

unsettled point is the question whether the corona takes part in the sun's rotation. Sir Norman Lockyer explained the connection between the spectra of stars and their temperature, and referred to the discovery that the spectrum of the sun's chromosphere is similar to that of the principal absorbing layer in  $\gamma$  Cygni, which he characterised as a Rosetta stone of solar and stellar spectroscopy. He showed how the spectra of the various layers of the chromosphere indicate a gradual increase of temperature from without inwards, and announced with reserve, that the Indian photographs suggested that the wave-length of the chief coronal line required revision. Sir William Crookes suggested the appointment of a joint committee of chemists and physicists to examine quietly the question of solar spectra. Captain E. H. Hills exhibited his photographs of the spectrum of the inner corona. Captain Abney and Prof. Thorpe, who intended to take part in the discussion, were unable to be present at the meeting.

In meteorology, the Ben Nevis Committee sent a report of extended work, a station having been established at a point half-way up the mountain, and observations taken hourly during a portion of the year. The Committee on Meteorological Photography reported through Mr. Clayden that the work of simultaneously photographing clouds near the sun from two stations in an east and west line had been continued, the results showing that in hot, thundery weather the alto-cumulus and cirro-cumulus clouds attain great heights, sometimes reaching 90,000 feet. In order to make observations in the early morning and late afternoon a change of base line to a north and south direction is contemplated. The report of the Seismological Observations Committee deals with many phases of earthquake work, and in introducing it Prof. Milne emphasised the importance of securing better accommodation for seismological apparatus. He compared the seismological laboratories of Italy and Japan with the only one of this country, namely his own house at Shide, Isle of Wight. The Sectional Committee has taken steps towards securing the aid of the Government in providing suitable housing for seismological apparatus. The Montreal Meteorological Observatory reports having obtained successfully in McGill University Physical Laboratory records of the temperature on the top of Mount Royal; the installation of other apparatus recording at a distance is being proceeded with. Prof. Callendar described an application of his platinum thermometer as a sunshine recorder, by registering the temperature-difference between a bright and a blackened thermometer. Mr. A. L. Rotch recorded an ascent of the Hargrave kite to a height of 11,440 feet at Blue Hill, Mass., U.S.A. Dr. van Rijckevorsel drew attention to a similarity, even in details, between the annual curves of temperature, air-pressure, rainfall, magnetic declination, vertical and horizontal magnetic force. He considered this to be a proof of similarity of origin of magnetic and meteorological phenomena. Mr. Douglas Archibald indicated a classification of weather types in western Europe, lasting for several days, and thus permitting the possibility of extending the present daily forecast. Simultaneous telegraphic reports from a greater number of stations would be necessary. Mr. Hopkinson read a paper on the climate of south-western England.

Among papers on general physics, Mr. W. N. Shaw exhibited a pneumatic analogue of the potentiometer, in which air-currents set up by gas jets at the lower ends of two tubes take the place of electric currents. The author pointed out its application to some problems of ventilation. Mr. A. W. Warrington described hydrometers of total immersion, which are hydrometers loaded with platinum weights until they are on the point of sinking; a slight rise of temperature of the liquid then causes them to do so. For liquids, the method is accurate to one part in a million. For solids, a kind of Nicholson hydrometer without tray is used, and the temperature is determined at which the instrument has no weight in water (1) loaded with mercury alone, (2) loaded with the solid and mercury. The results are accurate to one part in 100,000. Mr. W. R. Barker described and exhibited some interesting old weights and measures of Bristol. In sound, if we except Lord Kelvin's communication on the continuity of undulatory theory for sound, elastic-solid and electric waves, the only paper presented was that of Dr. R. J. Lloyd on the articulation and acoustics of the spirate fricative consonants. In this paper the differences between the articulation and resonance of the consonants  $f$ ,  $th$ ,  $h$ ,  $s$ ,  $sh$  and  $ch$  are discussed, and the author points out that the first three differ in the length and width of the frictional passage of the throat producing them, whereas the last three require some kind of fore-cavity

which modifies and subdues the frictional noises. In the case of  $s$  and  $sh$  there is strong resonance from both the fore-cavity and the hinder cavity, the two sounds being differentiated by the second friction against the tips of the lower teeth in producing  $s$ .

