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X. *Description of a Clinometer.*

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MEMBER OF THE GEOLOGICAL SOCIETY.

[Read May 20th, 1814.]

In every description of stratified rocks the importance of determining the position of the plane of stratification, by referring it to some standard, is so obvious that to insist on it would be a needless intrusion upon the time and attention of this Society. The object of the present paper is to submit to the Society a description of an instrument contrived for the above purpose, accompanied by drawings, and to add an explanation of the method of using it. This instrument has received the name of the *Clinometer*.

The Clinometer consists of two parts, the *plate* and the *quadrant*. Plate 25, exhibits both lying horizontally, the quadrant in the position in which it lies packed in its case. Plate 26 shews the two parts put together, lying upon an inclined surface, and adjusted for an observation to determine its position. In both plates every part of the instrument is represented of the real size, and the references in the description are made to both by the same letters.

The plate represented by A, is circular and of brass. On the under surface, near the edge, it is thickened by a ring to give it greater strength. It is supported by three feet *a a a*, placed at equal distances just within the ring, and made of wood, with their ends flat and broad, of a form somewhat oval, and having its length

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in the direction of the margin. Wood is preferred to metal for the feet, as less likely to slip on a smooth surface; and they are made broad at the end, to prevent the position of the plate and the firmness of its rest from being too much affected by the minute inequalities of a rough one. The flat ends of the feet are adjusted to a plane parallel to the upper surface of the plate; and the fibre of the wood is set perpendicularly, in order to prevent any derangement from the expansion and contraction of the wood attending the changes of moisture. On the upper surface near the edge, is a circle divided into degrees, which are numbered from zero to 90° through the four quarters successively in the same order; and it is of no consequence whether this is done from left to right, or from right to left. In the center of the plate is a circular hole *b*, to receive an axis on the under side of the base of the quadrant. For securing it, there is a bolt *c c*, which slides below, and is worked by a catch *d* rising through an oval hole in the plate and made flush with its surface.

B represents the quadrant, which has all its frame-work of brass. CC is its base, which traverses upon the plate; at *e* is the button of the central axis, which is secured in the center of the plate by the hollowed end of the bolt beneath, and at *f* is the clamp and milled-head screw, for fixing the quadrant to the edge of the plate in any direction. At *l* is a rectangular aperture, through which the divisions of the plate are seen, and read off by an index on the middle of the bevelled side of the aperture nearest to the central axis. D D is the graduated arch, fixed firmly to the base, and at right angles to the plane of its under surface. It is divided into degrees, which are numbered from below. At *h* is the head of a short axis passing through the center of the arch, and revolving with the motion of the radial bar *m m*, which carries with it the

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spirit level EE, and the compass *o o o*. This axis is made to move with a degree of friction sufficient to support the weight of the radial bar in any position. The level turns upon its axis by two pivots *p p* set in two small plates projecting from the extremities of the radial bar, and through the same plates, immediately below the level, passes a strong conical axis *r r*, to one end of which the compass is fixed, and with which it revolves.

The compass-box has its bottom, as well as its top, made of plate-glass, and each of the two pieces is set in a cylindrical rim of brass which forms its sides. To the middle of this rim there is fixed, on the inside, an annular brass plate, silvered and graduated in the same manner both above and below. The divisions are of two degrees. There are two zeros, one in each intersection of a line passing through the center, and on both sides of each of them the divisions are numbered alike, till they meet in two *nineties*, in a line at right angles to the first. At *g* is a catch for working a bolt sliding on the outside, which lifts the needle from its pivot in the usual way, by the bent lever *s*. The needle has the north pole marked on the under, as well as the upper, side, and also an index line drawn from one end to the other.

In adjusting the different parts of the quadrant to each other regard must be paid to the following circumstances; that the axis of the level may be parallel to the line from the center of the quadrantal arch to the index on the radial bar; again, that when the radial bar is home upon the base, the axis of the level may be parallel to a line, in the plane of the base, from the center to the index of the base, and that the index of the radial bar may at the same time point to zero; also that the line of the two zeros in the compass may be parallel to the axis of the level, at least, when the plane of the compass is at right angles to that of the quadrantal arch.

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The clinometer may be used to determine the position of any plane surface to which the plate can be applied, so as to admit of observation with the quadrant. The upper surface of a rock is that which presents itself most frequently, and the mode of observing it may be thus described.

As the surface of a rock afforded by a strata-seam seldom approahes to a perfect plane, a part of it must be chosen, which appears to give the mean, or average position of the stratification. If the surface be smooth, the quadrant may be fixed upon the plate, before the plate is set down upon the rock. If the surface be rough, the plate must first be set down, and adjusted by the eye, till its surface appears to coincide with the mean position of the stratification; the quadrant is then to be fixed on. In fixing the quadrant upon the plate, the clamp should be thrust upon the edge, before the button of the central axis is inserted. No regard need be paid to the situation of the zeros of the plate.

