THURSDAY, APRIL 24, 1919.

THE NATION'S DEBT TO SCIENCE.

THE noble record of the universities and schools of England in the recent war may one day come to be written. It is doubtful if anyone has realised as yet how great will be its full extent. There is one page in particular which will contain more than is grasped even by those who have had the best opportunities of doing so. It will tell of the special work of the men who have been trained in the scientific and technical laboratories.

The war has called for every ounce of scientific knowledge and effort. It could not be otherwise when great nations have been straining their utmost, and when the advantage has so often gone with the best use of every help that modern knowledge could give. The scientific battle has been fought by the laboratory men.

The mastery of the air, for example, has depended on the skill and courage of the pilot, but also, very vitally, on the perfection of his machine. The latter, in its turn, has depended on the knowledge gained with infinite care by those who have tested out each detail of design. The engine itself with its many complicated parts, the form of the struts and planes, the covering fabric and the varnish applied to it, the recording instruments, the photographic gear, the signalling apparatus, the machine-guns, the bomb-dropping arrangements, each of these has been the subject of experimental research requiring the highest technical skill. Each was improved beyond all belief during the war: by how much labour and devotion only those intimately connected with the work can tell. Some of our finest men of science lost their lives in this service. Yet on all this improvement the success of air warfare depended, for it was the last additional strength or trustworthiness, quickness of manœuvre, or power of flight that gave the pilot confidence and superiority; and the staff who carried out this work, whether at Government experimental stations or at the National Physical Laboratory, or elsewhere, were for the most part drawn from the laboratories of the universities and technical schools.

So, too, with the brigade of chemists, who did so much in the war. Professors and lecturers became senior officers in the brigade; junior officers were drawn from the students. They fought the German gas, devising the protective masks and instructing the Army in their use; they worked out the processes for manufacturing gases on a large scale for the use of our own armies. The huge industry of the manufacture of explosives required the solution of chemical problems, which they accomplished, and so saved the nation vast sums of money, and made it possible to supply the Army with all that it wanted. They produced the smoke-screens, and the special bullets that brought down Zeppelins and observation balloons. They solved innumerable problems involved in the great business of supplies; they were constantly the advisers of the Munitions Department, of the health authorities, of the Intelligence, and in a thousand-and-one ways they were indispensable to the progress of the war. The nation has indeed cause to be grateful to its chemical laboratories.

A body of keen young physicists, drawn from various universities of the Empire, developed the methods of sound-ranging until it became possible to locate with extraordinary accuracy the positions of enemy guns, even during the continuous roar of the Western front; they were responsible for a great part of the locations on which artillery work depended. The same methods applied to under-water work by the Admiralty experimental stations made it possible to locate with accuracy explosions occurring hundreds of miles from the shore, and incidentally have furnished the hydrographers with a means of shortening enormously the work of charting the seas. Much of the work of the Admiralty stations, especially that which related to anti-submarine defence, may not, of course, be discussed in public. It can only be noted that here also the universities and technical schools were largely represented on the staffs.

It is impossible even to enumerate the various branches of scientific service. There was the highly efficient and most important gauge work of the National Physical Laboratory; the work of the men who listened for and located the underground operations of the enemy miners; the wide range of most important optical work, from the submarine periscope to the aeroplane camera; the research work on wireless telegraphy, which was so immensely advanced during the war; the meteorological work which was of such great service to the air forces; the geological work of the front; the bacteriology; and so forth. It is impossible to give the barest recital of all the scientific work involved in the immense problems of the medical service. In every section of the operations by land, by sea, and in the air urgent experimental work was carried on, results were obtained which were of the highest importance, and the first-class scientific work which was required was carried out mainly by the men already mentioned, the science teachers and students of the universities and technical institutions.

The war may now be over, and these special occasions for service may no longer exist. But in the long new struggle before us the need for scientific training and method is as great as ever. Our capital is gone. We must pay our debts and earn our living, and, besides, we must amend the pre-war conditions of our workers' lives. It cannot be done except by making every use of the knowledge we have already, and by labouring to add to it: that is to say, by following scientific methods. The services of the laboratory-trained men will still be indispensable. That there is a general understanding of the position is shown by the crowding of new students into the universities, and the demand for instruction in science.

But where are the teachers and the apparatus for teaching? Even before the war the salaries, especially of the junior staff, were poor and the positions few. Many of the former teachers will not come back, for some have been lost in the war, and others are being attracted by the better prospects of research laboratories and commercial work. The universities have no funds wherewith to meet the proper increases of salaries or any increase of staff, for their grants remain unchanged, all expenses have increased, but they may not raise their fees. The number of students is growing rapidly, and, as things are, increase in numbers generally means an increase in expenditure. Most of the universities are really unable to carry on without increased aid from the State.

The sowing of the seed is the last thing that may be neglected if there is to be a harvest, and all our experience, thrown into strong relief by the war, shows that the harvest of the successful development of the work of this country, work which is to pay our debts and bring comfort to our peoples, will follow only on the application of scientific method and research, which is the seed sown in universities and technical schools.

FOUNDATIONS OF ELECTRICAL THEORY.

The Theory of Electricity. By G. H. Livens. Pp. vi + 717. (Cambridge: At the University Press, 1918.) Price 30*s*. net.

ELECTRICAL theory, the most rapidly growing part of physics, has now reached such dimensions that no author can hope to produce a text-book which will deal effectively with its many aspects. A series of such books is necessary which shall take different points of view and lay especial emphasis in certain broad directions. We already have several, and notably the works of Jeans and Richardson, which are both comparatively recent. But lacunæ remain, and one of these the present author has set out to fill. We may say at the outset that he has filled it with considerable success, for the work now before us in no way constitutes a reduplication of any important part of an existing treatise. It is, moreover, one which can be recommended without reserve to a student who is anxious to obtain a clear picture of the fundamental principles underlying certain important, and often rather neglected, aspects of electromagnetic theory.

This is said advisedly, for the feature of the book which makes the strongest appeal to the reader is probably the excellent account of that much-discussed and rather chaotic subject, the energy, stress distribution, and general mechanical relations of polarised media. Matters of this kind are usually presented very imperfectly to the student, in spite of the classical foundation which exists in papers by Larmor, and the author has done good service in directing attention to them by their incorporation, in a consistent and very complete form, within the compass of a treatise of this size. If any other section of the work were selected as deserving of special mention, it should probably be that devoted to conduction of electricity by metals, with some of the small, though fundamental, phenomena which accompany it. The author has himself contributed a great deal of work to the subjects described in these sections, and is especially qualified to give an effective account of them.

The preface describes the work as largely the outcome of a course of lectures delivered ten years ago by Sir Joseph Larmor. We may express regret that such a fine compliment is so rarely paid to those who lecture by members of their audience. Although dealing with a mathematical subject, the mathematical side is kept under control by the author, who does not expound it beyond the point necessary for a real comprehension of the principles involved, and an insight into the manner in which they must be worked out in detail. References to the more complete or elaborate investigations are provided as footnotes, and, though by no means exhaustive, these are sufficiently numerous to direct the reading of those who wish to pursue special sections of the subject.

There are two main divisions of electrical theory at the present day, both extensive. In the first place, we have the original framework of Faraday and Maxwell, developed for systems in motion by Larmor, and just afterwards, with more generality, by Lorentz. Superposed on this is the more speculative side, including the principle of relativity, theories of atomic structure, photo-electricity, and other branches, together, in fact, with all the phenomena for which the quantum theory has been invoked. We call this section speculative only by comparison, in that its mathematical and logical foundations and inter-connections are of a lower order of security. It has been well developed in existing treatises, and is not seriously touched upon in the present work. The need for a comprehensive treatise on the older form of theory, satisfactory from the point of view of mathematical and physical consistency, if not always capable of including certain phenomena within its scope, has always been felt, and this work supplies the need in a satisfactory manner. We have mentioned the principle of relativity, and in this special case it would obviously have been part of the author's plan to include some of the more striking developments of this principle in connection with gravitation, which are all very recent, and were very inaccessible in this country until the publication of Prof. Eddington's report by the Physical Society after the present work had been printed. The author himself indicates a wish to include some account of this subject, if a future edition should be called for. We are disposed to concur in his main thesis that the essential introduction to the student should be in terms of the older established theory on which the newer and more variable structure has been built—a thesis not directly expressed, but everywhere implied.

Some of the more analytical processes are dealt with in a special introduction, apart from the rest of the book. This contains such subjects as Green's and Stokes' theorems—especially in their application to moving circuits—differentiation of potential integrals, Kirchhoff's theorem—too frequently neglected—and, in particular, an elementary account of the properties of vectors and their nomenclature. This introduction is brief, but should be a great assistance to the student in preventing later diversions of his attention from the main theme. There is considerable difference of opinion as to how far the use of vector notation is in fact an assistance to economy of thought in all readers. There appears to be a personal element or predisposition in the matter, but, fortunately, the question does not arise here, as a too exclusive use of vectors is not adopted, and the style of the book is such that it should prove easy to any reader qualified to make a serious study of the subject.

No error of statement, or remark capable of a wrong interpretation, has been detected, and evidently special care has been bestowed on clearness of statement in sections where, from the nature of the subject, such clearness is not easily attained. There are apparently very few misprints, and the work, which is produced by the Cambridge University Press in the form now familiar by many recent examples, is in keeping with the traditions of the Press. J. W. N.

THE ADVANCEMENT OF EDUCATION.

(1) *The Spiritual Foundations of Reconstruction. A Plea for New Educational Methods.* By Dr. F. H. Hayward and Arnold Freeman. Pp. lxi+223. (London: P. S. King and Son, Ltd., 1919.) Price 10*s*. 6*d*. net.

(2) *The Great War Brings it Home. The Natural Reconstruction of an Unnatural Existence.* By John Hargrave ("White Fox"). Pp. xvi+367. (London: Constable and Co., Ltd., 1919.) Price 10*s*. 6*d*. net.

(1) WE welcome the freshening breeze in the educational proposals brought forward by Dr. Hayward and Mr. Freeman. "The function of the schools is to educate the community into a knowledge of Truth, a sense of Beauty, and a love of Goodness; that function they have failed to discharge." According to the authors, the failure is largely due to laughably "unpsychological" methods. A revolution is necessary. "Arithmetic, handicraft, language, and kindred efficiency subjects may be *taught*—taught to Jack and Jill by Bob and Dick." But "the class teaching of the Bible, literature, music, history, and certain other subjects should be largely abolished in favour of a liturgical, ceremonial, or celebrational treatment." There should be days *devoted* to great personalities (St. Paul, Alfred the Great, Joan of Arc, St. Francis, George Washington) or great ideas (the League of Nations, France, agriculture, science, freedom). The humdrum duties of life should be expounded in lessons in which the main emphasis is on the reason, matters of personal hygiene, for instance, being brought home by scientific argument. In the liturgy reason would be subordinate to feeling—to "admiration, hope, and love." Representatives of all sects, parties, professions, movements, etc., as well as teachers, should be urged to give addresses to the whole school at times set apart for this in the liturgical arrangements. On such occasions, so far as accommodation could be provided, parents and "the public" should be invited.

The authors expound these proposals with conviction, and we are wholly convinced. If even a little could be done in the directions indicated (and in some cases illustrated in concrete detail) there would be education of the heart and conscience, an enrichment of the memory, a widening of horizons, and a vitalising of the whole school life. The authors have taken the trouble to anticipate and answer thirty objections, and this makes good reading.

In addition to the proposals we have referred to, Dr. Hayward and Mr. Freeman advocate the preparation and utilisation of charts showing the geological ages, the course of human history, the solar and stellar systems, the history of science, of art, and of great ideas. This is an educational method used here and there, but, on the whole, undreamt of and long overdue. The charts can be made vivid if brains are put into the making of them, and where colours are used it pays to get an artist to choose them. We should personally have liked more "Nature" days than the authors seem to think of, but we are heart and soul with their recommendations.

(2) Mr. Hargrave's book was written before the war, but he has been able to strengthen it since his return to civil life. For his convictions have been deepened by experience, and the urgency of his recommendations seems to him greater than ever. He has been impressed with the unnaturalness of man's life in ordinary civilised conditions. Instead of evolving a sane, healthy, and hardy race, the trend of civilisation seems to be in the opposite direction. The type that is being increasingly produced is not only

unnatural; it is not even fitted for civilised conditions. Too many lives are lacking in health, happiness, and real efficiency. What Mr. Hargrave pleads for is more outdoor education and a renewed enthusiasm for vigour. Modern educational methods have tried to dispense with the natural individual recapitulation of racial history, and the result has been a dismal failure. Mr. Hargrave pleads for real sojourning with wild Nature, camp education, tribal training for boys, hardihood camps for young men, adolescence initiations, and open-air meditation. Perhaps there is a tendency to exaggerate the importance of tribal training; perhaps the author is not quite sound in his view of human instincts and their origin; perhaps it is not very fortunate to speak of "that process of natural selection known as Evolution"; perhaps the practical difficulties in the way of methodical open-air education for large numbers are under-rated; but there is no doubt that the book is full of the true eugenist enthusiasm and of valuable suggestions for making much of outdoor life and Nature's school. It expresses the boy scout's idea raised to a higher power.

