	......	......	....	104 56½
m u'	......	......	75° 7′ to 39′ approx.	75 0	75 4
m' n	......	......	......	53 55	54 2½
p' m	......	......	93° approx.	....	93 8½
m' λ	......	......	......	19° 40′ to 20° 28′	20 3
b p	57 43	57 41			
p p'	64 34	64 35	......	about 63° 35′	64 26
m k	......	......	......	64 30	64 4
m u	......	......	46° 30′ to 48° 8′	46° 55′ ∣ 47° 32′	47 12
u m'	......	......	131 approx.	....	132 48
m' t	......	......	92 30	91 40	92 40½
t' m	......	......	87 17	87 22	87 19½
h m'	......	......	......	67° 30′ to 70°	68 32½
u u'	......	......	about 28°	28° 40′ approx.	29 48
t t'	......	......	......	....	40 59
$m(c)\overline{m}'$	23 24	23 25	......		
a p	52 20	52 28	......		

A facile cleavage runs parallel to the face (0 0 1); a less facile cleavage is parallel to the faces of the form {1 1 0}.

The great facility with which the former cleavage is produced precluded the formation of sections for the polariscope.

In one crystal which showed one of the ring-systems the plane of the optic axes was evidently perpendicular to the plane of symmetry, the acute bisector lying in that plane; and it appeared that the dispersion of the bisectors in that plane for different colours gave the position of the bisector for blue rays nearer to the normal of *a*, or (1 0 0), than that of the red rays. The position of the acute bisectors was approximately determined as being about $11\frac{1}{2}^\circ$ on the normal to (1 0 0), and $32\frac{1}{4}^\circ$ on the normal to (1 0 1).

II. *Second group.*—The second type of the crystals of nitroso-terpene (figs. 4 & 5) includes those formed from the oils of orange, bergamot, and caraway. They belong to the mono-symmetric system; and their arc-elements may be represented as 1 0 0,0 0 1 = 79° 1′, 1 0 0,1 0 1 = 38° $25\frac{3}{4}'$, 1 0 0,1 1 0 = 40° $25\frac{1}{2}'$. The crystals representing the orange and the bergamot preparations, especially the former, generally give fairly good images from the faces 0 0 1, $\bar{1}$ 0 1, and 1 1 0; those from 1 0 0 are usually in the condition of many bands; while the reflections are never good from the face 1 0 1. The faces {0 0 1} are generally hollowed. The reflections from the faces on the caraway crystals, and particularly from 1 0 0, are less perfect than those from the other preparations. In the following Table the measurements marked with an S were made by Mr. Elliot Steel. The only faces that occur on any of these crystals are those of the following forms:—

a, {1 0 0}; *c*, {0 0 1}; *k*, {1 0 1}; *d*, {$\bar{1}$ 0 1}; *m*, {1 1 0}

	Calculated.	Bergamot.	Orange.	Caraway.
a c	79° 1′	79° $2\frac{1}{2}'$ | 79° S.	79° ′	79° ′
a k	38 $25\frac{3}{4}$	....	37 14	38 to 40°
c d	24 $4\frac{1}{2}$	24 4 | 24° 6′ S.	24 4 & 24 $6\frac{1}{2}$	24 8
d a′	76 $54\frac{1}{2}$	77 2 | 76 34 S.	76 56	77 21
a d	103 $5\frac{1}{2}$	103 $3\frac{1}{2}$	103 5	
m m′	99 9	99 7 | 99 10 S.	99 9	99 8
m $\bar{m}$′	80 51	80 52	....	80 52
a m	40 $25\frac{1}{2}$	40 $26\frac{1}{2}$ | 40 25 S.	40 26–27′	40 21 | 40° 30′ S.
m k	53 $23\frac{1}{2}$			
m′ d	99 56		99 58 to 100 2 99° 50′	
m c	81 $39\frac{1}{2}$	81 41	81 38 S.	81° to 52°

A distinct cleavage runs parallel to the faces of the form {0 0 1}. It was not possible to determine the direction in the crystal of the acute bisector of the optic axes.

III. *Terpene Hydrate* (fig. 6).

Crystals of terpene hydrate, made by Dr. Tilden from dextro- and from lævo-rotatory turpentine-oil, exhibit no distinction in the character of their forms. They are in fact crystallographically identical, belonging to the orthosymmetrical (or rhombic) system, and presenting the forms *a* {1 0 0}, *m* {1 1 0}, *o* {1 1 1}, and *k* {1 0 1}, and occasionally *b* {0 1 0}.

The crystals of terpene hydrate have been measured by List (Pogg. *Ann.* vol. lxvii. p. 364), by Rammelsberg (*Crystallogr. Chem.* p. 406, and Suppl. p. 227), and by Arzruni (Pogg. *Ann.* vol. clii. p. 282), who has also determined the optical characters of the substance. The measurements made by me accord very nearly with those obtained by Arzruni.