The radial bar must be set home upon the base; and while one hand presses the plate firm against the rock, the other must be applied to the head of the screw *g*, and bring the quadrant round till the level, properly adjusted by turning it upon its axis, is horizontal. Its axis will now be parallel to the line of stretch, that is, to a line determined by the intersection of the plane of the stratification with the plane of the horizon. The division on the plate, to which the index of the base points, is then to be noted, and the quadrant carried upwards to the same division in the next quarter of the plate; when it will have described an arch of 90°, and of course be now in a vertical plane, at right angles both to the plane of the stratification and to the plane of the horizon. After clamping the quadrant to the plate in this position by turning the screw *g*, the hand is shifted to the compass in order to

raise the radial bar till the level, duly adjusted on its axis, marks the horizontal line. When this has been done, and the needle has settled, the degrees on the compass are to be read off between the zero farthest from the quadrant, and the point of the needle nearest to that zero. This gives the magnetical bearing of the plane of the dip, that is, of a plane at right angles to the line of stretch on that side on which the plane of the stratification sinks below the plane of the horizon. The instrument may then be lifted from the rock, and the angle of the dip read off upon the quadrantal arch, being the angle which the plane of the stratification makes with the plane of the horizon. The bearing of the line of stretch is deduced from the bearing of the plane of the dip, as being at right angles to it. A correction for the magnetical variation gives the true position.

The roof of a cavern or of a mine, and sometimes the overhanging of a rock, may present an under surface for observation; but the instrument can scarcely be employed without an assistant to hold the plate firmly pressed upwards.

For an observation of this kind, the level and the compass-box must be inverted upon their axis, so as to have their faces turned towards the plate. The level is to be brought to the horizontal line as in the former case; but the quadrant must then be carried *downwards* through an arch of 90° and clamped by the screw. The radial bar is also to be drawn *down* till the level becomes horizontal. The magnetical bearing is read off upon the under side of the graduated plate in the compass.

The origin of the instrument is as follows:—A few years ago Mr. Griffiths, of Dublin, when making a mineralogical tour in the Highlands of Scotland, employed for measuring the dip of strata an instrument, which differed little from a common road

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level, except in the size of the graduated arch, while he observed the bearing at the same time by a compass carried separately. Mr. Jardine of Edinburgh made the important improvement of having the compass mounted upon the radial bar, and placed it between the center and the graduated arch. Soon afterwards I had an instrument made in imitation of this, but, in order to reduce the radius of the arch, I had the compass fixed at the end of the radial bar. There was a difficulty in applying the base of this instrument to the surface of a rock, so as to place it with precision in the line of greatest depression, and the endeavour to remedy it led me to the idea of the plate. Two other clinometers were successively made for me upon this plan, with such further improvements as experience gave rise to; and the last was adapted for observation upon an under surface, upon the suggestion of Mr. Jardine. This last contained all the principles of the instrument in its present state, and was given as a model to Mr. Troughton, who, in making that which has now been described, introduced a more simple construction of the radial bar, and shewed that ingenuity which distinguishes every object of his labours, by other alterations conducive to strength and lightness as well as to greater ease and accuracy of observation.

The chief objection to the instrument in its present form, is the weight of the plate. But it is necessary that it should have a certain diameter, in order to admit of its adjustment by the eye to the mean plane of the stratification, and it must have a thickness sufficient to prevent it from bending much under the pressure required to hold it against a steep surface. No substance occurred besides a metal, that was not liable to some objection, particularly that of warping.

The clinometer may be employed for other purposes, besides

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that of determining the position of strata. The contents of a solid contained by planes may be determined from the dimensions and relative positions of these planes, and for ascertaining the latter the clinometer may be used, where great accuracy is not wanted. Mr. Jardine has used it in gauging a pond, of which the sides were pretty regular slopes. By having the end of the button of the central axis and the bottom of the milled head screw so adjusted by grinding, that they may be in a plane parallel to that of the base of the quadrant, he has made the quadrant useful in supplying the place of a common spirit level upon many occasions.*

* The instrument may be had from Mr. Cary, Optician, in the Strand.

