Cristobal were observed at the time of the earthquake to be covered by clouds of, to all appearance, gaseous vapour; and the Padre Bravo, Curate of Lilio, asserts, that the movement of Banajoa was so awful to behold that residents of that village, situated at the base of the mountain, feared that it would fall over and bury them beneath it.

The two sheets containing diagrams of the five principal shocks were lithographed at Manila, under the careful supervision of Father Faura, and I thought it better to send them as received rather than attempt a tracing, the lines being so complicated. I have not appended a translation of the few descriptive notes on the sheets, as the terms used are almost identical with their English signification.

February 24, 1881.

THE PRESIDENT in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read:—

I. "On a Simple Mode of Eliminating Errors of Adjustment in Delicate Observations of Compared Spectra." By Professor G. G. Stokes, Sec. R.S. Received February 12, 1881.

When the identity or difference of position of two lines, bright or dark, in the spectra of two lights from different sources has to be compared with the utmost degree of accuracy, they are admitted simultaneously into different but adjacent parts of the slit of a spectroscope and viewed together. It was thus, for instance, that Dr. Huggins proceeded in determining the radial component of the velocity of the heavenly bodies relatively to the earth. It is requisite that the two lights that are to be compared should fall in a perfectly similar manner on the slit: and it will be seen, from a perusal of his paper, how careful Dr. Huggins was in this respect.

In a paper read before the Royal Society on the 3rd instant, Mr. Stone has proposed to make the observation independent of a possible error in the exact coincidence of the lights compared by constructing a reversible spectroscope, by which the light should be refracted alternately right and left, supposing for facility of explanation the slit to be vertical.

The idea is an elegant one, but I apprehend that there would be considerable difficulty in carrying it out. For a spectroscope giving large dispersion is of considerable weight, and the reversal of so heavy an apparatus would be liable to introduce possible errors arising from flexure.* It would be difficult to make sure that such did not exist, at any rate, unless the instrument were constructed with great nicety and firmness, which would add considerably to the cost; and even then the care and time required for the reversal would help to obliterate the observer's memory of what he had seen in the first position of the instrument.

A method has occurred to me of effecting the reversal without reversing the spectroscope, but merely giving a lateral push to a little apparatus which need not weigh more than a few grains.

If the base of an isosceles prism be polished as well as the sides, and a ray of light parallel to the base and in a plane perpendicular to the edge fall on one of the equal sides of the prism so as to emerge from the other, after suffering an intermediate reflection (which will necessarily be total) at the base, its course after refraction will be parallel to its course before incidence; and there will, moreover, be no lateral displacement, provided the lateral distance of the base from the incident ray be such that the point of reflection is at the middle of the base.

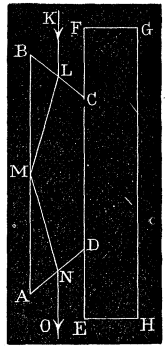
If the slit of the spectroscope be covered by such a prism, placed close to the slit and facing the collimating lens, to the axis of which its base is parallel, it will not disturb the general course of the light incident on the spectroscope, nor even produce a lateral displacement provided the lateral position be that mentioned above; but in consequence of the reflection there will be a reversal as regards right and left, and any error in the placing of the lights to be compared will thus be detected and eliminated, by comparing the spectra seen with the light from the slit direct or reflected. If the prism be placed quite close to the slit it may be made very minute in section, though it should be long enough to cover the slit, and then the change of focus which it produces will be insignificant.

There will be no need, however, to make the prism so very minute, nor to place it so close to the slit, provided it be associated with a plate to take its place in the direct observation, and compensate for the change of focus which is produced by its introduction.

Let ABCD be a section of the prism, let M be the middle point of the base AB, KLMNO the course of a ray passing as above described, which is supposed to be the axis of the pencil coming through the

* After the present paper was sent in to the Society, I was informed by Mr. Stone that the spectroscope he had in his mind was a direct-vision one, which could be turned in its socket, the slit and cylindrical lens remaining fixed. To such an instrument the objection as to flexure would not apply.

middle of the slit. Let ϕ be the angle of incidence, which will be half the angle of the prism, and the complement of either angle A or B, ϕ' the angle of refraction, μ the index of refraction, b the



base AB, l the length of path, LM+MN, of the ray within the glass, p=LN. In spectroscopic work it is the focus of rays in the primary plane that we have to deal with; and we get for the shortening (s) of the focus, or, in other words, the distance by which the slit is virtually brought nearer to the collimating lens,

$$s=p-l\frac{\cos^2\phi}{\mu\cos^2\phi'}.$$

But since MBL=90°−ϕ and MLC 90°−ϕ' we have

$$l=b\frac{\cos\phi}{\cos\phi'}; \quad \text{also } p=l\cos(\phi-\phi');$$

whence $$s=b\left\{\cos(\phi-\phi')\frac{\cos\phi}{\cos\phi'}-\frac{\cos^3\phi}{\mu\cos^3\phi'}\right\}=t\left(1-\frac{1}{\mu}\right),$$

where t is the thickness of a compensating plate which shall produce the same shortening of focus. In the figure, the part of the prism which is out of use is represented as cut away, to make the instrument more compact, and EFGH represents the compensating plate. The faces CD of the truncated prism, and EF, HG, of the plate, of course need not be polished, and had better perhaps be blackened.

In the figure I have taken 80° for the angle of the prism, and supposed μ to be 1·52, which data give t=1·225b, nearly. A blunter angle would have made the instrument a little more compact in the direction AB, but I wished to avoid needless loss of light by the two reflections that accompany the refractions. The size of the prism and compensating plate must depend upon its distance from the slit, and

the angle subtended at the slit by the objective of the collimator. It should be a little larger than what is just sufficient to take in the largest pencil that is to be observed, but not beyond that. The object in keeping it as small as conveniently may be, is that only a trifling change of focus may be required when the instrument is pushed aside altogether, and the slit viewed directly through the spectroscope, without the slight loss of light due to the two reflections.

