sponded to so willingly by scientific men and societies that they overlook the necessity of making any recompense for work done. In the medical services every qualified practitioner receives rank and reasonable pay, while consultants are given generous retaining fees. In legal circles also no advice is expected without a retainer is attached to it; and in this connection we are interested in the announcement that "according to a statement made in the House of Commons Sir John Simon, as Attorney-General, drew 18,000*l*. as his remuneration for the past year." It should be unnecessary to urge that the laws of nature are of as much importance as the laws of the land, and that as in the present crisis men of science can be of greater service to the nation than lawyers or politicians, they should receive at least sufficient reward for it to enable them to put aside their daily work in order to take up national duties. There will be no lack of volunteer workers among scientific men, but the State should understand that its responsibility for payment on account of expert opinion is at least as great in the case of science as it is in law, medicine, and engineering.

THE EVOLUTION OF THE GONIOMETER.

THE goniometer—as the instrument used for the measurement of the interfacial angles of crystals is called—has gradually developed from a simple and crude piece of apparatus to a refined and somewhat complex optical instrument, and the measurements made with it have become increasingly more accurate as the form improved, while on the other hand the methods of investigating the morphological characters of crystals have on the whole become simpler. Nicolaus Steno, who (in 1669) was the first to study the angles between the plane surfaces of crystals, laboriously determined them by slicing the crystals perpendicular to the edges bounding the faces in question, and outlining the sections on paper. The first instrument used for the purpose of measuring the interfacial angles is that known as the contact-goniometer, and was devised by Carangeot in 1783; it is used to this day for measuring large rough crystals. This type consists essentially of two arms, one movable with respect to the other, which are laid on the faces in question at right angles to their common edge; the position on a graduated scale of the end of the movable arm beyond the pivot gives the angle required. A cheap form of this type made in cardboard or celluloid was designed by S. L. Penfield in 1900. Accuracy to single degrees of arc is the utmost that can under the most favourable conditions be expected of the contact-goniometer.

To the ingenuity of W. H. Wollaston, in 1809, is due the reflective form of goniometer. In this type the common edge of the pair of faces under measurement is set in line with the axis of a rotatable graduated circle, and the position of the circle is read when some distant signal is reflected by the particular face in a predetermined direction; the circle is rotated, and the reading taken corresponding to the second face. The difference betwen the pair of readings gives the interfacial angle required. In the original form the graduated circle was vertical, and no means existed for fixing accurately the direction of reference. In a goniometer described shortly afterwards, in 1810, by E. L. Malus, a telescope of low power was used for receiving the reflections, and assuring, therefore, the constancy of the direction of reference, and in 1839 J. Babinet designed an instrument with a horizontal circle. E. Mitscherlich introduced many improvements and accessories in 1843; he added a collimator in place of a distant signal, and his screw arrangements for centring and adjusting the crystal are in principle the same as those generally used now. The horizontal-circle form of goniometer is extensively used at the present day, and the optical features and accessories have been brought to a high standard of perfection by the well-known firm of R. Fuess, of Berlin, who have devoted considerable attention to crystallographical instruments. Spider-lines were first used in the collimator, and afterwards the ordinary spectroscope-slit, but neither are satisfactory for goniometer work owing to the diffusion of the image on reflection at the tiny faces such as often occur on crystals. The difficulty was investigated by C. F. M. Websky, and in 1878 he described a slit, the jaws of which consisted of coplanar circular discs in contact, or nearly so, at the middle. This slit allows plenty of light to pass at the top and bottom, and the constriction at the centre admits of refined readings. In its original form, or slightly modified, this slit is universally used in modern goniometers. For the purpose of viewing the crystal while in position and determining what face gives a particular reflection, the telescope is usually supplied with a lens which is applied in front of either the objective or the eyepiece for converting it into a microscope of low power. In a well-made instrument, if the crystal reflections admit, readings may be made to 30 minutes of arc.

Various modifications of this type have from time to time been devised. In 1903 H. A. Miers used an inverted form, that is one in which the crystal is suspended below the graduated circle, for making observations on crystals growing in their mother liquor. He also designed a stage goniometer for the measurement of the optic axial angle of small crystal flakes under the microscope. More recently, in 1911, Dr. A. Hutchinson designed a convenient form of inverted goniometer for the study and measurement of tiny crystals or crystal fragments. In the universal goniometer (Fig. 1), as he terms it, the telescope A and collimator C are placed at some convenient angle to one another, and a microscope B is so arranged that its axis bisects the angle between them. The instrument may be used in the ordinary way as a goniometer, as an axial-angle apparatus (a fitting carrying nicol and condensing lens being placed for the purpose opposite the microscope), as a total-reflectometer of the Kohlrausch type (the crystal being immersed in a specially made tank containing a highly refractive liquid), and as a refractometer by the prism method (the telescope being removed and attached to the graduated circle, and the crystal-holder transferred to the rod used for bearing the tank-table).