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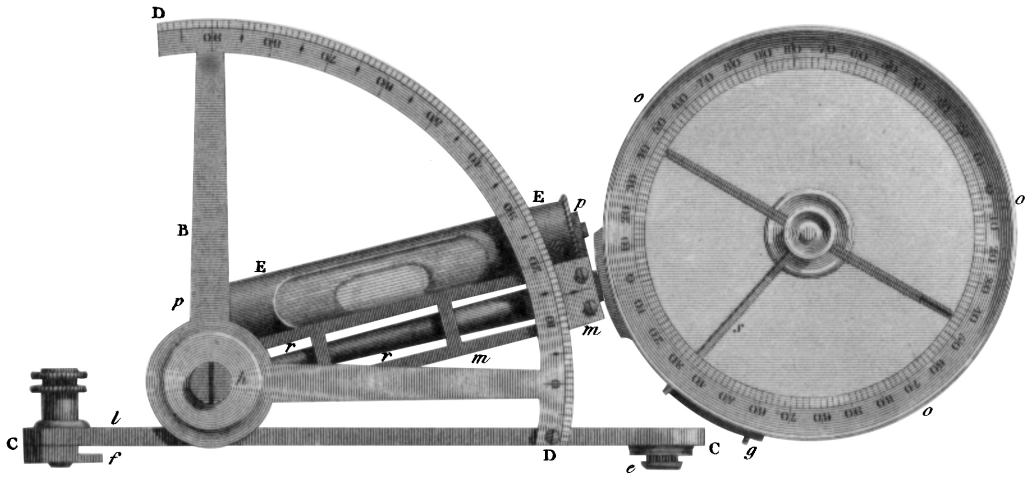
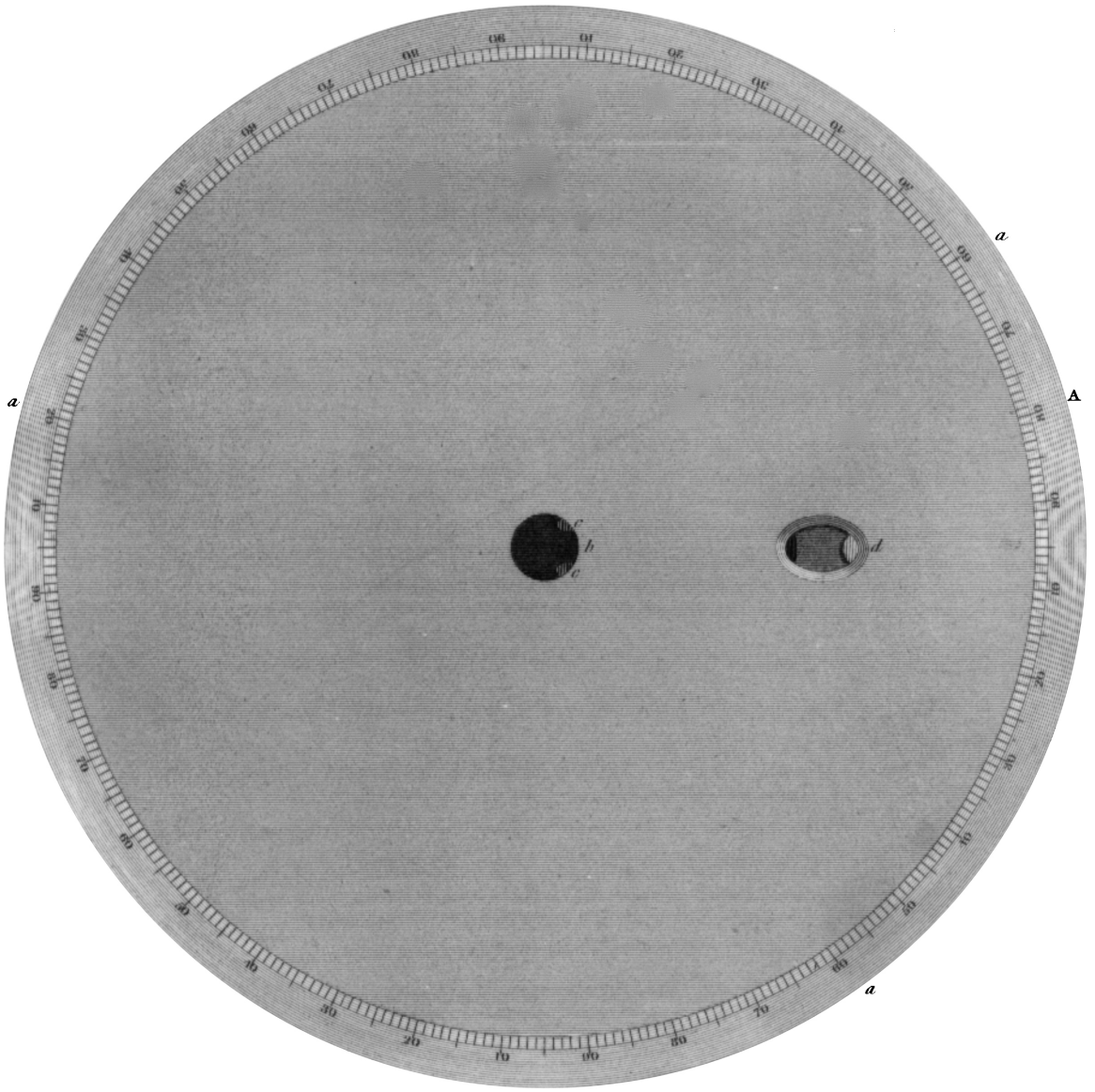
CLINOMETER