Two general remarks we venture to make in reference to both books: (*a*) Half a loaf is better than no bread, and if a teacher cannot go all the way either with the open-air education of Mr. Hargrave or with the "spiritualised" education of Dr. Hayward and Mr. Freeman he may go some way; and (*b*) the relative failure of past educational endeavours is not wholly due to imperfect methods; it is largely due to imperfect material. Who is bold enough to set limits to what improved nurture can do? but a soberminded vision cannot ignore the sad limitations of inborn nature. Yet one remembers a famous answer given to Nicodemus. J. A. T.

OUR BOOKSHELF.

The Cultivation of Osiers and Willows. By W. P. Ellmore. Edited, with Introduction, by Thomas Okey. Pp. x+96. (London: J. M. Dent and Sons, Ltd., 1919.) Price 4*s*.

THE growth of osiers, as willows used for basket-making are popularly called, was a declining industry before the war, owing to foreign competition. From Germany, Holland, and Belgium we received, year after year, not only increasing quantities of osiers, but also large importations of baskets and basket-ware, as well as huge consignments of hoops for herring barrels, which are the product of a year or two's extra growth of the common species. Alarmed at the decline of an important local industry like basket-making, the Board of Agriculture, in order to encourage the extension of the area under willow cultivation, published a series of articles by Mr. W. Paulgrave Ellmore on the subject in its Journal for 1911 and 1912, which were reprinted in 1913 as a booklet—"Board of Agriculture, Miscellaneous Publications, No. 18." The present handbook is an enlargement of this, and is well worthy of the attention of farmers and landowners who have land suitable for the growth of willows. Osiers, it is necessary to point out, require good land in order to succeed, such as low-lying alluvial tracts beside rivers and streams, and they fail miserably on wet, undrained, swampy, or peaty soils.

Mr. Ellmore gives sound information on the cultivation and harvesting of the osiers and on the preparation of the rods for the market. A chapter on the numerous varieties which are used gives no botanical details, but is of interest in pointing out the special uses, adaptations to soils, etc., of these puzzling forms, which are generally supposed to have arisen through hybridisation of the four or five species under which they are classed. Another chapter deals with insect pests and methods of control. A final chapter treats of the three willows which are grown for their timber.

Standard Tables and Equations in Radio-telegraphy. By Bertram Hoyle. Pp. xiv+159. (London: The Wireless Press, Ltd., 1919.) Price 9*s*. net.

IN his preface the author claims that no such complete book of tables and equations exists for the use of radio engineers. It is difficult, however, to see the guiding principle he has adopted in selecting his formulæ and tables. Several of the tables are antiquated, if not actually obsolete, and some of the information might well be given in an elementary text-book of arithmetic.

The author begins by giving the latest formulæ for calculating the capacity and inductance of various geometrical-shaped objects with high accuracy. Judging from this and other books on the subject, one would infer that radio-telegraphists spent most of their time in making calculations by the laborious formulæ so familiar to readers of the mathematical bulletins of the Bureau of Standards. Yet it is of importance to be able to calculate the capacity between spherical conductors or between parallel wires, and so we wonder why no formulæ are given for them in this book.

We find a table of haversines, but, as the haversine is not defined and we have forgotten what it means, it is no great help. We are given tables of all kinds of wire gauges—the Birmingham, the Brown and Sharpe, Stubs's steel wire, Whitworth's, piano-wire gauge, etc. For practical purposes these gauges are obsolete. Electricians and cable-makers nowadays talk about a 0·0100 wire—*i.e.* a wire the diameter of which is the hundredth of an inch. They do not talk about a No. 33 wire S.W.G. It is astonishing how long the gauge system, which was hopelessly unscientific, lasted in this country. We hope that when the cable-makers' new standards are published next summer the wire gauges will soon be forgotten.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Ionisation and Radiation.

WHEN X-rays pass through a gas, only a very small fraction of the molecules—in favourable circumstances, one in a billion—is ionised by them, and the extent of this ionisation is unaffected by temperature. Writers on radiation seem to have difficulty in reconciling this with the wave theory of light. I venture to suggest that the difficulty arises from an imperfect comprehension of what the wave theory requires.

The inverse square law of intensity ought not to hold for very small spaces and very small times. The uniform spherical wave spreading out from a point source is a mathematical fiction. What we really have is a very great number of spherical wavelets, each diverging from a different electron, criss-crossing in various directions, and consequently interfering with one another. For example, suppose that there are n electrons in the source, all close together, and that the intensity of radiation is required at a point P at a distance r, great in comparison with the linear dimensions of the source, and so sensibly the same for all the electrons. Let the intensity at P due to a single electron be I/r^2. Then the resultant intensity may be anything from 0 to n^2I/r^2, according to the number of wavelets coincident in phase at P, the lower values predominating. If the phases of all the different waves are absolutely at random, the problem reduces to a celebrated one solved by Lord Rayleigh, and the chance of a particular intensity J is

$$\frac{r^2}{In}e^{-Jr^2/In}dJ.$$

It follows simply from the laws of chance that the intensity must be exceptionally great at some points; the very existence of an average value implies this. If one in a billion molecules is ionised, the ionising intensity works out at 27·6 times the average intensity at P. If there is any regularity of structure in the source, Lord Rayleigh's expression may not do justice to the higher intensities.

Thus it is not necessary to assume that X-rays consist of neutral atoms, or that the ether has a fibrous structure, or to take refuge in the nebulous phraseology of the quantum theory; the explanation follows naturally from the principle of interference as expounded by Fresnel. R. A. HOUSTOUN.

University, Glasgow, April 11.

The Whiteness of the Daylight Moon.

WATER holding in suspension fine particles of mastic scatters a blue light. Place behind the containing vessel a yellow surface. (1) If this is bright, its light, transmitted through the vessel, prevails, and we see the yellow. (2) Subdue the illumination of the yellow surface sufficiently, and the water appears white, the yellow and the blue just compensating each other. (3) Subdue the yellow still more, and the scattered blue again becomes evident. If in case (2) we use a Nicol, then, for minimum transmission, the white changes to yellow; but, for maximum transmission, to blue, because the scattered blue light is largely polarised.

Now Nature supplies us on a large scale with an admirable example of similar phenomena. Suppose the moon to be at her first quarter in daylight. The moon's reflected light is yellowish, that of the sky is blue, due to scattering, and is considerably polarised 90° from the sun. Between us and the moon there is sky. The whiteness of the daylight moon is, in my opinion, an example of case (2) above, and at the first quarter I find that she behaves to a Nicol in the way already described. I have not previously met with any account of this grand natural example of the fact that a mixture of blue and yellow lights produces white. C. T. WHITMELL.

Invermay, Hyde Park, Leeds, April 15.

REFRACTOMETERS.

AMONGST the physical properties which are characteristic of a substance, the refractive index is one of the most important. From a theoretical point of view, the fact that refractivity is mainly an additive quantity—the molecular refractivity being approximately the sum of the atomic refractivities—is highly significant. From a practical point of view, the ease and accuracy with which refractive indices can be determined by modern methods are of great service, both to the physicist and to the chemist, in the examination of the materials with which they have to deal. Whether for purely scientific or for technical purposes, such a determination affords a rapid method of finding the concentration of solutions and the purity of oils, fats, waxes, and foodstuffs. New applications are continually arising in a variety of industries dealing with drugs, sugars, paints, varnishes, glue, gelatine, and other colloids. The physicist finds the method of service in the identification of optical glasses or in the study of singly or doubly refracting crystals.

A ray of light passing from an optically dense to a rarer medium is bent away from the normal to the surface, and when the angle of incidence assumes a certain definite value the emergent ray just grazes the common surface. For angles of incidence greater than this *critical angle*, the light is no longer refracted, but undergoes total internal reflection. The refractive index, in passing from the rare to the dense medium, is the reciprocal of the sine of the critical angle. It is interesting to learn that the first to apply this property as a practical method for finding the refractive index was Wollaston, who constructed and described in the *Philosophical Transactions* in 1802 a critical-angle refractometer, using a right-angled prism as adopted later by Pulfrich.

In 1874 E. Abbe, of Jena, described the refractometer which, as constructed by the firm of Zeiss, has been familiar for the past forty years. In this instrument the substance to be examined is placed on the hypotenuse face of a right-angled prism, having one of its angles accurately 60°. When the substance is a solid, optical contact with the prism is made by means of a liquid of higher refractive index than the solid; when a liquid is to be examined, one or two drops are enclosed as a film between two similar prisms. It has been pointed out previously in these columns that *both* these prisms should be made of glass of high refractive index, in order to secure sufficient illumination (NATURE, June 21, 1917). The prism system is rotated by means of the index arm until a dark shadow comes into the field of view of the telescope, and the edge of the shadow is adjusted exactly on the cross-lines. The refractive index for sodium light is then read directly on the scale of the instrument, the accuracy of reading being one or two units in the fourth decimal place. When white light is employed, the dispersion of the emergent light is neutralised by means of an Abbe compensator. It is satisfactory to find that British firms have produced instruments which are undoubtedly superior to the German pattern, and that they have been able to supply the demand in various Government Departments that has arisen during the war. The firm of Adam Hilger now produces standardised instruments in which not only the mechanical, but also the optical, parts are interchangeable (Fig. 1). Tables of refractive

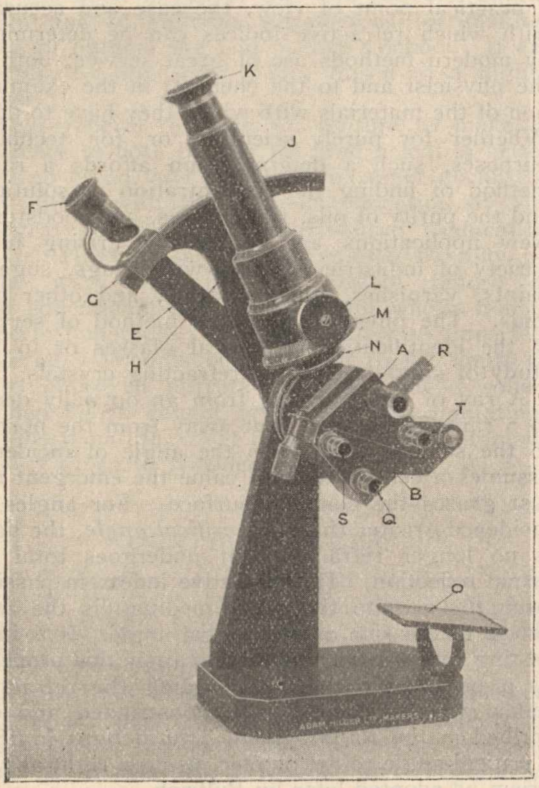

FIG. 1.—Abbe Refractometer (Adam Hilger, Ltd.). A, Upper prism jacket; B, lower prism jacket; E, reader arm; F, reader; G, scale; H, scale arm; J, telescope; K, telescope eyepiece; L, milled head for Abbe compensator; M, scale for Abbe compensator; N, adjusting ring for lower D.V. prism; O, mirror; Q, S, and T, prism jacket nozzles; R, nozzle with thermometer chamber.

indices of industrial substances are in course of publication, and should prove of great value.

Messrs. Bellingham and Stanley have produced an instrument of distinctive design, embodying several improvements on the German type (Fig. 2). The prism-box is now designed to open away from the operator, which makes it much easier to examine plastic or solid substances. It is no longer necessary to reverse the instrument, and full use may be made of the illuminating mirror. At the same time, the change permits of greater rigidity of construction. The reader arm is provided with a slow motion by a simple friction device, and the halves of the prism-box may be separated automatically by a small movement of the clamping head. The lower half is so constructed that it can be removed quickly without tools.

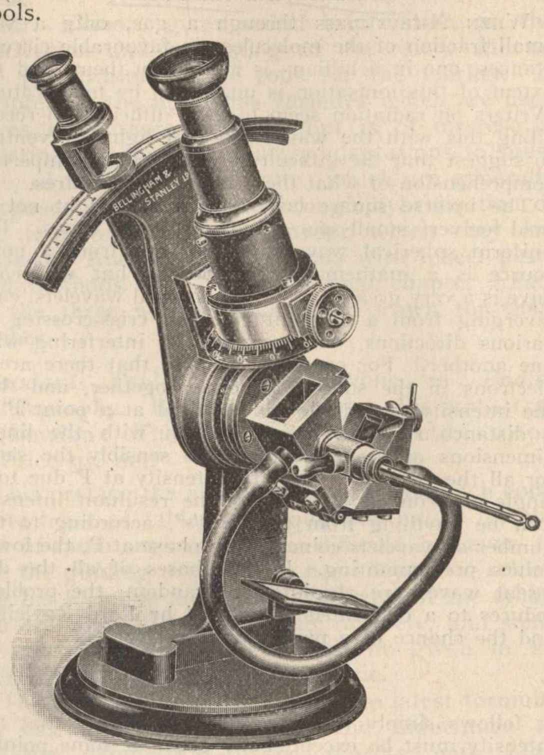

FIG. 2.—Abbe Refractometer (Bellingham and Stanley, Ltd.).