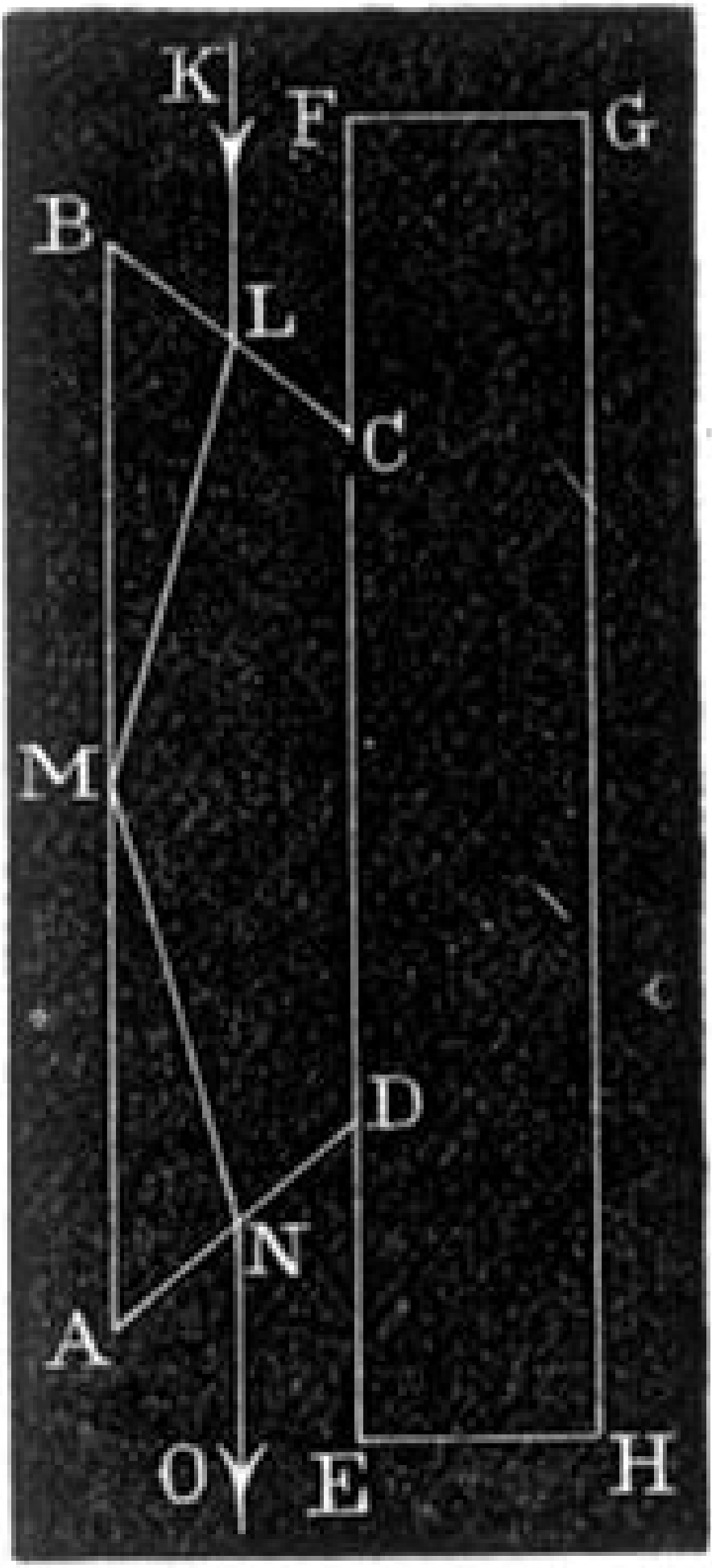
The compensating plate is represented as placed at the narrow end of the prism, which permits of the two being cemented together, thereby facilitating the support. I do not think that the minute quantity of light which is reflected at L, and scattered at the surface (even though blackened) FC in such a direction as to mingle with the direct light would be any inconvenience, being too faint to be visible at all. If it were wished to avoid this, or to get more easy access to the surfaces AD, BC, for cleaning if requisite, the plate might be placed at the other side; but in that case it must not be cemented to AB, as that surface is wanted for total reflection.

The little instrument I have suggested may conveniently be called a *slit-reverser*, to distinguish it from other arrangements which have been proposed, and in which the spectrum itself is reversed.

P.S. Feb. 21.—The method proposed above is more directly applicable to such an object as the comparison of really or apparently coincident lines in the spectra of two elements than to astronomical measurements, because in the latter case a great part of the difficulty arises from a want of perfect accuracy in the clockwork movement of the equatoreal. Yet I cannot help thinking that even for astronomical work the method will be found useful; for we can pass in a moment from the direct to the reflected image of the slit, and *vice versâ*, and by taking the measures alternately in the two modes, and combining them exactly as in weighing with a balance that is still swinging, any error progressive with the time would tend to be eliminated.

II. "Notes on Physical Geology. No. VII. On the Secular Inequalities in Terrestrial Climates depending on the Perihelion Longitude and Eccentricity of the Earth's Orbit." By the Rev. SAMUEL HAUGHTON, Professor of Geology in the University of Dublin. Received February 19, 1881.

The attention of geologists was first called by M. Adhémar, and afterwards more fully by Mr. James Croll, to the possible importance of these long inequalities in climate, in explaining the climates of geological periods, which differ considerably from those of the present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