We shall take another occasion to refer to the proceedings of the Magnetic Conference.

During the meeting a collection of physical apparatus was exhibited in the physical laboratory of University College by Messrs. J. J. Griffin and Sons. It included an assay balance entirely free from steel, carrying 5 grammes and weighing to 0.00002 gramme, and a chemical balance weighing to 0.0001 gramme, both of which were provided with arrangements for weighing fractions of a gramme without opening the case. Holloway's crucible furnace, Davis' induction coil and X-ray bulbs, were also exhibited, as well as a simple form of apparatus for the measurement of expansion of solids, in which a rod fixed in a water bath between two glass rods is heated and displaces the glass rods; these pass through the sides of the water bath, and their displacement is measured directly by micrometer screws. The absence of optical devices for measurement increases greatly the simplicity of the instrument, which is said to yield fairly good results for lecture purposes.

### MATHEMATICS AT THE BRITISH ASSOCIATION.

SATURDAY in the British Association week is a holiday for most of the Sections; the mathematicians and physicists, thus freed from competition, bid for two audiences instead of one, and take papers on mathematics and meteorology in separate rooms. This year the mathematical session, over which Lord Kelvin presided, was very well attended.

The first paper, read by Colonel Allan Cunningham, was a report on the work of the Committee appointed some years ago, with Lord Kelvin as chairman, for calculating tables of certain mathematical functions. It was explained that a set of tables has been prepared, giving the residues of powers of 2 for all prime moduli less than 1000. The plan is much the same as that of Jacobi's Canon Arithmeticus; but Jacobi uses as base a primitive root of the prime number concerned, which is inconvenient in practical calculations. The tables are now complete in MS., and nothing remains but to print them. It is to be hoped that the Association will see its way to printing them separately in quarto, as their usefulness will be much diminished if they are printed on the smaller page of the Annual Report; but it seems likely that, partly for financial reasons, they will not be published at all for another year.

The next paper, "The mathematical representation of statistics," by Prof. Edgeworth, was read in abstract by one of the Secretaries, in the absence of the author; and the following one, "On the use of logarithmic co-ordinates," by Mr. J. H. Vincent, was taken as read, but is to be published in full in the Annual Report.

One seldom sees lantern illustrations to a paper read at the mathematical session. But the next two subjects on the list can be treated experimentally as well as mathematically. In the first, "A new method of describing cycloidal and other curves," Prof. Hele-Shaw, of Liverpool, showed a new instrument for drawing the curves which can be got by rolling one circle on another. Perhaps its most striking feature is that the radii of the fixed and rolling circles may be as great as we please, their centres not being restricted, as in the ordinary instruments, to the limited range of a drawing board. Thus the radius of the fixed circle may be made infinite, when its circumference becomes a straight line, and the common cycloid is traced on the paper.

Another considerable advantage is, that the complete curve required can be drawn in many cases where the ordinary methods would only give a portion of it, or would only give the whole curve after several operations.

Since an ellipse of any eccentricity may be described by means of a point attached to a circle rolling within another of twice its diameter, it is clear that this instrument can be used for drawing ellipses. It differs from the elliptograph of Messrs. Alexander and Thomson, which depends on the same property, in having two pairs of toothed wheels instead of one; this improvement gets rid of some of the defects of the older arrangement, with which ellipses can only be got under limited conditions.

The inventor expressed his opinion that mathematicians would

find this instrument a help in explaining to beginners the properties of roulette curves in general. While most teachers will probably reply that machines of this kind are more trouble than they are worth in teaching, no one will question their interest to the full-grown mathematicians themselves.