When measurements of a higher degree of accuracy are desired than is possible with the Abbe type of instrument, the dipping refractometer (Fig. 3) may be employed, but with a single fixed prism readings can be obtained only over a limited range of refractive index. The prism of the instrument dips into the liquid, which is placed in a small containing vessel, and the refractive index is determined by the position of the border-line of total reflection seen in the eyepiece. The eyepiece carries a photographic scale, and a micrometer screw adjustment is provided whereby the position of the border-line with respect to the scale division may be measured directly. A table is supplied giving the refractive index in terms of the scale reading. In the German type of instrument the prism is cemented into its holder, and can be used only for solutions of refractive indices between 1·325 and 1·367. In hot and moist climates the solution frequently creeps up through the cement on to the upper face of the prism. When this occurs, or when the prism is damaged, it is necessary to return the entire instrument to the makers. Messrs. Bellingham and Stanley have improved the design of the instrument, and arranged for the prism to be capable of easy removal for cleaning purposes or for renewal. An additional advantage of this method of construction is that a series of prisms may be employed, giving further ranges of refractive indices

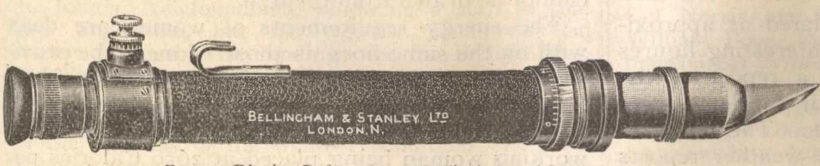

Fig. 3.—Dipping Refractometer (Bellingham and Stanley, Ltd.).

up to 1·55, with an accuracy of three or four units in the fifth decimal place.

For measurements of still higher accuracy, the Pulfrich refractometer is available (Fig. 4). In ordinary use this instrument will give results four or five times as accurate as those obtained by

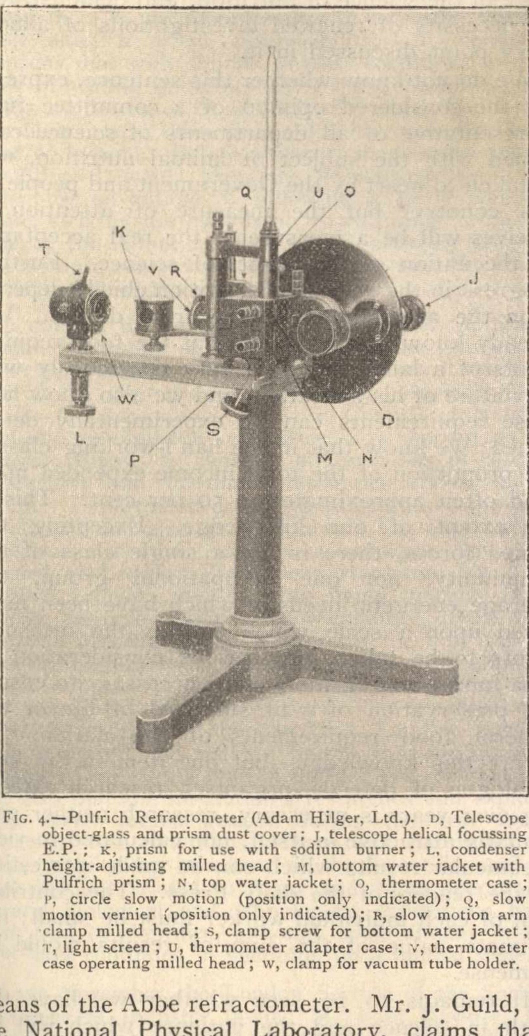

Fig. 4.—Pulfrich Refractometer (Adam Hilger, Ltd.). D, Telescope object-glass and prism dust cover; J, telescope helical focussing E.P.; K, prism for use with sodium burner; L, condenser height-adjusting milled head; M, bottom water jacket with Pulfrich prism; N, top water jacket; O, thermometer case; P, circle slow motion (position only indicated); Q, slow motion vernier (position only indicated); R, slow motion arm clamp milled head; S, clamp screw for bottom water jacket; T, light screen; U, thermometer adapter case; V, thermometer case operating milled head; W, clamp for vacuum tube holder.

means of the Abbe refractometer. Mr. J. Guild, of the National Physical Laboratory, claims that, with proper care in design and use, the Pulfrich refractometer will give results accurate to the fifth decimal place, not only in the dispersion, but also in the absolute index. In this instrument the substance to be examined is placed on top of the horizontal surface of a block of glass of known refractive index. Rays entering the substance from one side can pass out from the opposite vertical surface of the Pulfrich prism only when they enter above the horizontal boundary surface. A sharp line representing the rays which have just been able to enter the prism is observed in the telescope. The angle of emergence is measured by rotation of the telescope, which is attached to a divided circle. Messrs. Hilger have designed a new instrument in which all screw-heads are brought within reach of the observer's right hand. Direct readings on the vernier of the divided circle are accurate to one minute, and on the divided drum of the slow motion to six seconds. In accurate measurements the questions of temperature control and of the source of light employed must receive careful consideration.

THE ATLANTIC FLIGHT.

THE first attempt to cross the Atlantic by aeroplane will go down to posterity as one of the milestones in the progress of aviation, and there seems little reason to doubt that this feat will soon be accomplished. The two main factors affecting the result are the trustworthiness of the engine and the state of the weather. The best engines of to-day are capable of running for periods considerably longer than that required for the crossing, and, although it is impossible to say that a given engine will accomplish a twenty-hour run without mishap, the chance of failure due to engine breakdown is by no means exceptionally great. On the other hand, the weather is extremely difficult to forecast, and very little information is obtainable as to the conditions prevailing at a height of 10,000 ft., even though the surface conditions are fairly well known. Every possible provision will be made for the safety of the aviators in the case of a forced descent at sea, but the element of risk is naturally a very serious one, and we can but admire the men who are so ready to face it.

Mr. Hawker, on his Sopwith machine, is carrying a collapsible boat, attached to the upper side of the fuselage, containing signalling devices and provisions for two days. Even with such a precaution the risk would be very great in a rough sea, and the chance of attracting the attention of ships would be small. It is understood that Mr. Hawker will not be able to send, but only to receive, wireless messages. This is unfortunate, for in the event of a forced descent the machine would take about ten minutes to glide from a height of 10,000 ft., and there would be ample time to get into communication with any vessels in the vicinity. It is intended to drop the undercarriage of the Sopwith machine soon after starting, a gain of several miles per hour being thus rendered possible owing to the decreased head-resistance of the machine. A daylight landing is a necessity under these conditions, and a slight crash is inevitable.

The time of crossing is estimated at approximately twenty hours, and some interesting figures relating to this point given in a report of the Meteorological Section of the Air Ministry were referred to in last week's NATURE. These figures are based on the average of the weather reports available, and show that under the best conditions the time of crossing for a machine with a speed of 100 miles per hour, flying from west to east, is only 14½ hours in the month of April, and under the worst conditions 23 hours. The corresponding times for an east-to-west crossing are 21 and 36 hours. The advisability of a start from the American side is thus plainly demonstrated.

Although Mr. Hawker, with his Sopwith machine, was the first to be prepared for the start, it seems likely that prevailing bad weather will give other competitors time to get ready, and that the Atlantic attempt will be of the nature of a race. It is to be hoped that the desire to be first across will not lead any competitor to start before the weather conditions are reasonably favourable, as the risks are sufficiently great under the best conditions, and the loss of such experienced pilots as those engaged in the present attempt would be most regrettable. Meanwhile, every endeavour will doubtless be made to choose the best moment for the start, and we will hope that before many days are past a new and great triumph will be added to the annals of aeronautical science.

THE FOOD REQUIREMENTS OF MAN.

THE Food (War) Committee of the Royal Society has recently issued a report[1] on the food requirements of man and their variations according to age, sex, size, and occupation, which summarises existing knowledge in a manner intelligible to the ordinary citizen. The customary units of measurement are carefully defined, and it is suggested that the energy requirements of those engaged in various occupations should be estimated in terms of the amount of energy necessarily set free in the body to ensure equilibrium under the given conditions.

A provisional classification is into sedentary work, where the excess expended during eight hours' work over that transformed during eight hours' sleep is not more than 400 Calories; light work, the excess being 400–700 Calories; moderate work, 700–1100 Calories; heavy work, 1100–2000 Calories. The method is illustrated upon the data of Becker and Hämäläinen, the food requirements of males being found to vary from 2750 Calories for a tailor to 5500 for a woodcutter. In the following section the influence of external temperature is discussed, regret being expressed that the statistics of consumption during different months of the year are so inadequate that valid inferences cannot be drawn from them.

The energy requirements of women are dealt with on the same lines as those of men, the provisional figures ranging from 1783 Calories for a seamstress to 3281 for a laundress (net energy values), the food requirements of the average working woman being placed at 2650 Calories per diem.

In the following section the scanty data concerning the needs of children and adolescents are epitomised, and the report ends with a cautious description of the qualities of the proximate principles and their respective *rôles* in a dietary. The final sentence runs as follows: "The above report shows how very inadequate is our present knowledge of the science of nutrition, and demonstrates the necessity of renewed investigations of almost every point discussed in it."

We do not know whether this sentence, expressing the considered opinion of a committee fully representative of all departments of science concerned with the subject of animal nutrition, will be taken to heart by the Government and people of this country, but the measure of attention it receives will be a measure of the real acceptance by the nation of the gospel of science. Further progress in the science of nutrition chiefly depends upon the accumulation of accurate details. We already know, for instance, that the food requirements of a labouring man vary enormously with the nature of his avocation, and we also know how these requirements can be experimentally determined; we know that in the hand-working classes the proportion of the total income expended upon food often approximates to 50 per cent. This is the extent of our knowledge. Excepting the armed forces, there is not a single class of the community, not one occupational group, the average energetic needs of which have been measured upon a scale which entitles the measurements to be taken into serious consideration as data for estimating the income necessary to ensure the preservation of a fit standard of life or the general food requirements of the nation. To secure this knowledge—but one item in the long catalogue of defects—organised research extending over years is necessary, research neither particularly attractive in itself, nor calculated to yield spectacular results which can be made interesting to the readers of the daily Press. The contribution of each individual worker must be small; the ultimate value of the sum of results would be immense.

It remains to be seen whether we have the faith in science and the patience which will be necessary to replace the scattered fragments, which are all we now have, by a well-compacted body of exact information.

[1] Report on the Food Requirements of Man and their Variations according to Age, Sex, Size, and Occupation. Pp. 19. (London: Harrison and Sons, 1919.) Price 1s. 6d.

NOTES.

THE Atlantic has not yet been spanned by aircraft, although two aeroplanes are reported as ready for the eastern flight, and at present are only waiting quieter and more favourable conditions in mid-Atlantic. Towards the close of last week much snow fell at St. John's, Newfoundland, rendering a start at that time impossible, but the weather conditions had become favourable for landing over the British Isles, and have continued so for some days, the weather during Easter being remarkably fine and clear. The *Times* for the early days of the present week shows by the bulletins of the weather conditions along the Atlantic course issued by the Air Ministry that the barometric pressure has been very high both over the British Isles and in Newfoundland; but, although the weather is fine and the winds are light, there is much fog over Newfoundland, extending eastward so far as 43° W. longitude. In central Atlantic the barometric pressure is lower than on either side, and the fog, together with the winds, "constitute unfavourable conditions for the flight." If the Air Ministry intends to say when the conditions in mid-Atlantic are favourable—and from the daily bulletins given there is an inference that it does—the Ministry undertakes a great responsibility. It commonly happens that with similar weather conditions to those now prevailing on either side of the Atlantic storm-areas are developed in mid-Atlantic, and follow a more northerly track than usual, drifting towards Greenland or Iceland. Before a start is made under present conditions it would. therefore, be worth while to consider the advantage of following a fairly southerly route, striking northwards on approaching the eastern side of the Atlantic. This would probably lengthen the distance somewhat, but it might lessen the chance of falling in with a storm.

A COPY of the report of the secretary of the Smithsonian Institution of Washington for the year ending June 30, 1918, has been received. From it we learn that at the suggestion of the National Advisory Committee for Aeronautics the U.S. Council of National Defence appointed a committee, now known as the Aircraft Board, to consider all questions of aircraft production and to make recommendations to the military Departments for the production and purchase of aircraft and aircraft appliances. The experimental laboratory of the Advisory Committee has been erected at Langley Field, near Hampton, Va. The original Langley man-carrying flying machine, after several successful flights, is now exhibited in the U.S. National Museum. This machine is the first heavier-than-air man-carrying machine constructed, although it did not have a successful flight until more than ten years after its construction. The machine confirms the claim that the late Prof. Langley was the first to design and build a heavier-than-air machine capable of carrying a man in flight. The report points out also that the institution's researches and explorations were limited greatly during the year under review by war conditions. There was, naturally, unusual activity by members of the scientific staff in investigations related to Army and Navy operations. Several biological and ethnological expeditions have been held in abeyance, although some already in the field have continued in operation on a limited scale.

