ON THE USE OF THE GLOBE IN THE STUDY OF CRYSTALLOGRAPHY.[1]

IN modern treatises on crystallography, the crystal is imagined projected radially on the surface of a sphere, and the spherical triangles so obtained are dealt with by spherical trigonometry. Problems in astronomy and mathematical geography are also commonly dealt with by the methods of spherical trigonometry. But they can also be dealt with completely by the method of graphical construction on the surface of a sphere where the angles and arcs are directly measured with a divided circle; and the use of spherical trigonometry is dispensed with. Many years ago it occurred to the author that what eliminated the use of spherical trigonometry in the one case might eliminate it in the others: hence the idea of the use of the globe in the study of crystallography. Various arrangements of globe and circles were described and exhibited. The usual method of mounting globes on a polar axis, round which it can revolve inside a metal meridian, supported in its turn at right angles to a horizontal circle or equator, was found to be inconvenient. It is necessary to be able to reach every part of the globe, and to have it steady for drawing, and the fixed circle and axes stand greatly in the way of this. The instrument found most generally useful was a black globe, along with a system of brass circles, divided into degrees, which can be applied directly and exactly to any part of its surface. The system of brass circles is called the *métrosphère*, invented by Captain Aved de Magnac, of the French Navy, and published by E. Bertaux, of Paris. With this instrument every problem in the geometry of crystals can be solved with ease and accuracy by graphic construction alone.

The various manipulations occurring in the use of the globes were described and illustrated. In the practical determination of a crystal, the inclinations of its faces are observed with the goniometer. From these observations, treated usually by the methods of spherical trigonometry, the elements of the crystal, namely, the inclination of its axes and the proportion of its parameters, are deduced. The process is then reversed, and the elements found are assumed, and from them the inclinations of the faces are calculated. The usefulness of the globe was illustrated by demonstrating how these two processes can be carried out by simple graphical construction. On the globe, the face of a crystal is represented by its pole, or the point where the radius of the sphere, which is perpendicular to the face, pierces the surface of the sphere. The angle between two faces, measured by the goniometer, is the angle contained between their normals. It is therefore ready to be transferred directly to the globe on which it is entered as an arc. In doing so, any point on the globe is taken as the pole of the face from which a start is made. From this a great circle is drawn in any direction. When the first angle has been measured on the goniometer, it is laid off on the globe as an arc, of an equal number of degrees, along this great circle, and from the initial fixed point. The poles of the first pair of faces are situated at the extremities of this arc, which becomes the *base line* of the survey of the crystal. By triangulation from it, the angles being supplied by the goniometer, the positions of the poles of all the faces are placed as points on the globe.

The intersection of a face with the surface of the globe is a circle, which may be described on it with a pair of compasses, taking the pole of the face as centre. The circles in which any two faces, which are not parallel, meet the sphere, cut each other in two points. If these points be joined by the arc of a great circle, we obtain the projection of the edge which the two faces make on meeting. It is perpendicular to the great circle passing through the poles of the two faces. If it be carried parallel to itself to the centre of the sphere, it coincides with a diameter, and its poles are indicated by points on the globe. When the operation has been repeated with all the edges, we have a second group of points on the globe, which catalogues the edges occurring on the crystals.

If the circles of intersection, with the surface of the sphere, of any three faces, not in the same zone, be considered, the arcs connecting each pair of intersections meet in a point which is the projection of the *corner* formed by the three faces which meet there. A third group of points, representing corners, is thus obtained on the globe, and the characteristics of the crystal are exhausted.

If the corners be carried parallel to themselves to the centre, they find themselves already represented by the intersections of the diameters representing their edges. If the similar poles of any such group of diameters be connected by arcs of great circles, a spherical triangle or polygon is marked out, and its area compared with that of a hemisphere is a measure of the corner, just as the arc is the measure of the angle which it subtends. The secondary figures thus described on the surface of the sphere are always different from the primary ones. Thus the corners of the cube, when collected at and radiating from the centre of the sphere, delineate the regular octahedron, which in its turn, when similarly treated, delineates the cube. From this point of view they are reciprocal inversion forms.

Having got a complete projection of it on the globe, the crystal can be studied. It can be referred with equal ease to any system of coordinates and to any number of different systems; it is only necessary to shift the *métrosphère* over the surface of the globe. In fact, there is now no question touching the geometry of the crystal which cannot be directly answered after making one or more simple measurements; and the distinction between easy questions and difficult ones has almost disappeared.