A second paper by the same author dealt with his experiments on the motion of a viscous fluid between two parallel plates. A remarkable theorem, due to Sir George Stokes, which was communicated together with the experimental paper, renders this work of great importance. In Prof. Hele-Shaw's arrangement, liquid is forced between close parallel plates, past an obstacle of any form; and the conditions chosen are such that, whether from closeness of the walls, or slowness of the motion, or high viscosity of the liquid, or from a combination of these circumstances, the flow is regular. This is best attained by using glycerine as the fluid; then by colouring the jets which enter between the plates at certain points, the lines of flow in the liquid are made visible, and can be thrown on a lantern-screen or copied. Now Sir George Stokes's discovery is this, that the stream-lines thus experimentally obtained are the same as the stream-lines in the steady motion of a *perfect* (i.e. absolutely inviscid) liquid flowing past an infinitely thin long rod, a section of which is represented by the obstacle between the parallel walls which confine the viscous liquid. A complete graphical solution is thus experimentally obtained of a problem which, from its complexity, baffles the mathematician except in a few simple cases.

Owing to the similarity, so far as mathematics are concerned, between problems relating to the motion of a perfect fluid and the problems of electricity and magnetism, this gives also a method of investigating electrical and magnetic problems, in which the effect of placing a body of any required form and resistance (i.e. with any value of  $\mu$ ) in a uniform field can be obtained.

The beauty of the experiments greatly interested the audience, many of whom were probably unable to follow easily Sir George Stokes's mathematics; it is to be hoped that some of the results will figure before long as diagrams in hydrodynamical textbooks.

Of the next paper, "Graphic representation of the two simplest cases of a single wave," by Lord Kelvin, an account will subsequently appear in these columns.

At meetings of the mathematical session in future years it is proposed to have a number of reviews of recent progress in various branches of pure mathematics, similar to those frequently prepared by German and American mathematicians. Several such reports are being arranged for next year, and this year a paper on "The recent history of the theory of the functions used in analysis" was given by Mr. E. T. Whittaker. The paper traced some of the more notable developments in the theories of special classes of functions, notably the automorphic functions and the functions of harmonic analysis. Then, speaking of the way in which most of the knowledge reviewed has been gained, "Isolated functions are invented, as Legendre's and Bessel's functions were invented, for the solution of physical problems. The work of the pure mathematician is to find the connection between them, to assign them places in an ordered series, and to develop their common theory. The arrangement once made, the gaps in the series are manifest. Every gap points to a function hitherto unknown, which is discovered and returned to the physicist, as the interest on his original deposit."

Two papers by Dr. Johnstone Stoney followed. The first, "The dynamical explanation of certain observed phenomena of meteor streams," attempts to account for the facts observed in meteoric showers on the earth, by considerations as to the streams of meteors which cause them. A shower may be very short, or it may last several days; its radiant—the point in the sky from which the stars appear to shoot—may remain fixed, or it may move; the disposition of the shower about its maximum may be symmetrical, or it may not; and in all these respects, the showers due to the same stream of meteors may behave differently in different years.

At each encounter of the meteors with the earth a number are caught and blaze themselves out in the atmosphere; a still larger number narrowly escape, and are deflected from their course by the earth's attraction. Dr. Stoney showed how the subsequent history of these "clino-meteors" will account for the facts noticed. This is especially interesting in view of our approaching encounter with the Leonid meteors.

In a second paper, "A survey of that part of the scale upon which nature works, about which man has some information," Dr. Stoney reviewed the range of our knowledge of magnitudes, and discussed what might be if the scale of our conceptions were of another order.

The last paper on the day's list was by Prof. G. J. Stokes, of Cork, on "The imaginary of logic." The search for a philosophical theory of  $\sqrt{-1}$  has occupied men's minds ever since it was found that "impossible" quantities were useful. After classifying various views on the matter, the author said that the generally adopted position, that  $\sqrt{-1}$  is uninterpretable in single or pure algebra, is paradoxical; for how can what is essentially meaningless possess an important meaning in its extraneous use? Then explaining the logical theory of the imaginary, he applied it to De Moivre's Theorem. The paper concluded with a comparison of the Calculus of Boole's Laws of Thought with that of Grassmann's Ausdehnungslehre, and some remarks on the relation of non-commutative algebras to ordinary mathematics.