LAST November the London Section of the Society of Chemical Industry invited M. Paul Kestner, the president of the Société de Chimie Industrielle, to deliver an address in London, and advantage was taken of this occasion to inquire whether it was possible to promote some co-operation between French and English chemists. M. Kestner, with characteristic public spirit, has during the last few months taken energetic steps to bring this about, and the recent conference held in Paris marks an important advance. Among those taking part in the conference were Prof. Chavanne (Belgium), Profs. Moureu and Matignon, M. Kestner, and M. Poulenc (France), Senator Paterno and Dr. Pomilio (Italy), Mr. Henry Wigglesworth, Col. Norris, and Dr. Cottrell (United States), and Sir William Pope, Prof. Louis, and Mr. Chaston Chapman (Great Britain). It was decided to form an inter-Allied confederation for pure and applied chemistry which should organise permanent co-operation between the various countries, and co-ordinate scientific and technical knowledge as well as contribute to the advancement of chemistry in its fullest extent. The inter-Allied council is to consist at the moment of six representatives from each of the nations mentioned above. The first meeting will be held in London on July 15–18, when the inter-Allied council will be the guests of the Society of Chemical Industry, the annual meeting of which then takes place. For the time being the secretary of the inter-Allied federation will be M. Jean Gerard, 49 rue des Mathurins, Paris. Particulars of the London meeting can be obtained in due course from Dr. Stephen Miall, 28 Belsize Grove, N.W.3.

ON April 14 the Board of Agriculture and Fisheries was notified that a dog suspected to be suffering from rabies had been killed at Byfleet, Surrey. Post-mortem investigation proved that the dog was rabid. It had wandered from a house in Ealing on April 11, and during its three days' wandering is stated to have bitten five persons and several dogs. Two or three further cases of suspected rabies have since been reported in the London area. In consequence, the Board has made an Order prescribing the muzzling of dogs with wire-muzzles over an area which includes the whole of the counties of London and of Middlesex, nearly the whole of Surrey, and portions of Buckinghamshire, Hertfordshire, Berkshire, and Hampshire. It is to be hoped the necessary muzzles will quickly be forthcoming (at the moment of writing they are difficult to procure), that the authorities will rigorously enforce the Order, and that the public will support their action. It may be recalled that the similar Order by Mr. Walter Long in 1896–97 ensured complete immunity from rabies in this country for more than twenty years. Since rabies reappeared in Devon and Cornwall last September 150 cases have been reported.

AT the annual meeting of the Society of Glass Technology, held on April 16 in the Applied Science Department of the University of Sheffield, Mr. W. F. J. Wood, president of the society, referred in his presidential address to the Research Association that has been formed in the glass industry. A provisional committee has been appointed, and at an early date all manufacturers in the industry will be invited to join the Glass Research Association. Substantial promises have already been received, and it is felt that the scheme will be a decided success. Sir Frank Heath, Secretary of the Department of Scientific and Industrial Research, also addressed the meeting. He pointed out that the glass industry had been engaging the anxious consideration of the Government as much as, if not more than, any industry in the country since the war began. During the war the Department had been enabled to help the industry in many ways, and would do so in the future. There was a great call from other industries besides that of glass for State aid in research. Research was insurance for knowledge, and he appealed to the Research Association to get the best men possible for their work. Mr.

S. N. Jenkinson has been elected president of the society for the ensuing year.

THE annual meeting of the Society of Chemical Industry will be held in London on July 15–18. The King has consented to act as patron and the Prince of Wales as vice-patron. The opening meeting will be held at the Mansion House on July 15, when the Lord Mayor will extend the civic welcome, and Prof. Henry Louis will deliver his presidential address. Arrangements have been made for the delivery of an address by Sir William J. Pope, and for the holding of conferences on Empire sugar production, the leather, dye, and fermentation industries, and power plants in chemical works. Further particulars will be announced later.

ON Tuesday next, April 29, Prof. A. Keith will give the first of a course of four lectures at the Royal Institution on British Ethnology: The People of Wales and Ireland. On Thursday, May 1, Dr. H. S. Hele-Shaw will give the first of two lectures on clutches. The Friday evening discourse on May 2 will be delivered by Prof. J. W. Nicholson on energy distribution in spectra; and on May 9 by Sir George Macartney on Chinese Turkestan: Past and Present. On Saturday, May 3, Prof. H. S. Foxwell will give the first of two lectures on chapters in the psychology of industry.

THE spring and autumn meetings of the Institute of Metals will be held, respectively, in London on May 19 and in Sheffield on September 24–25. At the London meeting Prof. F. Soddy will deliver the ninth annual May lecture on "Radio-activity," for which cards of invitation may be obtained from Mr. G. Shaw Scott, 36 Victoria Street, S.W.1, upon receipt of a stamped and addressed envelope. The Sheffield meeting will be the first provincial gathering of the institute to be held since the war. The headquarters will be at the University of Sheffield.

WITH the view of giving archæologists and other people interested in the question of the antiquity of the human race an opportunity of examining some of the flaked flints found in the detritus bed beneath the Red Crag of Suffolk, Mr. J. Reid Moir has, with the co-operation of the council of the Royal Anthropological Institute, arranged for a good series of these specimens to be exhibited in the rooms of the institute, 50 Great Russell Street, W.C.1, for one month from Friday, May 2.

THE subject for the Jacksonian prize of the Royal College of Surgeons of England for 1920 is "The Results and Treatment of Gunshot Injuries of the Blood-vessels." The subject for the next Triennial prize of the college is "The Anatomy, Morphology, and Age-changes of Cervical Ribs in Man, including a Description of the Associated Ligaments, Muscles, Blood-vessels, and Nerves."

WE regret to see the announcement of the death of Mr. D. Rintoul, head of the physics department of Clifton College since 1885, when he succeeded the late Prof. A. M. Worthington in that post.

THE life of the Rev. Stephen Hales, F.R.S. (1677–1761), is reviewed in an interesting article by Prof. F. Smith in the *Veterinary Review* (No. 1, vol. iii., 1919). Hales's work on experimental physiology, animal and vegetable, is well known, but his equally important researches in hygiene are apt to be overlooked. He devoted years of his life to the study of ventilation, and introduced, though not without considerable opposition, mechanical ventilation into prisons and ships. He also dealt with the ventilation of mines and hospitals, and noted that wounds healed better in tents with good ventilation than in foul air.

ACUTE infective polyneuritis is the subject of an article by Sir John Rose Bradford, E. F. Bashford, and J. A. Wilson in the *Quarterly Journal of Medicine* (vol. xii., Nos. 45 and 46). The disease is apparently a newly recognised one, characterised by generalised palsy of peculiar character. The clinical features and morbid anatomy of the disease are fully described. The disease has been transmitted to monkeys by inoculation of human spinal cord under the membrane of the brain. Very minute coccoid bodies are present in the spinal cord, and by the Noguchi culture method cultivations of a similar micro-organism were obtained. The organism measures $0{\cdot}2\mu$–$0{\cdot}5\mu$ in diameter, is rounded, oval, or kidney-shaped, and is difficult to stain. By dark-ground illumination it is merely a minute, highly refractile, undifferentiated body. The cultivations inoculated into monkeys reproduce the disease clinically and pathologically.

THE annual report of the Scottish Marine Biological Association shows that, notwithstanding the absence of the superintendent, Lieut. R. Elmhirst, on naval service, the marine station at Millport continues to contribute valuable researches in several branches of marine biology. Dr. J. F. Gemmill has made progress with his study of the development of Asteroids, and has succeeded in rearing crosses between *Solaster endeca* and *Crossaster papposus* up to the commencement of metamorphosis. He has also reared and studied the early development stages of several anemones. Other researches mentioned in the report are those of Mr. J. S. Sharpe on calcium metabolism in molluscs, and on the action of guanidine on the neuro-myal system of decapod crustacea; of Mr. H. Leigh-Sharpe on *Calliobdella nodulifera*; and of Mr. James Dick on the medusæ of the Clyde. The usual educational work has been continued, the Nature-study classes for teachers being a successful feature.

WE are glad to see that Australian ornithologists are paying increasing attention to the subject of the food of their native birds. In the January issue of the *Emu*, which has just reached us, Mr. Sidney Jackson comments on the inestimable benefits of the letter-winged kite (*Elanus scriptus*), which had established nesting colonies in the midst of an area of several hundred miles infested with millions of rats, on which they were feeding their young. Specimens of two species of these rodents were collected. The larger and more numerous was the long-haired rat (*Epimys longipilis*), the smaller the sordid rat (*E. sordidus*). The birds rested by day and hunted by night, when their prey came forth to feed. In the same issue Messrs. S. A. White and A. M. Morgan record the results of their examination of the stomachs of cormorants, which have lately been condemned on account of the supposed ravages they commit on food-fishes. They are able to show conclusively that the charges against these birds are absolutely without foundation, since no food-fishes were found, but only specimens of slow-moving species haunting weedy places, where their capture was easy.

IN 1915 R. Dodge and F. G. Benedict, of the Nutrition Laboratory of the Carnegie Institution of Washington, published a volume entitled "Psychological Effects of Alcohol." In this book they recorded the results of an investigation upon the influence of alcohol on a number of physiological processes, including various reflexes and certain kinds of reaction-time, as well as other processes of more psychological interest, such as memorising and the speed of free associations. They tested the effects of doses of 30 c.c. and 45 c.c. of absolute alcohol in ten subjects, and found a general depreciation of function on the days on which alcohol had been administered. One of their subjects showed the injurious effect of the alcohol in far less measure than the rest, although it produced certain general effects, such as sleepiness and a feeling of intoxication, which might have led one to expect the experimental tests to show a lowering of function. Dr. Walter R. Miles has now published a second volume entitled "Effect of Alcohol on Psycho-physiological Functions" (Washington, 1919), which is entirely devoted to a more extensive study of this apparently resistant subject. Using precisely the same methods as Dodge and Benedict, and working in the same laboratory under the same general conditions, Dr. Miles obtained results agreeing fairly closely with the general average of the earlier investigation. In twenty-seven out of thirty sets of results the effect of the alcohol was to lessen the value of the subject's performance, and in eleven cases this depreciation amounted to as much as from 10 to 37 per cent. The anomalous results of the first investigation seem to have been due to the effect upon the average of one or two days on which the subject had done especially well after he had taken alcohol.

THE remarkable richness of the flora of South-West China, especially in certain families, is illustrated by several papers by Prof. Bayley Balfour, W. W. Smith, and W. G. Craib which have recently appeared in the Transactions and Proceedings of the Botanical Society of Edinburgh (vol. xxvii., parts 2 and 3) and in the Notes from the Royal Botanic Garden, Edinburgh (vol. x.). The plants were collected mainly by Messrs. Forrest and Kingdon Ward. The place of honour is held by the Rhododendrons, in which genus fifty new species are described, including several from Upper Burma and Bhutan. There are also a number of new Primulas, some of which were collected in the Himalayas, a few striking autumn-flowering gentians, and two new genera of Gesneraceæ, as well as novelties in other families. Prof. Balfour also describes some interesting observations on Rhododendron seedlings, in which a juvenile character, the presence of an intense red colour, due to an anthocyanin pigment, on the undersurface of the leaf, persists for several years, and is gradually replaced by the peculiar hairiness which characterises the adult leaf. It is suggested that the change is correlated with a change in climatic relation. The young plant passes from a position in which its foliage is subject to the conditions of light, moisture, heat, and air-current belonging to a stratum at the soil-surface, to one some distance above the surface in which the same external factors operate in different intensity. Temperature and speeding-up of metabolism are prime considerations in the first environment, control of loss of water in the second. The anthocyanin development is an adaptation to the former, the hairy indumentum to the latter. Prof. Balfour also discusses, under the title "The Genus Nomocharis," a puzzling little group of lily-like plants from western China, which combine some of the characters of the true lilies and the fritillaries.

THE Experimental and Research Station at Turner's Hill, Cheshunt, an offshoot from the Rothamsted Experimental Station, continues its good work for nurserymen and market-gardeners growing under glass. The manurial experiments have been continued on substantially the same lines as in previous years, and have given practically the same results; again it is shown that farmyard manure is an efficient manure for cucumbers, and cannot adequately be replaced either by hoofs or bone-meal. Tomatoes, on the other hand, require potassic fertilisers and not so much nitrogen; indeed, in the experiments nitrogenous fertilisers have actually reduced the crop. Phosphates also had less effect than had been anticipated. The results recall those obtained at the Woburn Fruit Farm in their somewhat unexpected nature, and they bring out the necessity for a detailed physiological study of the phenomena of fruiting. The work on partial sterilisation has been extended during the year. Mr. W. B. Randall placed at the disposal of the committee a sum of money enabling it to appoint a special investigator, Mrs. D. J. Matthews (Miss Isgrove), who is studying the effect of various substances on the noxious organisms of the soil. Hitherto no agent has been found to be quite so effective as steam, and it seems possible that a mixture of substances will be necessary, one to deal with animals and another with fungi. A beginning has also been made with the study of the Noctuid moth, *Hadena oleracea*, which has become a serious menace to the tomato-growing industry; during the current year this work is to be extended considerably. A remarkable phenomenon is the zig-zag nature of the curve showing the yields of tomatoes on successive rows of plants. The outside row, as might be expected, shows the highest yield; the other rows give alternately high and lower yields. It is difficult to account for these observations, but the differences are greater than are obtained by differences in manuring. The report is full of interest to the plant physiologist.

ACCORDING to the Journal of the Franklin Institute for November, 1918, tests have been made to find the transmission factors for several slightly diffusive glasses for two kinds of illumination, viz. (1) a narrow beam of light perpendicular to the surface of the specimen, and (2) uniformly diffused light reaching the specimen from all directions above its plane, known as hemispherical illumination. The transmission-factor is, generally speaking, less for diffused (hemispherical) illumination than for the narrow beam of light. The transmission-factor of the glasses studied depends upon the position of the glass with respect to the source of light. For a narrow beam of light the transmission-factors are usually considerably greater when the rough surface faces the light than when the smooth surface is towards it. This is specially noticeable in ribbed glasses, but has not been noticed in etched glasses.