The parameters of the crystal are

$$a : b : c = 0{\cdot}8082 : 1 : 0{\cdot}4788,$$

the angles calculated from which elements, and the averages of those obtained by measurement on four crystals (two from each source), form the two columns in the following Table:—

Angles.		By calculation.	By measurement. Arzruni.	Maskelyne.
		° ′ ″	° ′ ″	° ′ ″
a m	=	51 3 30		51 3½
m m′	=	77 53	77 49 20	77 53
m b	=	38 56 30		38 56¼
a k	=	64 26 30		64 26¼
k k	=	51 8		51 18
m o	=	52 44	52 49 40	52 36 15
a o	=	67 37 30		67 37¼
o o′	=	44 45	44 38 30	44 49
b o	=	61 54		
o k	=	28 6	28 1 30	28
o o′	=	56 12	56 8 30	56 2 30

The faces *m* give in general excellent images; the faces *o* give a banded image. Arzruni's parameters are 0·8072 : 1 : 0·4764.

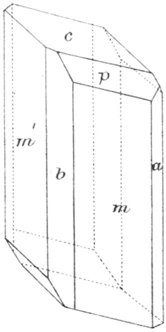
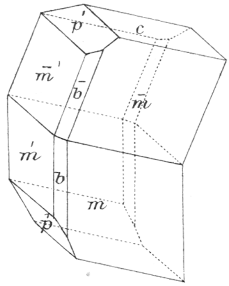


Fig. 1.

Fig. 2.



Nitroso-terpene type 1.

Fig. 3.

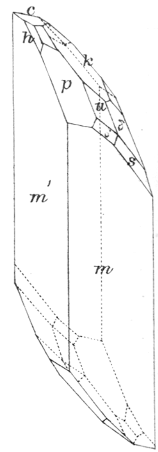
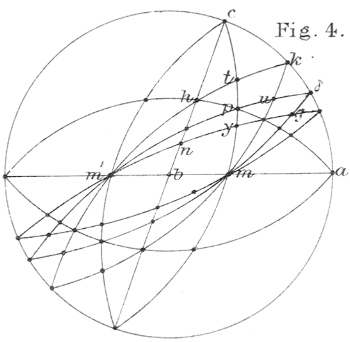


Fig. 4.



Nitroso-terpene type 2.

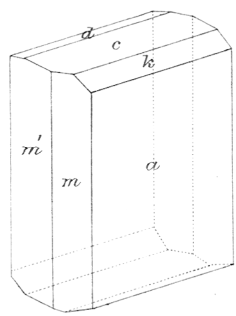


Fig. 5.

Nitroso-terpene. type 2.

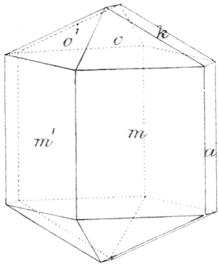


Fig. 6.

Terpene-hydrate.

Fig. 7.

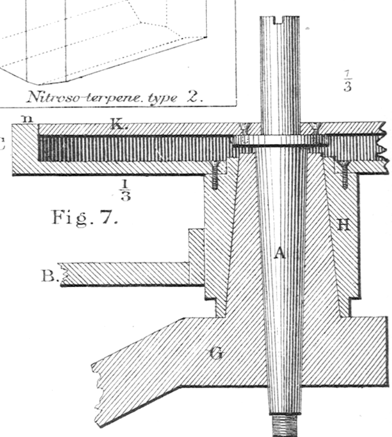
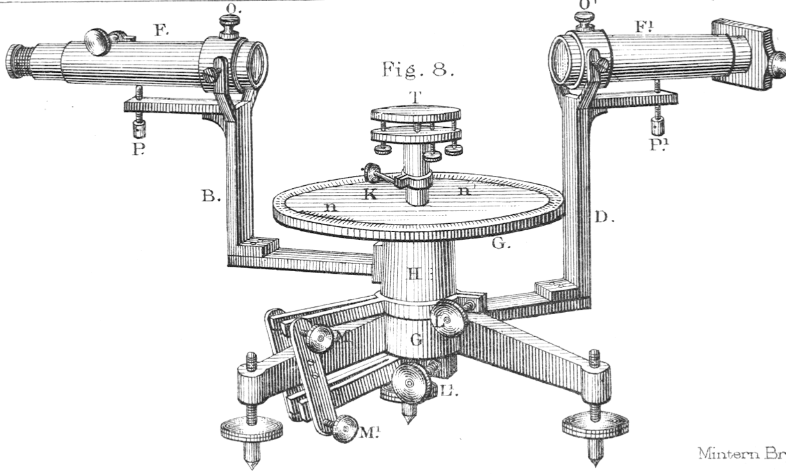


Fig. 8.



Mintern Bros. lith.