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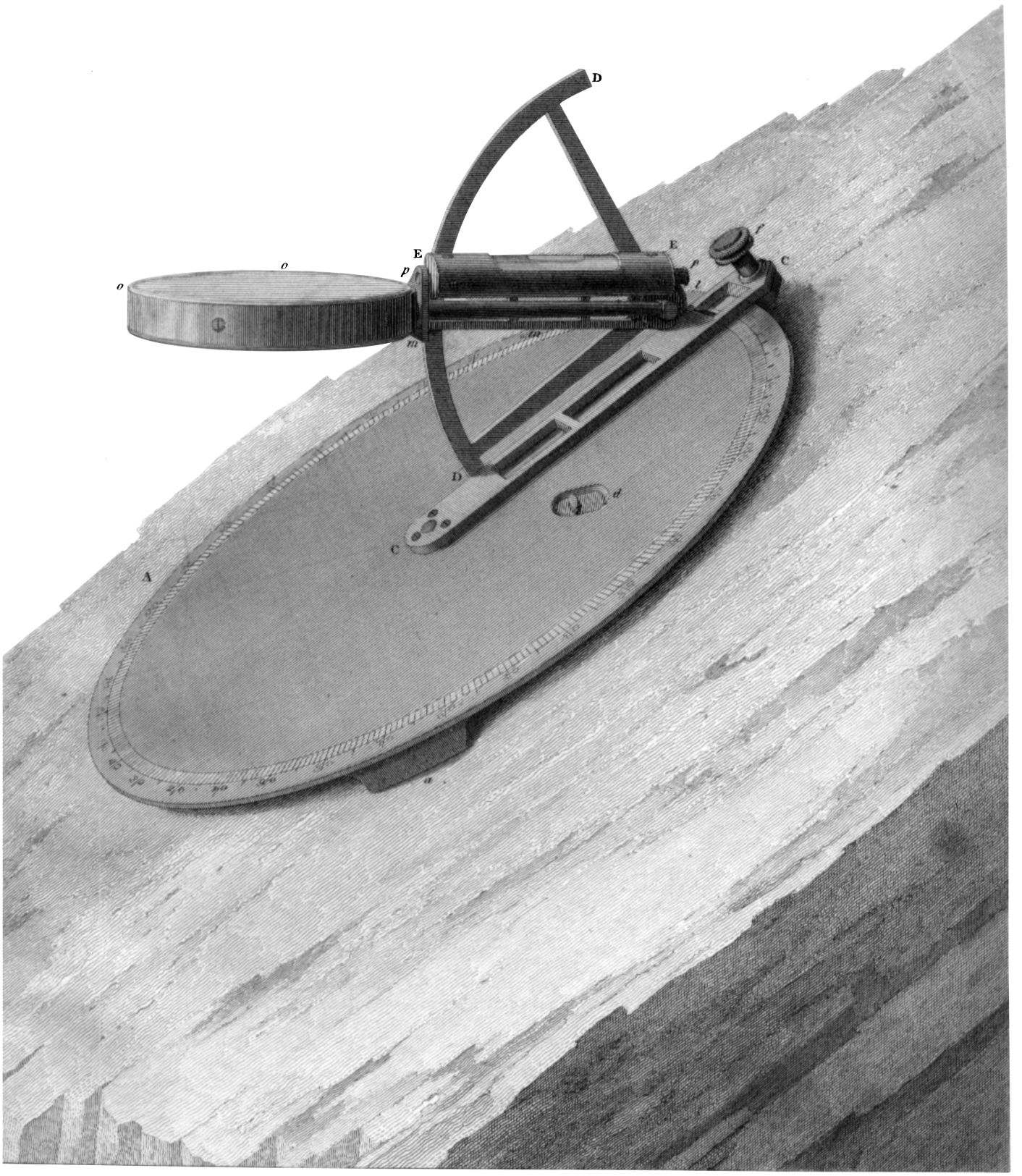

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