THE two sections of *Science Abstracts* for 1918 are now completed by the issue of the index parts for physics and electrical engineering. The former section extends to 575, and the latter to 492, pages, of which 62 and 37 pages are occupied by the indexes. The number of abstracts in the two sections is 1283 and 886 respectively, which are both 25 per cent. less than those of three years ago. The average length of an abstract, which has for some years been greater in the electrical engineering than in the physics section, has in the three years increased in both sections by 3 per cent. So far as can be seen from a glance through the volumes, this appears to be due to a relatively small number of abstractors supplying long abstracts rather than to a general increase in length of all abstracts. The art of conveying information in a few concise and readable lines is acquired only by practice, and a little editorial admonition might lead to a considerable improvement. Every physicist and every electrical engineer anxious to keep abreast of the times owes much to *Science Abstracts*, for without it his knowledge of what has been done in enemy countries during the last five years would have been very fragmentary.

REFERENCE has already been made in our "Notes" to the Admiralty salvage operations during the war. An article in the *Engineer* for March 21 gives an account, with illustrations, of the submersible salvage pumps and engines employed in these operations. It is not always convenient to supply current from a salvage vessel, and in such cases the electric current for driving the pumps is supplied by an oil engine-driven dynamo. It is essential that the plant should be weatherproof and unaffected by sea-spray or rain. Although a dynamo which will withstand being submerged has not yet been produced, the oil-engines described in the article are capable of being covered with water without coming to any harm. The engine cannot, of course, work while submerged. The necessity for an engine of this kind arose in connection with the installation of centrifugal pumps on a wreck situated in tidal waters, which had, owing to unforeseen circumstances, to remain in position while the tide rose and completely submerged the plant. A number of these engines have been built at the Bedford works of Messrs. W. H. Allen, Son, and Co. Up to the present there are two standard sizes, one with two cylinders of 12 brake-horse-power, and the other having four cylinders giving from 46 to 50 brake-horse-power.

AT the annual meeting of the Institute of Metals, held on March 25 and 26, the fourth report to the Corrosion Research Committee of the Institute of Metals was presented by Capt. Bengough and Dr. Hudson. The publication of this investigation, which is subsidised by the Department of Scientific and Industrial Research, has been considerably delayed owing to the request of the Admiralty that the results should not be made available during the war. The report is divided into three main parts. The first is devoted to the question of the nature of the attack which takes place when metals such as zinc, copper, and aluminium, and alloys such as 70:30 brass, corrode in neutral or nearly neutral liquids, *e.g.* distilled water and sea-water. The second section is devoted to the consideration of the behaviour of condenser tubes in similar liquids, and variations of behaviour in different samples of tubes of nominally the same composition. The third section is an attempt to set out in some detail a statement of the practical problems of corrosion in sea-water, which appear to the authors to be very different from what is usually supposed. A preliminary account is also given of experiments carried out with the object of testing an electrolytic process of protection and a pre-oxidising process designed for the same end. The authors express the view that corrosive attack on condenser-tubes is more diverse in character and complicated in nature than has been generally supposed. The first action is one of chemical oxidation, and secondary actions are of great importance. No one single remedy is likely to be found effective for all the different kinds of attack which occur in practice. The nature of the tube used and the protective measures chosen should be dependent on the particular set of conditions.

"CO-ORDINATION of Research in Works and Laboratories" is the title of a paper by the late Mr. H. R. Constantine read before the Institution of Electrical Engineers on March 27. A scheme is outlined in which it is proposed to place under the direction of a central board all the laboratories attached to the universities, colleges, and training institutions of the country, as well as many experimental laboratories connected with private works. The board would keep full records of what each laboratory was doing, and receive all inquiries for research work to be done; it would keep a record of results published all the world over. Further, the board would be invested with power to order any laboratory to undertake certain research work, or to leave another research alone, or, indeed, to transfer, if considered advisable, part of its equipment or *personnel* to another laboratory. Finally, all discoveries would be communicated to the board, which would have power to dispose of them after consideration of the rights of the individual worker. If adopted, the scheme would apparently supersede the Industrial Research Associations established already in connection with the Department of Scientific and Industrial Research, which has had a grant of 1,000,000*l.* placed at its disposal by the Government, and has been for some time actively at work. It is also as well to point out that the research work carried on in universities and other teaching institutions is conducted not wholly for the sake of the results looked for, whether purely scientific or technical, but for the educational purpose of training students in method. Moreover, as repeatedly pointed out, the original researcher in connection with fundamental problems will not usually be willing to unfold his ideas to others, at any rate in their early stages, before they have been tested.

AMONG forthcoming books of science we notice the following:—"Problems of Fertilisation," Prof. F. R. Lillie (*Chicago: The University of Chicago Press; London: The Cambridge University Press*); "Influenza: A Modern Account of its Pathogenesis, Symptoms, Complications, Sequels, and Treatment upon Combined Specific and Non-specific Lines," Sir T. J. Horder (*Henry Frowde and Hodder and Stoughton*); a new edition, thoroughly revised and enlarged, of "Practical Physiological Chemistry," S. W. Cole, with an introduction by Dr. F. G. Hopkins (*Cambridge: W. Heffer and Sons, Ltd.*); "Commercial Forestry in Britain: Its Decline and Revival," E. P. Stebbing; "Conifers: A Key to their Identity and Converse," C. C. Rogers, illustrated; "Tin," G. M. Davies; "Manganese," A. H. Curtis; and new and revised editions of "Heredity," Prof. J. Arthur Thomson, illustrated, and "Hydrographical Surveying: A Description of the Means and Methods Employed in Constructing Marine Charts," the late Rear-Admiral Sir W. J. L. Wharton, revised and brought up to date by Admiral Sir Mostyn Field (*John Murray*); "A Woman Doctor: Mary Murdoch of Hull," H. Malleson, and "Advance in Co-Education," edited by A. Wood (*Sidgwick and Jackson*).

OUR ASTRONOMICAL COLUMN.

CHANGES ON JUPITER.—Observers appear to be fairly well agreed on the character of the recent variations in some of the more prominent and durable of Jovian features. The Rev. T. E. R. Phillips, who has devoted much attention to Jupiter's appearance in recent years, says that the opposition of 1918–19 will be a memorable one. To his eye "the south tropical disturbance and the hollow in the southern belt have practically disappeared, but the red spot remains quite distinct on a night of good definition." The changes which have affected this particular region of the surface have been rapid and most remarkable. Mr. Phillips employs two instruments, one a $12\frac{1}{2}$-in. reflector and the other an 8-in. refractor. He regards it as likely to afford much satisfaction to observers that the red spot continues to retain a definitely elliptical outline, for the obliteration of this familiar marking would be regarded as a great loss by all students of the planet. That this object may at some future time regain its former (1878–80) conspicuous aspect is quite possible, and it should be attentively watched for changes of both shape and motion.

THE ORIGIN OF NOVÆ.—Prof. W. H. Pickering examines various theories of the origin of novæ in *Popular Astronomy* for November last. He rejects the theory of collision of star with star on the grounds that novæ are too numerous for this and that the period of brilliance is too short. The first difficulty, but not the second, is avoided by the theory of collision of star with nebula; it would probably require years, not days, for a star, even at the enormous speed indicated by the spectroscope, to traverse a nebula of average size. Prof. Pickering prefers the hypothesis of a body of small planetary dimensions falling into the star and penetrating the photosphere to some depth before it exploded. He pictures its conversion into gas as being so rapid and violent as to scatter the materials of the photosphere to a considerable distance all round, thus producing an immense, but short-lived, increase of light. He notes that he is drawing on the star's own energy for the outburst, the falling planet merely acting as the trigger. The dark and bright bands of the spectrum are explained (as on many other theories of novæ) by the outer shells of gas being cooler, and so absorbing light, while the light from the gases streaming out on the remote side of the star, having its wavelength altered by motion, is not arrested by the cool gas on the near side. Newcomb, in "The Stars: A Study of the Universe" (p. 138), suggested a similar explanation, treating the stars as hollow globes of highly heated and condensed gas; a foreign body, on falling, might break the shell, when the interior gases would burst forth. "What magnitude the outburst might assume it is impossible to say."

CELESTIAL SYSTEMS.—The Memoirs of the College of Science, Kyoto University (vol. iii., No. 7), contain a paper by Shinzo Shinjo and Yoshikatsu Watanabe on the angular momenta of celestial systems. The authors examine all the binary and multiple systems for which sufficiently accurate data are available (including eclipsing variables). They show that the resulting momenta are confined within tolerably narrow limits, and exceed several hundredfold the angular momentum of the solar system. In studying the possible origin of angular momentum they examine the case of a spherical swarm of meteorites, and show that, for a given mass, the larger the individual meteorites the greater the probable momentum. To produce the momentum of the solar system they conclude that the individual meteorites must have been about 20 km. in diameter. The size would require to be much larger to satisfy the conditions of the binary systems. It is conjectured that swarms with the largest meteorites would condense into two or more nuclei, those with medium-sized meteorites into single orbs which would afterwards divide into two, those with meteorites 20 km. in diameter into planetary systems. In the case of dust-swarms or gaseous nebulæ, the number of constituents is so immense that the resulting angular momentum is infinitesimal. While the paper does not give a complete system of cosmogony, it sheds fresh light on some of the stages of the process.

COTTON-SEED BY-PRODUCTS.

ON February 5, at the Royal Society of Arts, Mr. Ed. C. de Segundo read a very interesting and suggestive paper on "The Removal of the Residual Fibres from Cotton-seed and their Value for Non-textile Purposes." Mr. de Segundo explained that there are two main classes of cotton-seed, viz. the bald, black, or clean seeds, such as Egyptian, Sea Island, Brazilian, etc., of which practically the whole "lint" is removed by the process of "ginning," or separating the lint or textile fibre from the seed; and the white, woolly, or fuzzy seeds such as American, which are still covered with a short white "fuzz" or lint after ginning. Indian cotton-seed is really of the latter class, though the fuzz remaining on the seed is much shorter than in the case of the American.

To deal with these two classes of seed, two different methods have been adopted. The black seeds are crushed whole, and the residue after extraction of the oil is pressed into cattle-cake. The white seeds are first "delinted," which removes part of the short fuzz left on the seed after ginning, the machine used being practically the same as the saw-gin used for the ginning itself. The short fuzz or "linters" thus removed is used for guncotton, blotting-paper, waste, etc. The seed is then "decorticated," a process of separating the hull, with the fuzz still remaining on it, from the kernels or meats. The latter are then crushed alone, and the oil is taken out in a much purer form than is possible under the whole crushing process, because the presence of the hull or shell gives a darker colour to the oil. Incidentally, the process afterwards required to remove this dark colour gives the oil a slightly bitter taste, which made the value of such oils distinctly lower than those got by the decorticating process. The crushed kernels give a very fine residual product known as cotton-seed meal, which has recently been attracting particular attention because it has been shown to possess very high qualities as human food. Its protein and fat contents are very high, and mixed with potato- or wheat-flour it produces a most valuable form of food.

As it happens, the two processes above described have come to be known as the British and American processes respectively, because the British crushers have only had the opportunity of handling the Egyptian and Indian cotton-seed products in large quantities. The bulk of the American crop has, naturally, always been handled in the States. The Indian crop known as Bombay seed has always been imported into this country and crushed whole without previous delinting, because its seed-lint was scarcely long enough to be worth removing, and its presence in the cake (though it took long to convince the users of it that this was true) did no material harm if properly handled, while it gave a much bulkier, and therefore cheaper, cake.

The two improvements with which Mr. de Segundo has been connected are, first, the production of a machine which, after ginning and delinting in the ordinary way, takes a further quantity of "seed-lint" from the seed. This seed-lint is of considerable commercial value for many non-textile purposes, such as paper-making, artificial silk, explosives, and cellulose acetate, the peculiarity of the process being the very clean and pure condition in which it delivers the lint. Its removal also adds to the value of the seed for crushing purposes, saves freight by reducing its bulk, and minimises the danger of heating, and hence the risk of fire by spontaneous combustion. The second improvement is a process of removing the last vestige of fibre from the hulls after decortication, thus taking two further by-products out of the last residue of the former process. It was the first of these improvements that was mainly dealt with in the lecture.

The importance of these processes to the cotton industry is certain to be very considerable. There are many new areas in the British Empire where cotton is being developed, such as Uganda, Nigeria, and parts of the Sudan, where the woolly seeded varieties have been found the most suitable, but the seed has never been fully utilised because the crops were comparatively small, and the cost of handling

Cotton seed products

them under the disadvantageous conditions found in these areas was scarcely covered by the value of the by-products. But by increasing the value of these products the scale may be turned, and such a system rendered profitable, and it would certainly be an advantage to these areas to have such a supply of oil and cattle and other foods as these by-products would yield. Again, there are other areas where cotton is struggling against the rivalry of other competing crops, and where the scale might just be turned in its favour by the increased value of its by-products. Reference was made to the position of India, where the seed-crushing industry has never been properly developed, and it was agreed that such a process as the seed-lint removal might make all the difference.