The projection of the crystal has been constructed from supposed observed angles on the goniometer; but it is equally easy to construct it from its crystallographic specification—that is, the inclination of the axes and the proportion of the parameters.

The projections, of the normals to the faces, or the coordinate planes, are found by constructions on these planes. These positions are marked on the sphere by the points on the coordinate circles where they meet its surface. A great circle drawn through any one point, at right angles to the coordinate circle, contains the pole of the face. It is also contained in another great circle, found in the same way. It is fixed in their point of intersection.

In this way every possible face, permitted by the specification, can be easily and readily placed on the sphere by its representative pole; and the angles between every pair can be at once taken off with a pair of compasses or a tape. In a few minutes a complete catalogue can be made of the angles which each face makes with every other one. The advantage of this is particularly apparent in the oblique systems, which on the globe are dealt with as readily and as easily as those of the regular system.

In conclusion, the author alluded to other uses of the globe, where it does easily, and without fatigue, work which can be done in no other way without great labour; and he pointed out an important indirect advantage, gained by its use, in the education of the sense of direction, which is generally only sparingly developed in the mind.

[1] Abstract of a Paper read before the Chemical Society, December 6, 1894, y J. Y. Buchanan, F.R.S.

THE USE OF SAFETY EXPLOSIVES IN MINES.

A LARGE committee was appointed by the North of England Institute of Mechanical Engineers in 1888, to investigate and report upon the subject of flameless explosives in relation to their degree of safety in mines. Experiments with various explosives and appliances connected with shot-firing were commenced in 1892 at Hebburn-upon-Tyne, and a number of papers referring to them have been contributed to the Institute's *Transactions*. The first part of the Report of the Committee has just been published, and it clears away many of the doubts and uncertainties connected with the employment of safety explosives in underground workings. Into the details of the experiments we have not space to enter, but the following conclusions deduced from them show the kind of results obtained:—

(1) All the high explosives (ammonite, ardeer powder, bellite, carbonite, roburite, and securite) are less liable than blasting-powder to ignite inflammable mixtures of air and fire-damp. These explosives, however, cannot be relied upon as ensuring absolute safety when used at places where inflammable mixtures of air and fire-damp may be present.

(2) The variable results following upon the detonation of high explosives appear to be due in some measure to defective admixture of, or variation in the proportions of, the ingredients used in the manufacture of the explosive.

In view of the changes from time to time made in the proportions and constituents of high explosives, it seems desirable that this information should be afforded by the manufacturers to the users of the explosive.

(3) In the storage of high explosives, it is desirable that every care should be taken to insure their being maintained in a proper condition. It is also certain that these explosives alter in character with age.

(4) It is essential that similar examinations of the working-places and precautions which are in force in mines where blasting-powder is used, should be rigidly observed when a high explosive is employed.

(5) In selecting a high explosive for use in a mine, it should not be forgotten that the risk of explosion is only lessened and not abolished by its use.

(6) All of the high explosives on detonation produce evident flame.

(7) The emission of flame from a blown out shot of a detonated high explosive is not prevented by the quantity or length of stemming used.

(8) In the case of a charge of a high explosive which has missed fire, if a short length of stemming (proved up to 8 inches) has been employed, the charge can be detonated by another cartridge of the explosive and additional stemming being placed in the hole in front of the original stemming.

The experiments were carried out under the direction of Mr. J. L. Hedley, H.M. Inspector of Mines, and Mr. A. C. Kayll, the Engineer to the Committee.

The sincere thanks of mining engineers are due to the Institute for bearing the great expense involved by the experiments, and to the many mining companies, associations, and private firms that have rendered valuable assistance in the matter.

THE UPSALA MEETING OF THE INTERNATIONAL METEOROLOGICAL COMMITTEE.[1]

AT the meetings of the International Meteorological Committee, held at the University of Upsala, in August, the secretary submitted a brief report, with the questions proposed for discussion. A statement of these, with the decisions, follows:—

International Bureau.—A report was presented by Prof. Hildebrandsson, in which the functions and cost of such a bureau were considered. The committee decided against its establishment.

Agricultural Meteorology.—Upon the proposition of Mr. Scott, it was decided that the methods employed to distribute weather predictions to farmers, and the results of climatological discussions relating to the crops in the various countries, be published.

Establishment of Stations for Cloud Observations.—Prof. Hildebrandsson presented a pamphlet containing a detailed account of the principal methods employed in these investigations. The committee adopted these resolutions:—

Since experience shows that the altitude of clouds can be easily determined with sufficient accuracy, the generalisation of these investigations in all countries is recommended, preferably by the use of the photographic process. Observations of direction and relative velocity should be made at as many stations as possible, and measures of height at a limited number of suitably distributed stations.