### FORTHCOMING BOOKS OF SCIENCE.

IN the list of M. Félix Alcan (Paris) are to be found:—"Névroses et Idées Fixes," by Prof. Raymond and Prof. Pierre Janet; ii. "Fragments de leçons cliniques sur les névroses, les maladies produites par les émotions, les idées, obsédantes et leur traitement"; "L'éducation de Sentiments," by P. F. Thomas; "La Méthode dans la Psychologie des Sentiments," by Prof. F. Rauh; "Opérus de Taxinomie," by Durand de Gros; "Chirurgie du péricarde et du cœur," by Prof. F. Terrier; "L'auditiens et les organes," by le Dr. Gellé (Bibliothèque scientifique Internationale); "La céramique ancienne et moderne," by Guignet and Garnier (Bibliothèque scientifique Internationale); "La géologie expérimentale," by Prof. Stanislas Meunier.

The list of Messrs. Baillière, Tindall, and Cox includes:—"Aids to Psychological Medicine," by T. A. Beadle; "Chronic Nasal Obstruction, and Deformities of the Upper Jaw, Teeth, and Palate," by Dr. M. P. Mayo Collier; "Dictionary of Medical Terms," by H. de Méric, Part i., English-French, Part ii., French-English; "A Text-book of Operative Veterinary Surgery," by Dr. George Fleming, Part ii.; "Cattle Tuberculosis; a Practical Guide to the Farmer, Butcher, Meat Inspector," by Dr. T. M. Legge; "Aids to Materia Medica," by Dr. W. Murrell; "Essays for Students," by Stephen Paget; "The Analysis of Food and Drugs," in five parts, by T. H. Pearmain and C. G. Moor, Part ii.; "The Chemical and Biological Examination of Water"; and new editions of "Heart Disease, with Special Reference to Prognosis and Treatment," by Sir Wm. H. Broadbent, Bart., F.R.S., and Dr. J. F. H. Broadbent; "The Throat and Nose and their Disease," by Lennox Browne, illustrated; "Manual of Physiology, with Practical Exercises," by Prof. G. N. Stewart, illustrated; "Handbook of Surgical Pathology," by Drs. W. J. Walsam and A. A. Kanthack; "Aids to the Diagnosis and Treatment of Diseases of Children (Medical)," by Dr. J. McCaw; "A Guide to the Examinations of the Conjoint Board in England, and for the Fellowship of the College of Surgeons, with Examination Papers," by F. J. Gant; "Handbook for Attendants on the Insane, Prepared by Authority of the Medico-Psychological Association; "Practical Guide to the Public Health Acts, and Correlated Acts for Officers of Health and Inspectors of Nuisances," by Dr. T. W. Hime.

Messrs. Blackie and Son, Ltd., promise:—"Recent Advances in Astronomy," by Dr. A. H. Fison; and "The Science of Life," by J. Arthur Thomson.

Messrs. W. Blackwood and Sons give notice of:—"A Text-book of Agricultural Zoology," by Fred. V. Theobald, illustrated; "Intermediate Text-book of Geology," by Prof. Lapworth, F.R.S., founded on Dr. Page's "Introductory Text-book of Geology," illustrated; and a new edition of "Introductory Text-book of Zoology," by Prof. Henry Alleyne Nicholson, F.R.S., and Alexander Brown, illustrated.

The list of the Cambridge University Press includes:—"Collected Mathematical Papers," by Prof. P. G. Tait; "The Scientific Papers by John Couch Adams," vol. ii., edited by Profs. W. G. Adams and R. A. Sampson; "A Treatise on Octonions," a development of Clifford's bi-quaternions, by Prof. Alexander McAulay; "On the Kinetic Theory of Gases," by S. H. Burbury, F.R.S.; "A Treatise on Spherical