A seed-lint defibrating machine was shown working at the lecture, and samples of all the by-products were exhibited, including bread, scones, and cakes made with a proportion of cotton-seed flour. There was a very useful discussion after the lecture by a number of experts representing different sections of the trades affected.

A BRITISH GEODETIC AND GEODYNAMIC INSTITUTE.

A COMMITTEE, consisting of Dr. Shipley (the Vice-Chancellor), Dr. H. K. Anderson, Col. Sir C. F. Close, Sir Horace Darwin, Sir F. W. Dyson, Dr. E. H. Griffiths, Sir T. H. Holdich, Sir Joseph Larmor, Col. H. G. Lyons, Prof. Newall, Sir Charles Parsons, Sir Napier Shaw, Sir J. J. Thomson, and Prof. H. H. Turner, has been formed for the purpose of making an appeal for the creation and endowment of a geophysical institute at Cambridge. The question of the establishment of an institute of this character has been under consideration by the British Association for the last three years. A large and representative committee reported unanimously in favour of the project, which was then considered by the Conjoint Board of Scientific Societies. This Board also reported that there was a real need for such an institute. The chief reasons which have been put forward on behalf of the scheme are:—(1) Geodetic work must form the basis and control of all the State surveys of the Empire, on which about a million sterling was spent annually before the war. (2) A geophysical institute could render great assistance in connection with the particular group of geodetic problems now of most practical interest in the United Kingdom, namely, those associated with levelling, mean sea-level, and vertical movements of the crust of the earth. (3) Such an institute is greatly needed to assist in the study of the tides and in attacking the great problems which must be solved if tidal prediction is to advance beyond its present elementary and fragmentary state. (4) There is at present no provision for the collection and critical discussion of the geodetic work which is being done within the Empire, or for its comparison with the work of other countries. There is no institution available for research work or higher training in geodesy. There is no British institution which can be referred to for the latest technical data and methods, and until the outbreak of war it was the custom of many British surveys (notably the Survey of India), when confronted with geodetic problems, to refer to the Geodetic Institute at Potsdam. This was not even then a very satisfactory arrangement, and now a radical change is inevitable.

Discussion as to where the institute could most suitably be established has led to the selection of Cambridge, for it is essential that an institute of geodesy and geodynamics should be closely associated with a great school of mathematics and physics, and it is only in connection with a great Imperial university that that width and freshness of outlook are to be sought which are essential to a progressive and practical science. The committee has evidence that an institute at Cambridge would be cordially welcomed by the national Survey Departments, both terrestrial and oceanographic.

It is estimated that an endowment of 50,000*l.* will be necessary if the proposed institute is satisfactorily to perform the double task of research and education, but it is hoped that if half that sum were contributed by private benefactions the remainder would be forthcoming from national funds. An essential part of the scheme would be the foundation of a university professorship of geodynamics to be held by the director of the institute. To place this professorship in line with other chairs recently endowed by private benefactions, and usually associated with the names of the donors or founded as memorials of national sacrifice in the great war, a sum of 20,000*l.* (which is included in the 50,000*l.* mentioned above) would be required. It is certain that all who have to do with our shipping interests or with aerial navigation would ultimately profit from the establishment of such an institute.

RESPONSIBILITIES OF BOTANICAL SCIENCE.

"SOME Responsibilities of Botanical Science" is the subject of Prof. B. E. Livingston's address to the Botany Section of the American Association for the Advancement of Science meeting at Baltimore last December (*Science*, February 28, 1919). The work of botanical science is at present carried on by a sort of guerrilla warfare, each man for himself; for a planned and productive campaign co-operation is necessary. The objects to be attained are twofold. The first is the conservation of knowledge already attained. The existing means for presenting botanical abstracts and *résumés* are merely makeshifts; there is need for a national or international institute for the furnishing of bibliographical information on request. Such an institute would be a great undertaking, with a permanent staff of departmental heads and a corps of bibliographical assistants; but it would seek the co-operation of all men of science. It would avoid enormous waste of time and energy on the part of scientific workers and research institutions, and give congenial employment to many who wish to serve in scientific work, but may not find their best places as teachers or research workers.

The second object is botanical research, which is considered under three heads: the planning of research, the procuring of data, and the interpretation and presentation of results. Prof. Livingston emphasises the absence of any recognition of the investigator as such, and the striking characteristic that most of the published work appears to be done by apprentices. The planning of scientific investigation deserves much more attention than it generally receives, and our selection of problems and planning of projected investigations would be greatly improved if co-operation between competent thinkers were more in vogue. The securing of the requisite observational or experimental data is the easiest part of investigation, but comparatively few writers trouble to interpret their results in a logically complete manner. A discussion is written from the point of view of one out of several or many logically possible hypotheses, and one of the greatest wastes in biological research lies in the publication of so many uninterpreted observations. Finally, there are the responsibilities towards applied botanical science, not only the practical applications in the arts, but also the philosophical applications to other branches of science.

OPHTHALMOLOGICAL TRAINING OF MEDICAL STUDENTS.

THE Council of British Ophthalmologists has issued a report dealing with the teaching and examination of medical students in ophthalmology. The first part of the report reviews briefly the efforts made up to the present by the General Medical Council to ensure better training of the medical student in this important subject. These, unfortunately, have not succeeded in their object, and it is still the case that "the general body of the medical profession does not possess a competent knowledge of diseases of the eye."

The second part of the report deals in detail with the requirements of all the examining bodies in Great Britain and Ireland and, for comparative purposes, with a large number of Colonial, American, and foreign universities. The analysis of these requirements shows that Great Britain stands almost alone in granting diplomas to practise medicine without evidence of an adequate knowledge of diseases of the eye. In Ireland and in the great majority of foreign and Colonial universities ophthalmology is one of the subjects of the qualifying examination, and the examinations in it are conducted by ophthalmic surgeons.

The council has therefore recommended (1) that no student shall be admitted to the final examination, qualifying to practise medicine, unless he has attended an ophthalmic clinic for not less than six hours a week during a period of three months, and has attended a course of systematic instruction in ophthalmology; and (2) that no student shall be considered to have passed the qualifying examination unless he has shown a sound knowledge of practical ophthalmology in an examination conducted by ophthalmic surgeons.

CLOCK ESCAPEMENTS.[1]

THE most ancient instruments for measuring time were probably some kind of sundial. Something of the kind is, no doubt, referred to in 2 Kings xx. and Isaiah xxxviii., where it is stated that the shadow moved back ten steps on the steps of Ahaz (for that is the literal translation). Herodotus ("Euterpe," cix.) tells us that the Babylonians introduced to the Greeks the πόλος and the γνώμον, no doubt some forms of sun-instruments. Frequent allusions are found in the classics to the clepsydra, which was made in various forms, always depending, however, upon the approximately uniform flow of water through a small hole.

But clocks, properly so called, cannot be traced with certainty earlier than the fourteenth century. In 1348 a curious iron clock was sent over from Switzerland, and was until recently kept in Dover Castle. It is now in the Science Museum at South Kensington. It is interesting as having no pendulum or balance-spring (both much later inventions), but, instead, a vertical spindle carrying a horizontal traverse loaded at the ends with weights. This vertical spindle has two pallets projecting from its sides, approximately at right angles to each other, which engage alternately the uppermost and lowermost tooth of a contrate wheel the axis of which is horizontal and in the same plane with the vertical axis first referred to. This is the "verge" escapement, which was for long afterwards used in both clocks and watches. No good timekeeping was possible with such an arrangement. Gravity did not come into the problem, and the speed of the movement was only restrained by its energy having alternately to create and destroy angular momentum in the swinging arms. The force of the train, however variable, was paramount.

The next step in horology, and undoubtedly the most important which has ever been made, was the application of the pendulum to clocks by the Dutch physicist and astronomer, Christian Huygens, in 1657. Galileo had discovered, about sixty years earlier, the isochronism (since found to be only approximate) of a swinging body, but, in spite of efforts made after his death to claim priority for him in the invention of the pendulum clock, the evidence has not convinced historians of his title to that honour.

Huygens, being aware of the fact that the motion of a particle under gravity was only isochronous, independently of the extent of the arc of swing, when the body describes a cycloid, and knowing the property of that curve to reproduce itself as an involute of an equal cycloid, attempted to secure the desired isochronism by suspending his pendulum from a silk thread which swung between two cheeks of brass cut to the shape of the cycloid, thus obliging the bob to trace an involute. But the silk was so affected by the weather that no good result ensued.

Another objection to the verge escapement was the large arc of swing necessary to permit the escapement to unlock itself. Huygens attempted to overcome this difficulty by making the verge the axis, not of the pendulum-crutch, but of a pinion gearing into a larger wheel to the arbor of which the crutch was attached. This construction permitted the angle of swing to be reduced at pleasure, but more friction was introduced, and little improvement was effected.

The calculation of the time of swing of a free pendulum describing a circular arc can only be made approximately, but the approximation can be carried as far as desired, and as the arc of swing is never large, a few terms suffice. This is the formula:—

$$T=\frac{\pi k}{2\sqrt{gh}}\left(1+\frac{1}{4}\sin^2\frac{\alpha}{2}+\frac{9}{64}\sin^4\frac{\alpha}{2}+\ldots\right)$$

from which, by differentiation,

$$\frac{dT}{d\alpha}=\frac{\pi k\sin\alpha}{16\sqrt{gh}}\left(1+18\sin^2\frac{\alpha}{2}+\ldots\right).$$

Here T is the time of swing of the pendulum from its highest position to the vertical, and α is the semi-angle—that is, the angle turned through from the highest to the lowest position. Now of the factors making up the expressions on the right-hand side of these equations, only π and g and the numerical coefficients can really be considered as constant. It has been suggested that even g may one day be shown to be variable. As for h and k—that is, the distance from the axis of motion to the centre of gravity and the radius of gyration respectively—these are well known to be dependent on temperature, and an interesting account might be given, if time permitted, of the evolution of the compensated pendulum. The recent discovery of alloys of iron and nickel the coefficient of expansion of which is very low has much facilitated this.

The factor which has most influence on the value of T is α, the angle of swing. The formulæ show us two things: first, that the wider the arc of swing the more a clock will lose, and, secondly, that a given small variation of arc is less harmful when the whole arc is small than when it is great. There are practical reasons, however, for not making it *too* small, which have led to the adoption of arcs of two or three degrees on each side of the vertical as, on the whole, the best.

[1] From a discourse delivered at the Royal Institution on February 21 by A. T. Hare.

This table gives the losing rate for variations of arc:—

Semi-arc		Daily loss		Difference
° ′		s.		
0	...	0		
0 15	...	0·1	...	0·1
0 30	...	0·41	...	0·31
1	...	1·65	...	1·24
1 30	...	3·70	...	2·05
2	...	6·58	...	2·88
2 30	...	0·28	...	3·70
3	...	14·31	...	4·53
3 30	...	20·16	...	5·35
4	...	26·33	...	6·17
4 30	...	33·32	...	6·99
5	...	41·14	...	7·82

It must be remembered that these figures only relate to a *free* pendulum, and with some escapements the errors introduced mask this result completely.

Many attempts, some of great ingenuity, were made to get better results from the verge, especially as regarded the reduction of the arc, but they were all superseded by the anchor, or recoil, escapement, invented (most probably) by the celebrated Dr. Hooke, and first made by William Clement in 1675. This is the escapement still used in all common clocks, but it has disadvantages which render it unsuitable for high-class work. The train exercises great "dominion," as it used to be called, over the pendulum, and is assisting gravity the whole time, hindering the rise of the pendulum and accelerating its fall, so that T may be considerably diminished when the train has been recently oiled without any corresponding variation of α.

But in 1715 George Graham, pupil of Tompion (both of whom were so esteemed as to be accorded burial in Westminster Abbey), made a most important modification of the anchor. He removed most of the flukes, leaving only a small sloping part near the tip, by sliding along which the extremity of the scape-wheel teeth could give the necessary impulse to the pendulum. The rest of the fluke he fashioned so that it should be a portion of a circle having its centre on the axis of the crutch-arbor, thus entirely preventing recoil of the movement, and, to a great extent, releasing the pendulum from the "dominion" of the train. During the time when the circular part of the fluke is passing along the tooth of the scape-wheel the motion of the train is entirely held up, and it is neither doing work on the pendulum nor having work done on it. The device is consequently known as the "dead-beat."

Numbers of escapements were devised after Graham's invention, which, though differing much from it in design, were, nevertheless, broadly speaking, mechanical equivalents of it. Such were Thiout's, Vérité's, Perron's, Leonhard's, Vulliamy's, Robert's, Berthoud's, Lepauté's, and Brocot's.

The designer of a turret-clock, however, always has in mind the serious variations in the force of the train caused by wind or snow on the hands, as well as by the thickening and drying of the oil on the bearings and the cutting and wearing of the pivots and of the teeth of the wheels and pinions. It was, therefore, long ago recognised that the proper function of the clock-train was not to drive the pendulum, but to record the number of its swings—that is, to tell the time—and to keep wound a smaller clock which should be independent of these disturbances, and could be made very simple, and even reduced to one wheel, if often enough rewound. This construction was proposed by Huygens, who did so much for the science of accurate timekeeping. The principle of these "remontoirs," as they are called, is very much the same in all. Some rewind a little weight, others keep a spring wound, but in every case, directly or indirectly, the pendulum has to unlock the rewinding mechanism by means of some device which is itself an escapement, and this cannot be effected without some friction.

