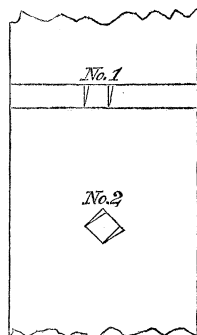


The highest and lowest rigidities which I have found for copper (extracted from the preceding Table) are as follows:—

Highest rigidity, 473×10^6 , being that of a wire which had been softened by heating it to redness and plunging it into water, and which was found to be of density 8.91. Lowest rigidity 393.4×10^6 , being that of a wire which had been rendered so brittle by heating it to redness surrounded by powdered charcoal in a crucible and letting it cool very slowly, that it could scarcely be touched without breaking it, and which had been found to be reduced in density by this process to as low as 8.674. The wires used were all commercial specimens—those of copper being all, or nearly all, cut from hanks supplied by the Gutta Percha Company, having been selected as of high electric conductivity, and of good mechanical quality, for submarine cables.

It ought to be remarked that the change of molecular condition produced by permanently stretching a wire or solid cylinder of metal is certainly a change from a condition which, if originally isotropic, becomes ælotropic* as to some qualities†, and that the changed conditions may therefore be presumed to be ælotropic as to elasticity. If so, the rigidities corresponding to the direct and diagonal distortions (indicated by No. 1 and No. 2 in the sketch) must in all probability become different from one another when a wire is permanently stretched, instead of being equal as they must be when its substance is isotropic. It becomes, therefore, a question of extreme interest to find whether rigidity No. 2 is not *increased* by this process, which, as is proved by the experiments above described, diminishes, to a very remarkable degree, the rigidity No. 1. The most obvious experiment, and indeed the only practicable experiment, adapted to answer this question, will require an accurate determination of the difference produced in the *volume* of a wire by applying and removing longitudinal traction within its limits of elasticity. With the requisite apparatus a most important and interesting investigation might thus be made.



V. "On Two New Forms of Heliotrope." By W. H. MILLER, M.A., For. Sec. R.S., and Professor of Mineralogy in the University of Cambridge. Received May 17, 1865.

A heliotrope is a mirror O provided with some contrivance for adjusting it so that any given distant point T may receive the light of the sun S

* A term introduced to designate a substance which has varieties of property in various directions (Thomson and Tait's 'Natural Philosophy,' § 676).

† See, for example, a paper by the author, "On Electrodynamic Qualities of Metals," Philosophical Transactions, 1856.

reflected from the surface of the mirror. This instrument has been constructed on three different principles. In Drummond's (*Philosophical Transactions* for 1826, p. 324), by a simple mechanism, a normal to the mirror is made to bisect the angle between the axes of two telescopes, one of which is pointed to T, and the other to S; consequently T will receive the light of S reflected from O. In Struve's (*Breitengradmessung*, p. 49) the mirror is directed by means of two sights attached to its support, which are brought into the line OT. The heliotrope employed in the Ordnance Survey (*Ordnance Trigonometrical Survey of Great Britain and Ireland, Account of Observations and Calculations of the Principal Triangles*, p. 47) is similar to Struve's, except that a single mark placed at a convenient distance in the line OT is substituted for the two sights. In the two heliotropes invented by Gauss (*Astronomische Nachrichten*, vol. v. p. 329, and v. Zach's *Correspondance Astronomique*, vol. v. p. 374, and vol. vi. p. 65), in Steinheil's (*Schumacher's Jahrbuch für 1844*, p. 12), and in Galton's an optical contrivance is connected with the mirror, so as to throw a cone of sunlight in a direction opposite to the cone of sunlight reflected from the surface of the mirror, the axes of the two cones being parallel, and either very nearly or absolutely coincident. Hence any point T, from which a portion of the former cone of light appears to proceed, will receive the light of the sun reflected from the mirror.

The heliotropes I am about to describe produce two cones of sunlight thrown in opposite directions, like those of Gauss, Steinheil, and Galton, but differ from them in having no moveable parts, and from all but Galton's, and the sextant-heliotrope of Gauss, with a second moveable mirror, in requiring no support except the hand of the operator.

One of these consists of a plane mirror, to an edge of which are attached two very small plane reflectors, *a*, *c*, forming with one another a reentrant angle of 90° , and making angles of 90° with the faces of the mirror. If a ray be reflected once by each of the two planes *a*, *c*, it is obvious that the first and last directions of the ray will be parallel to a plane containing the intersection of *a*, *c*, and will make equal angles with the intersection of *a*, *c*, which is also a normal to the face of the mirror. Therefore, if two parallel rays fall, one on the mirror, and one on either of the planes *a*, *c*, the direction of the ray reflected from the mirror will be parallel and opposite to that of a ray reflected once at each of the planes *a*, *c*. When the small reflectors are made of bits of unsilvered glass, the brightness of the image of the sun is so far reduced after the second reflexion, as not to interfere with the direct vision of T, and the mirror can be pointed without difficulty.

The other consists of a plate of glass having parallel faces *b*, *d*, with two polished plane faces *a*, *c* on its edges, making right angles with one another, and with the faces *b*, *d*, the face *d* being silvered, with the exception of a portion at the angle *adc* not larger than the pupil of the eye. It is easily seen that if a ray of light incident upon *b*, and refracted

through *b*, so as to be reflected internally once at each of the planes *a*, *c*, emerge through *d*, the planes of incidence and emergence will be parallel, and the incident and emergent rays will make equal angles with the edge *ac*, and therefore with a normal to the faces *b*, *d*. Hence the portion of the incident ray which is reflected from the mirror will proceed in a direction parallel and opposite to that portion of the ray which, after internal reflexion at *a* and *c*, emerges through *d*.

In order to ascertain that the construction of such an instrument presented no unforeseen difficulties, I requested Mr. T. E. Butters, of 4, Crescent, Belvedere Road, the well-known maker of sextant-mirrors and artificial horizons, to form the faces *a*, *c* on the edges of a piece of plate glass, and then had the face *d* coated with chemically reduced silver. Upon trial, the emergent light was found to be too bright; but after smoking the angle *adc* in the flame of a candle, in order to reduce the intensity of the light, it became perfectly easy to make the centre of the image of the sun coincide with the object T seen by direct vision.

An image of the sun of suitable intensity for pointing might be obtained by attaching to the edge of the mirror a piece of tinted glass, of the form of the corner *abcd*, with the faces *b*, *d* parallel to the plane of the mirror.

The Society then adjourned, over the Whitsuntide Recess, to Thursday, June 15, the President having announced the Meeting for the Election of Fellows to take place on Thursday, June 1, at 4 P.M.

June 1, 1865.

The Annual Meeting for the election of Fellows was held this day,

Major-General SABINE, President, in the Chair.

The Statutes relating to the Election of Fellows having been read, Mr. Brayley and Dr. Webster were, with the consent of the Society, nominated Scrutators to assist the Secretaries in examining the Lists.

The votes of the Fellows present having been collected, the following Candidates were declared to be duly elected into the Society.

The Hon. James Cockle, M.A.
Rev. William Rutter Dawes.
Archibald Geikie, Esq.
George Gore, Esq.
Robert Grant, Esq., M.A.
George Robert Gray, Esq.
George Harley, M.D.
Fleeming Jenkin, Esq.
William Huggins, Esq.

Sir F. Leopold M^cClintock, Capt.
R.N.
Robert M^cDonnell, M.D.
William Kitchen Parker, Esq.
Alfred Tennyson, Esq., D.C.L.
George Henry Kendrick Thwaites,
Esq.
Lieut.-Col. James Thomas Walker,
R.E.