It is obvious that in the case of a goniometer with a single circle only one zone of a crystal can be measured at a time. The difficulty of measuring with such an instrument a small, many-faced crystal is consequently very great, and there is grave risk of mistakes being made owing to tiny faces of similar appearance being confused. W. H. Miller, when measuring a complex crystal aggregate in 1874, was the first to recognise the advantage of defining the position of each face on a crystal by a pair of angular co-ordinates analogous to the latitude and longitude of a place on the earth's surface—in the case of a crystal it is, however, more convenient to make the pole the origin of measurements—and thus avoiding the necessity of altering the adjustment of the crystal, at least during the measurement of one half of it. In this method a goniometer with two circles mutually at right angles is required. Miller merely clamped one goniometer with a vertical circle on to another with a horizontal circle; a brief description of the instrument was given in a posthumous paper (published in 1882 by his successor, Prof. W. J. Lewis, F.R.S.), but attracted little attention. Instruments on similar principles were designed by E. S. Fedorov in 1889, and V. Goldschmidt in 1893. A different pattern, in which the optical parts are movable about a horizontal axis, was designed by S. Czapski in 1893. F. Stöber in 1898 described a simple piece of apparatus consisting of a graduated circle, to which a crystal-holder was attached radially, for replacing the ordinary crystal-holder of the one-circle goniometer. This attachment has the inconvenience that in any position of the telescope the reflections from certain diametrically opposite parts of the crystal are obscured, and it is necessary to move the telescope through a measured angle; moreover, since the circle moves in so large a collar, accurate readings cannot be expected.

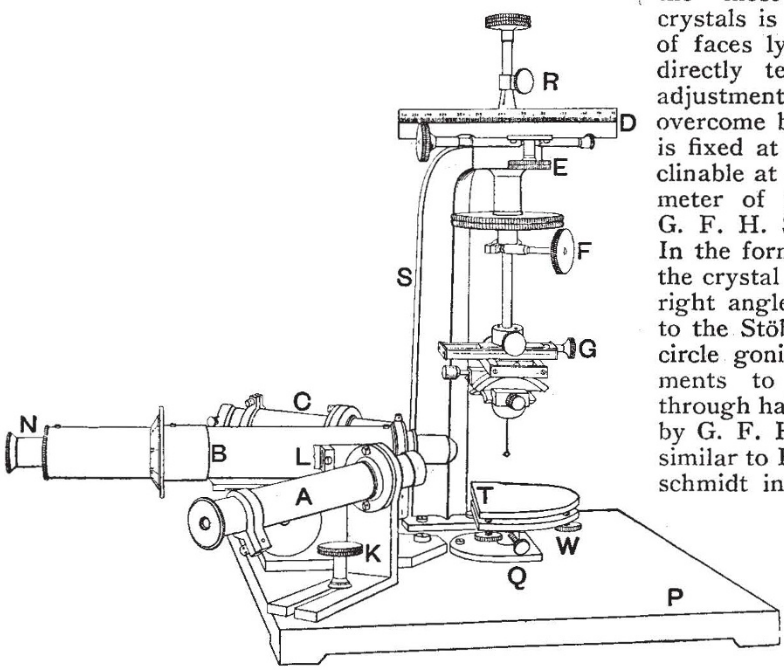

FIG. 1.—Hutchinson's Universal Goniometer.

In the measurement of a crystal with a two-circle goniometer, if, as happens in the triclinic and sometimes in the monoclinic systems, a face of symmetry is not crystallographically possible at right angles to the edge of the zone of symmetry by which the crystal is adjusted, measurements are not made in zones, and consequently the most important property characterising crystals is not utilised. In any case the zonality of faces lying in or near cross zones cannot be directly tested on the instrument without re-adjustment of the crystal. The difficulty may be overcome by the addition of a third circle, which is fixed at right angles to the second, and is inclinable at any angle to the first circle. A goniometer of this type was described in 1899 by G. F. H. Smith, and in 1900 by J. F. C. Klein. In the form designed by E. S. Fedorov, in 1900, the crystal has two motions about axes mutually at right angles in large semi-circular collars similar to the Stöber circle already mentioned. A three-circle goniometer with modified optical arrangements to allow of continuous measurements through half a revolution in any zone was designed by G. F. H. Smith in 1904. An instrument very similar to Fedorov's was described by V. M. Goldschmidt in 1912.

CHEMICAL FIRE-EXTINGUISHERS.

THE article on "The Extincteur and its Limitations" in NATURE of June 3 described some practical points relating to the construction, tests, and use of portable fire-extinguishers now widely advertised and purchased. So much attention has been given to the article that a supplementary account of the chemistry of such extinguishers should be of equal interest and service. In putting out fire the chief things to be aimed at are the reduction of temperature and the exclusion of oxygen. Either will suffice if it can be obtained in a great enough degree, for combustion will not proceed if the temperature of the burning substance is lowered beyond a certain point; nor—apart from special cases with which we are not now concerned—can it take place in the absence of oxygen. In one class of the special preparations devised for use as fire-extinguishers the two effects are usually combined; in another class the second effect is chiefly the means relied upon to secure extinction of the fire.

Water charged with carbon dioxide is the commonest example of the first class. The water