From the train-remontoir it is an easy step to the next great improvement. The question naturally arises: "Why rewind the train in the middle? Why not simply relift the pallets and let them fall by gravity on the pendulum?" This question was answered about the year 1716, when Alexander Cumming produced the first of the series of gravity escapements which have done so much to make the accurate turret-clock a possibility. His escapement is rather complicated and has several points where there is friction, and very soon after it was greatly simplified and improved by Thomas Mudge, a pupil of Graham's. Fig. 1 shows Mudge's escapement, and will be easily understood.

The tooth marked 1 has just lifted the gravity piece A′B′, and is resting on the dead face. The pendulum, moving to the right, is just about to lift the gravity piece, causing the dead face to slide along the tooth until it is clear of it. The wheel is then free to turn further, and the tooth marked 2 lifts the other gravity piece AB in a similar way. When

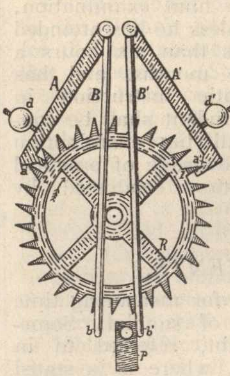

FIG. 1.

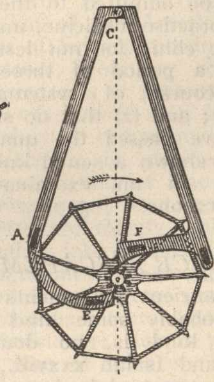

FIG. 2.

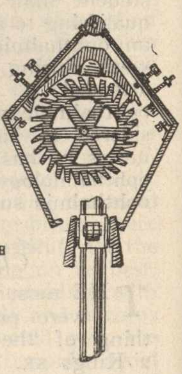
FIG. 3.

the pendulum has attained its maximum elongation to the right (carrying A′B′ with it) and begins to return, the pallet on A′B′ falls midway between teeth 1 and 3, thus falling rather farther than it rose, the balance of work done on the pendulum serving to maintain the latter in motion against the resistances. Each gravity piece is lifted by the wheel at a time when the pendulum is out of contact with it, and so the action of the train cannot disturb the pendulum except by the friction of the dead faces.

There is, however, a source of error to which Mudge's escapement is liable which was sufficient to condemn it. The driving power had to be ample, and there was danger either that the gravity pieces might be thrown clean off the wheel, allowing the latter to race and destroying all timekeeping, or that, if this complete "tripping" did not occur, they might, at all events, be thrown a little too high, so that the teeth of the scape-wheel, instead of resting in the exact corner, as tooth 1 is seen to be doing, would rest on the dead face nearer its extremity, and probably hold up the gravity piece, by friction, higher than it should. This fault was called by Lord Grimthorpe "approximate tripping," and if it occurred the constancy of the maintenance would be lost. This might probably have been cured by the use of a dashpot, with which Mudge's escapement would have been very considerably improved.

Mudge's escapement was followed by Bloxam's, the action of which will be obvious from Fig. 2. It is still to be seen in action in Bloxam's own clock, which is now, by his nephew's permission, at the Science Museum. The noteworthy feature in it is that the locking arms are much longer than the lifting teeth, so that the friction of unlocking is much reduced.

It was on Bloxam's design that Lord Grimthorpe improved in the construction of his well-known "double three-legged gravity escapement," used for the first time in the great clock in the Houses of Parliament. The principal feature in this escapement is the long wind-fly, which moderates the shock of impact of the teeth on the pallets, and which the large angular movement of the scape-wheel (60° at each tick as against 20° in Bloxam's) rendered effective.

A new principle was introduced into the gravity escapement by Capt. Kater about the year 1840, and is described in vol. cxxx. of the Phil. Trans. Fig. 3 is taken from Kater's paper, and shows clearly the design. The gravity pieces are lifted alternately as in Mudge's and Bloxam's constructions, but they do not themselves unlock the escapement, merely serving to upset the equilibrium of a heavy piece (seen in the figure above the wheel), which does the unlocking, but, owing to its high moment of inertia, gets slowly under way and so unlocks the wheel only when the gravity piece then in contact with the pendulum is no longer touching it.

Vérité produced a gravity escapement in which pivot friction was got rid of, but this escapement had four little balls hanging from four silk threads, and was somewhat delicate and complicated.

It occurred to me some time ago that Kater's principle might be applied in such a way that the pendulum should be entirely freed from all friction whatever, while the impulses given to the pendulum were exactly uniform. A full description of this escapement will be found in Patent Office Specification No. 113,501, but it may be said, very briefly, to consist in two little weights which rest alternately on the two ends of a rocking frame having considerable moment of inertia, and on two little upright stems at the ends of arms fastened to the pendulum near its point of support. When the rocker is horizontal, and the pendulum at rest and vertical, things are so adjusted that the weights are resting indifferently on both the pendulum arms and the ends of the rocker. If, then, the pendulum is pushed to one side, say the right, it carries the right-hand little weight upwards, relieving the rocker of its weight, and deposits on the opposite end of the rocker the other little weight. This upsets the equilibrium of the rocker, which commences to turn over, and so releases the scape-wheel, which turns the rocker back rather beyond the horizontal in the sense opposite to that of its last motion, so that when on its return the pendulum again exchanges weights with the rocker, it deposits the right-hand weight at a lower level than that at which it was picked up. The escapement is simple, and a clock fitted with it has given results which are encouraging.

Before concluding, I must refer to a remarkable series of papers which commenced last year to appear in the Proceedings of the Royal Society of Edinburgh by Prof. R. A. Sampson, the Astronomer Royal for Scotland. Prof. Sampson is, as all astronomers must be, much interested in accurate timekeeping, and has experimented with three different clocks, having escapements which I must very briefly describe. One is by Mr. Cottingham, and is essentially the same as an escapement which the late Sir David Gill, then Astronomer Royal at the Cape, had imagined. The pendulum is driven by a gravity piece which, so long as it is in contact with the pendulum, by that very contact completes an electric circuit which holds up an armature against the poles of an electromagnet. This armature is itself the stop which limits the travel of the gravity piece. The latter, therefore, goes on impelling the pendulum until it is brought up against the armature. When this happens the gravity piece is left behind by the pendulum and the circuit is broken. At once the armature falls against a stop, and the gravity piece is lifted, so that the pendulum takes it up again at a higher level than that at which they parted company. Sir David Gill found trouble from the slight adhesion which exists between two metallic surfaces when a current is broken between them, and gave much attention to experiments designed to avoid this. I do not know how far he succeeded, but it seems clear from Prof. Sampson's paper that the escapement is very successful now. The idea has probably occurred to many people. I began making a clock about thirty years ago on what was practically the same principle, but gave it up because at that time it did not seem practicable to find a battery capable of giving a current lasting nearly half a second for each second that passes.

Another of Prof. Sampson's clocks is driven by an escapement invented by Riefler, of Munich, which is unlike any of those we have been considering, and in which the necessary energy is communicated to the pendulum by bending the suspension spring. The block from which the suspension spring hangs, instead of being fixed as immovably as possible, which it generally is, is supported on knife-edges, and the suspension spring, which, of course, always tries to keep straight, causes the block to turn on these edges, and so unlock the scape-wheel, which bends the spring back against the motion of the pendulum and thus keeps it going.

The third escapement which is being observed at Edinburgh, and the last I propose to refer to, is that adopted by the Synchronome Co., and belongs to the class where the action takes place at the bottom of the pendulum or of the crutch instead of the top. This is fully described in the specification of a patent granted to Mr. Shortt, and numbered 9527 of 1915.

So much for escapements.

We may, in conclusion, for a moment review the difficulties attending the accurate measurement of time and note how they have been attacked.

If ever a perfect clock is constructed it will certainly be a pendulum clock, and it will have to fulfil two conditions, necessary and sufficient. They are these:—First, the moment of inertia of the pendulum must be invariable; and, secondly, the forces which act on it must be invariable. If these two conditions could be fulfilled, the last word in horology would have been said. So far, of course, neither condition has been fulfilled, but surprisingly good work has been done. As for the first condition, that the moment of inertia must be invariable, the chief difficulty is to avoid change by change of temperature. There are two ways of diminishing this change. The pendulum must be compensated in one of the well-known ways—by Harrison's gridiron construction; or that of Graham by the expansion of mercury in the bob; or, again, by the zinc and iron combination used in many turret-clocks; or, best of all, by availing ourselves of the low expansion nickel-steel recently introduced by Guillaume. Also, for added security, the whole clock must be enclosed in a thermostatic chamber, as is done by Prof. Sampson at the Royal Observatory at Edinburgh. The other condition is much more difficult. There is, besides the almost inevitable friction of the escapement, the effect of the buoyancy of the air. This last can be avoided by enclosing the whole clock in a glass case, tightly fitted, in which the air can be slightly rarefied and maintained at a constant pressure below that of the atmosphere. This would seem to offer a very satisfactory solution of the difficulty. Temperature error and buoyancy error having thus been to a great extent mastered, we come back to the forces connected with the maintenance and recording of the motion as the principal sources of uncertainty. And let no one suppose that little has been effected. Perfection in this, as in other human pursuits, is doubtless unattainable, but we approach it asymptotically, and we are farther along the asymptote than might be imagined. Prof. Sampson tells us that in his thermostatic chamber and barostatic cases, and with the Riefler, Cottingham, and Synchronome escapements which he is studying, the errors average no more than one-hundredth of a second per day—that is, at the rate of one minute in sixteen years, if the clock could run so long without stopping—truly an almost miraculous accuracy, unrivalled, I imagine, in any physical measurement. Anyone, therefore, who hopes to improve upon this has a difficult task before him. If it is true that *le mieux est l'ennemi du bien*, it must be acknowledged that *le mieux* has against him a most formidable antagonist.

[The lecture was illustrated by a number of working models.]

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

EDINBURGH.—Dr. James Drever has been appointed Coombe lecturer in psychology.

The University Court has resolved, subject to the approval of the Senatus and to the co-operation of the Town Council, to invite the British Association to hold the annual meeting in 1921 in Edinburgh.

An important step has recently been taken in the purchase of 100 acres of land for University extension. The land lies on the south side of the city, about two miles from the present University, and in the neighbourhood of the Royal Observatory on Blackford Hill. There will be ample scope in the immediate future, not only for the building of laboratories and hostels, but also for accommodation for sports and athletics.

GLASGOW.—The following doctorates were among the degrees conferred on April 22:—*M.D.:* W. E. Boyd. Thesis: "The Colloidal State of the Blood Serum and its Electrical Reactions." *D.Sc.:* D. Burns. Thesis: "On the Physiological Significance of Guanidin, especially in its Relation to Creatin-Creatinin Metabolism," with other papers.

THE standard of education in Central Europe presents notable divergences from that to which we are accustomed. It is measured by the percentage of illiterates among those who exceed the age of six years. As one goes east the percentage increases. Among the northern Slavs, the Czechs are well educated, their percentage being 4; next come the Slovaks with 20 per cent.; then the Poles of Galicia with a percentage twice that of the Slovaks; and finally there are the Ruthenes, or Little Russians, of Galicia, Hungary, and the Ukraine, with a percentage of 80, double that of the Poles. Among the Slavs of the south, the Slovenes who border on Italy have a percentage of 20; then come the Croats with a percentage of 60, and the Serbs with one of 70. Between the two branches of Slavs lie the Italians, who vary from 7 to 40 per cent. in illiteracy; the Germans of Austria, whose numbers lie between 2 and 20; the Magyars of Central Hungary, who are about as well educated as the Slovaks or Slovenes; and, finally, the Rumanians of Transylvania, three out of four of whom are illiterate. These differences are a result of two factors: first, nearness or remoteness from Western civilisation, and, secondly, religion—the western folk are Roman Catholics and the eastern folk adhere chiefly to the Greek Church.

A COPY of the calendar for 1917–18 of the Imperial University of Tokyo has been received. The calendar is published biennially, and an examination of the present issue serves admirably to illustrate what rapid strides in the provision of facilities for higher education have been made in Japan in recent years. Among other constituent colleges of the University the calendar deals with the College of Science, and gives full particulars of the extensive collections of specimens in the Natural Science Department and of the numerous adjuncts with which the college is provided; for instance, the Tokyo Astronomical Observatory, the Botanic Gardens of forty acres at Koishikawa, the Seismological Observatory, and the Marine Biological Station at Misaki, primarily intended for the use of instructors and students of the University, but available for other workers in biological research. Similarly, in connection with the flourishing College of Agriculture, every facility seems to have been provided. There are farm, nursery, and botanical gardens; laboratories for agricultural chemistry, forestry, fisheries, and for studying silkworm diseases, as well as numerous museums devoted to specific objects. A veterinary hospital is situated in the grounds of the college; a pomological garden has been laid out in Rokugo; and there are nine forests attached to the college. The University also includes an institute for the study of infectious diseases, where are arranged the investigation of the etiology, prophylaxis, and treatment of infectious and parasitic diseases, and experiments with disinfecting, prophylactic, and curative agents. The calendar runs to 402 pages, which teem with interesting particulars concerning the activities of the other faculties, and is illustrated also with charts, diagrams, and plans to make clear the working arrangements of this centre of higher learning.