The value of these investigations would be greatly increased if made at the same epoch, therefore it is proposed that they be commenced May 1, 1896, and continued for one year.

The stations already promised are situated in Batavia, France, Norway, Portugal, Prussia, Roumania, Russia, Sweden. United States: Blue Hill, and Weather Bureau (six stations).

Cloud Atlas.—The committee appointed at Munich reported slightly modified definitions of some types in the Hildebrandsson-Köppen-Neumayer Atlas, and submitted photographs and pastels for reproduction in the new atlas, as well as instructions for observing clouds. These were adopted by the Permanent Committee after discussion and modification. (See subjoined report.) A special committee, composed of M. Teisserenc de Bort and Prof. Riggenbach, with Prof. Hildebrandsson as chairman, was appointed to publish the atlas, and the choice of the colour of each place, to represent as nearly as possible the natural conditions, was left to its discretion.

More Rapid Transmission of Telegrams.—Dr. Snellen presented a joint report with Dr. Neumayer on this question, in which the necessity of giving the meteorological dispatches precedence over others, by opening a circuit system with the other central bureaus, was urged. The introduction of simultaneous observations in the various countries was deemed necessary. The committee referred the matter to the International Telegraphic Bureau at Berne.

In more or less intimate relation with this question was a proposition by Dr. van Bebber, on the importance of further experiments in tele-meteorography. Dr. Snellen explained the telegraphic transmission of the traces of self-recording instruments by the Olland apparatus, which operates over a short distance at Utrecht.

Scintillation of Stars.—At the request of M. Ch. Dufour, this question, which had been the object of investigations by M. Montigny, of Brussels, was brought before the committee. Further study by him, together with that of M. Ventosa, on the atmospheric movements observed around stars, was encouraged.

Maritime Meteorology.—A proposition of the Russian Admiral Makaroff, on the necessity of an international convention to arrange for the discussion of the data contained in ships' logs, was not approved.

Psychrometric Observations below Freezing.—This question was introduced by Profs. Hildebrandsson and Mohn. The employment of Ekholm's method for the reduction of mean values was recommended, but a report of further investigations was requested.

Exploration of Upper Air.—A resolution received from the *Congrès de la Science de l'Atmosphère*, which had recently met in Antwerp, on the importance of the balloon ascents now being made at Berlin for meteorological purposes, was confirmed in a more general sense.

Next Congress.—It was decided to convene a non-official congress at Paris in September 1896.

THE CLASSIFICATION OF CLOUDS.

In the cloud classification of Hildebrandsson and Abercromby, published in the Hildebrandsson-Köppen-Neumayer Atlas, in 1890, the word "diurnal" is added to the definition of Group D, so that it becomes:—

D. Clouds formed by the diurnal ascending currents.

In this way, the cumulus arising from a mass of aqueous vapour ascending through calm air is distinguished from the nimbus caused by the general ascension of the whole mass of moist air.

With this change the classification of the ten principal forms is:—

(*a*) Detached or rounded forms (most frequent in dry weather).
(*b*) Wide-spread or veil-like forms (wet weather).

A. Highest clouds, mean height 9000 metres.
  (*a*) 1. Cirrus.
  (*b*) 2. Cirro-stratus.

B. Clouds of mean altitude, 3000–7000 metres.
  (*a*) { 3. Cirro-cumulus.
       { 4. Alto cumulus.
  (*b*) 5. Alto-stratus.

C. Low clouds, 1000–2000 metres.*
  (*a*) 6. Strato-cumulus.
  (*b*) 7. Nimbus.

D. Clouds formed by the diurnal ascending currents.
  8. Cumulus. Top, 1800 metres; base, 1400 metres.
  9. Cumulo-nimbus. Top, 3000–5000 metres;* base, 1400 metres.

E. Elevated fog, below 1000 metres.
  10. Stratus.

N.B.—As the heights of the clouds marked * do not agree with the heights of these clouds found at Blue Hill, Mr. Rotch has asked that the altitude of the low clouds be placed below 2000 metres simply, instead of between 1000 and 2000 metres, since the bases of nimbus are frequently below 1000 metres; and also that the superior limit of the tops of the cumulo-nimbus be raised to 8000 metres.

The following are descriptions of the clouds, modified from those in the Hildebrandsson-Köppen-Neumayer Atlas.

[1] Extracted from a report by Mr. A. Lawrence Rotch, in the December number of the *American Meteorological Journal.*