THE British Science Guild has just issued a memorandum on the question of the appointment of a Departmental Committee to inquire into the existing provision of university and higher technical education in the United Kingdom, and also as to the desirability of appointing a consultative committee, including representatives of industry, to advise the Board of Education in matters affecting the relationship of science and industry to education. It is now thirty-seven years since the fruitful inquiry by a Royal Commission was held as to the provision for scientific and technical education, not only in this country, but also in Europe generally and the United States, which revealed our serious deficiency, and led ultimately to the adoption of the Technical Instruction Acts of 1889 and 1891, and to the valuable results which ensued. It is felt that the time is ripe for a further inquiry as to our present facilities for scientific and technical education with the view of ascertaining how far it is adequate to the needs of our chief manufactures in face of the great advances made abroad in the chemical, iron and steel, textile, optical glass, and other important industries. Especially is it desirable to learn what means exist for the encouragement and adequate training of efficiently educated youths as leaders in our chief industries and what number avail themselves of such training. Certainly it would be found far below that of Germany or the United States, our chief industrial competitors. Inquiry should also be made as to the disposition of our chief technical institutions, especially those equipped for the efficient training of *day* students, and as to the desirability of the official recognition of such institutions as specialise in the science and technology of certain industries, *e.g.* iron and steel at Sheffield; cotton textiles and chemical products, particularly dyes, at Manchester; the leather industry at Leeds; shipbuilding at Glasgow, Newcastle, and Belfast; mining at Wigan, Newcastle, and Cardiff; textiles other than cotton at Leeds, Huddersfield, and Bradford; mechanical and electrical engineering at various chief centres, etc. There is reason to believe that public opinion is ripe for much larger support both from local and State funds. The new Education Act will certainly add largely to the number of capable students who will need the help of maintenance scholarships, which should, in consequence, be very largely increased, so as to enable them to proceed to higher institutions for whole-time study. It is to be hoped that this important memorandum will be circulated to every Member of Parliament and to all the education authorities and chief industrial associations throughout the kingdom.

SOCIETIES AND ACADEMIES.

LONDON.

Optical Society, April 10.—J. W. **French**: The unaided eye. After a brief historical introduction, the principal dioptric features of the eye were considered, particularly those relating to the pupil reflexes. By means of a simple pupilometer the diameter of the pupil when applied to optical instruments was measured. The variations of the pupil with varying illumination of the whole retina, of the macula lutea, and of several zones of constant area were also measured and the results discussed. It would appear that for the macula lutea the pupil area varies as the fifth root of the illumination. The zone around the macula lutea is more sensitive, and the sensitiveness diminishes thereafter towards the margin of the retina. So far as the pupil reflexes are concerned, the two eyes are quite independent of each other; while the pupil area of the one eye under constant illumination remains constant, the other eye under simultaneous variation of the illumination varies in accordance with the above law. The variation of the pupil area with accommodation is quite independent of the illumination, and is determined by the refractive power of the crystalline lens.—T. **Smith**: The spacing of glass-working tools. In constructing optical systems the exact curvatures for the surfaces determined by calculation need not be employed, but the departures must lie between limits which will be functions of the nominal curvatures. It follows that a system of properly spaced tools should suffice to meet all normal requirements. The basis on which a system should be constructed is discussed, and a proposed standard list of tools is derived from an aberrational condition, together with assumed extreme relations between aperture and focal length and between aperture and radius of curvature. The total number of tools, which is finite, occurs as an independent variable in the formula on which the system is constructed, and in the absence of experimental investigations this must be determined by comparing the results obtained from an arbitrarily assumed value with the lists that manufacturers have found from experience to be reasonably spaced. A comparison between the list derived by assuming the total number of different curvatures in the complete set to be one thousand and the lists of two makers shows satisfactory agreement.

PARIS.

Academy of Sciences, March 31.—M. Léon Guignard in the chair.—A. **Lacroix**: The leucitic lavas of Trebizond and their transformations. From the data furnished by chemical analyses it is impossible to get an exact idea of the magmatic relations of these rocks, since the essential ratios are disturbed by chemical and mineralogical transformations of secondary origin.—G. **Bigourdan**: The observatory of Le Monnier in the rue Saint-Honoré. Historical account of Le Monnier's astronomical work and publications, and of his instruments.—Ch. **Barrois** and P. **Pruvost**: The stratigraphical divisions of the Coal Measures of the North of France.—H. **Douvillé**: Evolution and classification of Nummulites.—C. **Richet** and H. **Cardot**: Sudden mutations in the formation of a new race of micro-organisms. A study of the modification produced by an arsenical medium upon the production of lactic acid by a pure lactic organism. This organism does not gradually become accustomed to the poison, but the tolerance shows a series of sudden variations, each of which is marked by intense multiplication.—M. **de Sparre**: Conditions to be fulfilled for increasing the flow, and hence the work, in an hydraulic installation without modifying the pipe.—G. A. **Boulenger**: An interesting case of sexual dimorphism in an African snake, *Bothrolycus ater*.—M. Eugène Casserat was elected a non-resident member in succession to the late M. H. Bazin.—P. **Sabatier** and G. **Gaudion**.—Catalytic dehydrogenation by nickel in presence of hydrogen. Pinene, limonene, camphene, menthene, and cyclohexene carried by hydrogen over nickel at 350°–360° C. undergo simultaneously hydrogenation and dehydrogenation. The reaction has been applied to compounds containing oxygen. Cyclohexanol gives phenol; pulegone, a mixture of cresol and thymol.—S. **Lefschetz**: The analysis of algebraic varieties.—L. E. J. **Brouwer**: The enumeration of regular Riemann surfaces of Genus I.—A. **Véronnet**: The temperature of equilibrium of a gaseous star for any ray.—A. **Colson**: The theory of solubility.—C. **Chéneveau** and R. **Audubert**: Absorption in turbid media. Dispersion by internal diffusion.—P. **Vaillant**: The production of a continuous current by the application of an alternating electromotive force to a voltameter with platinum electrodes.—J. **Martinet**: The mobility of the hydrogen atoms in organic molecules. The action of phenylhydrazine on dioxindols. Although neither aldehydes nor ketones, dioxindols give phenylhydrazones with great ease. The preparation and properties of several of these phenylhydrazones are described.—G. **Guilbert**: Some examples of "cyclone compression." Cyclonic centres sometimes present the phenomenon of disappearing very rapidly, in twenty-four hours or even less. This the author terms "cyclone compression," and directs attention to several examples which have occurred recently.—A. **Jauffret**: The determination of the woods of two species of Dalbergia from Madagascar, according to the characters of their colouring matters. The colouring matters extracted from these two species by solvents give different chemical reactions and absorption spectra. These characters are constant for each species.—L. **Daniel**: Researches on the comparative development of the lettuce in sunlight and in the shade.—H. **Colin**: The utilisation of glucose and lævulose by the higher plants. Analyses are given of total dextrose and lævulose and the ratio of these two hexoses in various parts of the plant in the case of beetroot, Jerusalem artichoke, and chicory.—E. **Esclangon**: The physiological sensations of detonation.—E. **Bourquelot** and M. **Bridel**: Application of the biochemical method to the study of several species of indigenous orchids. Discovery of a new glucoside, loroglossine. This new glucoside was isolated from *Loroglossum hircinum* in crystalline form. It is hydrolysed by hot dilute sulphuric acid or by emulsin.—A. **Bayet** and A. **Slosse**: Arsenical poisoning in industries involving coal and its derivatives. The study of numerous cases of pitch-cancer in a briquette works showed that many of the symptoms strikingly resembled those of chronic arsenical poisoning. Arsenic was proved to be present in the pitch, in the dust floating in the air at the works, in the hair of all the workmen, and in notable quantities in the urine and blood of the greater number of the workmen. Analyses of the blood, urine, and hair of other workmen, living in the same district, but not employed in briquette-making, gave negative results for arsenic. Thus from both the chemical and the clinical examination the conclusion is drawn that the symptoms observed in workmen handling pitch are those of chronic arsenical poisoning.

BOOKS RECEIVED.

Joseph Priestley. By D. H. Peacock. Pp. 63. (London: S.P.C.K.) 2*s*. net.

The Geology of South Australia. By W. Howchin. In two divisions. Division i., An Introduction to Geology, Physiographical and Structural, from the Australian Standpoint; Division ii., The Geology of South Australia, with Notes on the Chief Geological Systems and Occurrences in the other Australian States. Pp. xvi+543. (Adelaide: The Education Department.)

Inorganic Chemistry. By Prof. J. Walker. Eleventh edition, revised and enlarged. Pp. viii+326. (London: G. Bell and Sons, Ltd.) 5*s*. net.

Elementary Chemistry of Agriculture. By S. A. Woodhead. Pp. vii+188. (London: Macmillan and Co., Ltd.) 3*s*. 6*d*.

Displacement Interferometry by the Aid of the Achromatic Fringes. By Prof. C. Barus. Pt. iii. Pp. 100. (Washington: The Carnegie Institution of Washington.)

Naval Officers: Their Heredity and Development. By C. B. Davenport, assisted by M. T. Scudder. Pp. iv+236. (Washington: The Carnegie Institution of Washington.)

Duration of the Several Mitotic Stages in the Dividing Root-tip Cells of the Common Onion. By Dr. H. H. Laughlin. Pp. 48+plates. (Washington: The Carnegie Institution of Washington.)

DIARY OF SOCIETIES.

THURSDAY, APRIL 24.

MATHEMATICAL SOCIETY, at 5.—K. Ananda Rau: (1) Lambert's Series; (2) The Relations between the Convergence of a Series and its Summability by Cesàro's Means.—G. H. Hardy and J. E. Littlewood: A Tauberian Theorem for Lambert's Series.

INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—Major A. C. Fuller: The Fullerphone, and its Application to Military and Civil Telegraphy.

MONDAY, APRIL 28.

INSTITUTE OF ACTUARIES, at 5.—P. H. McCormack: Group Insurance.

TUESDAY, APRIL 29.

ROYAL INSTITUTION, at 3.—Prof. Keith: British Ethnology—The People of Wales and Ireland.

FARADAY SOCIETY AND RÖNTGEN SOCIETY (Joint Meeting), at 5.—General Discussion: The Examination of Materials by X-Rays. Sir Robert Hadfield: Introduction of Discussion.—Prof. W. H. Bragg: Radio-metallography.—Prof. A. W. Porter: Abstracts of (*a*) Investigation of Metals by means of X-Rays, by F. Janus (Munich) and M. Reppchen (Cologne). (*b*) The Principles Governing the Penetration of Metals by X-Rays, by Dr. G. Respondek (Helensee).—M. H. Pilon and G. Pearce: Apparatus used for Radio-metallography.—Capt. R. Knox and Major G. W. C. Kaye: The Examination of Timber by X-Rays.—Sir Robert Hadfield, S. A. Main, and J. Brooksbank: (1) Testing the Absorption Power of Different Steels under the X-Rays. (2) X-Ray Examination as Applied to the Metallurgy of Steel. (3) Radiographic Examination of Carbon Electrodes used in Electric Steel-making Furnaces. (4) A Method of Testing an X-Ray Tube for Definition.—Lt.-Col. C. F. Jenkin: The Detection of Hair Cracks in Steel by means of X-Rays.—F. F. Renwick: The Behaviour of Photographic Plates to X-Rays considered in Relation to the Radiography of Metals.—Dr. R. E. Slade: Contrasts in X-Ray Photographs.—M. E. Schneider (Le Creusot): Radio-metallography.

ZOOLOGICAL SOCIETY, at 5.30.—Dr. W. T. Calman: Marine Boring Animals.—Noel Tayler: A Unique Case of Asymmetrical Duplicity in the Chick.—Geo. Jennison: A Chimpanzee in the Open Air in England.

INSTITUTION OF CIVIL ENGINEERS, at 5.30.—Annual General Meeting.

WEDNESDAY, APRIL 30.

ROYAL AERONAUTICAL SOCIETY, at 8.—Major H. E. Wimperis: Aerial Navigation.

THURSDAY, MAY 1.

ROYAL INSTITUTION, at 3.—Dr. H. S. Hele-Shaw: Clutches.

LINNEAN SOCIETY, at 5.—J. Small: The Pappus in the Compositæ.—Montagu Drummond: Notes on the Botany of the Palestine Campaign: I. The Flora of a Small Area in Palestine.—H. N. Dixon: Mosses from Deception Island.

INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—Dr. C. Chree: Magnetic Storms.

CHEMICAL SOCIETY, at 8.—Prof. J. H. Jeans: The Quantum Theory and New Theories of Atomic Structure.

FRIDAY, MAY 2.

ROYAL INSTITUTION, at 5.30.—Prof. J. W. Nicholson: Energy Distribution in Spectra.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—Dr. W. H. Hatfield: The Mechanical Properties of Steel, with Some Consideration of the Question of Brittleness.

SATURDAY, MAY 3.

ROYAL INSTITUTION, at 3.—Prof. H. S. Foxwell: Chapters in the Psychology of Industry.

CONTENTS. PAGE

Editorial and Publishing Offices:
MACMILLAN AND CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.

Advertisements and business letters to be addressed to the Publishers.

Editorial Communications to the Editor.
Telegraphic Address: PHUSIS, LONDON.
Telephone Number: GERRARD 8830.