THURSDAY, MARCH 14, 1918.

REFRACTORY MATERIALS.

Refractory Materials: their Manufacture and Uses. By Alfred B. Searle. Pp. xii+444. (London: Charles Griffin and Co., Ltd., 1917.) Price 15*s.* net.

IT is a pleasure to have the opportunity of acknowledging that the prime importance of refractory materials to our industries is at last receiving recognition. An attempt was made in 1909 (*vide Times*, January 21, and NATURE, January 28, of that year) to direct serious attention to this subject, but it was temporarily abandoned because of the failure of the majority to realise the urgency of industrial requirements. To-day we are on the border-line of danger at the other extreme. Contrasted with the apathy which prevailed a short time ago, the present attitude appears to some to border on hysteria. Schemes are being seriously entertained which, if not carefully handled, will lead to the Germanising of research in a bad sense, because certain suggestions which have been made seem based on the idea that the subject merely demands mechanical and routine observations on contractions, porosities, hardness, etc., and some suggestions, if adopted, would tend to suppress individuality. Mere interest in the problem *plus* a university degree are not a sufficient admission certificate to the adytum of clay-working. The neophyte requires initiation into the fundamental mysteries, so to speak, before he can wisely break the bond of silence.

The author of the present work has been a prolific writer on subjects more or less connected with clay-working. Although he has made no important original contribution to the art, his book is a very useful compilation, since it is convenient to have various fragments scattered in the technical journals collected into one volume. The serious student, however, may be dissatisfied with the inadequacy of the references to original sources, which are seldom given in sufficient detail, and in any future edition this blemish should be rectified. This is the more necessary because in some cases the originals have been so mutilated in transcribing as to convey erroneous impressions. An example occurs in the reference to the formulæ of the chief alumino-silicic acids, on pp. 4 and 9, where the essential point has been missed. In connection with the action of alkalis on clays (p. 5), it would have been better to give some indication of the large amount of work already published on the same subject, instead of waiting until the author of the book is able to fulfil his promise. The remarks on the actual composition of clays on pp. 4 and 5 are quite in accord with the general experience that clays are mixtures of various minerals, but there is something wrong on p. 7 when analyses of nine commercial clays are represented by complex graphic formulæ.

The statement on p. 41 that, "generally speaking, the compounds of silica are fusible, *with the one exception* [the italics are the author's] of the alumino-silicic acids (true-clays)," needs modifying, as it seems to imply that minerals like talc, olivine, leucite, topaz, zircon, sillimanite, and nontronite are fusible or are alumino-silicic acids.

On p. 42 we are informed that "the softening effect of mica is seldom noticeable below 1200° C., and that of felspar below 1300° C.," whereas on the previous page it is stated that "mica is a far weaker flux than felspar." Misprints are unfortunately rather numerous, though they do not always involve serious inaccuracies. A mild case occurs on p. 55, where *titanite* is represented as $CaTiO_5$.

The author apparently makes no distinction between yttria and ytterbia, for on p. 122 we find "yttrium oxide or ytterbia," and the latter name is again used instead of yttria twice on the next page. Another statement to which strong exception may be taken appears on p. 179, respecting "particles of iron sulphide (pyrite), which never give a red colour to the [fired] clay, but invariably show up as black or slagged spots." It would be interesting to know the authority for this. The proportion of grog to clay (1 to 8), as given on p. 284, for making saggers in Great Britain is far from being correct according to the practice of potters generally, if, indeed, for any British potters.

The results obtained by Wernicke referred to on pp. 96–97 doubtless justified the conclusions deduced by him and Wildschrey so far as the quartzites examined were concerned. But it would not have been out of place to add that some, at any rate, of the quartzites in the United States do not conform with these conclusions; for McDowell has expressly stated that the best American quartzites used for the manufacture of silica bricks show under microscopical examination no cementing ground mass, but consist solely of interlocking quartz crystals. This might be borne in mind in connection with the list of desiderata in quartzites for silica bricks, as set out on p. 98. The statement (on p. 96) that "it is essential to use a quartzite composed largely of tridymite" needs justification. Where can such quartzites be obtained?

One of the best features of the book is the description of processes with which the author is familiar; where he is on strange ground, serious mistakes have been made. For example, the attempt to cast glass pots by the method described on p. 341 could scarcely give a satisfactory result.

As previously intimated, the work possesses considerable value, notwithstanding such defects as those mentioned. The chapters deal with an exceptionally wide range of products and the corresponding raw materials, including the manufacture of firebricks from clay, silica, basic materials, bauxite, carbon, chromite, saggers, muffles, crucibles, glass pots, retorts, as well as fused silica ware, refractory porcelain, refractory mortars, and cements. The concluding chapter discusses the selection and application of refractory materials, and an appendix gives various standard specifications. The general index facilitates quick reference. J. A. A.

A SURVEY OF AMERICAN ETHNOLOGY.

The American Indian: An Introduction to the Anthropology of the New World. By Clark Wissler. Pp. xiii+435. (New York: Douglas C. McMurtrie, 1917.) Price 3 dollars.

IN this synthesis of American ethnology Mr. Clark Wissler has given us a book which we have long needed. An immense amount of work has been done in American ethnology, but the results are scattered in ponderous tomes and in innumerable papers in various journals published in diverse countries, and hitherto no scholar had attempted the systematisation of all these data, which manifestly required much patient labour. In terse, direct language the author has brought together the essential facts, and thereby enabled students to gain a clear idea of the technique and distribution of industries, the main features of sociological and religious systems, and the demarcation of the larger groupings. References are given for most of the statements, numerous plates and figures illustrate the text, and there are a number of most useful maps showing various distributions. The scope of the book can be best gauged by giving an epitome of the contents: Food areas (gathering, hunting, agriculture, etc.), textile and ceramic arts, decorative art, architecture, social groupings and regulation, and ritualistic observances. A consideration of these forms the basis for a classification of social groups according to their cultures. North and South America are divided into fifteen culture areas conformable to principles previously enunciated by the author, central spots being selected and the marginal variations noted. Then follow archæological, linguistic, and somatic classifications, and finally a correlation of classifications and a discussion of culture origins and of New World origins.

A few remarks may be made concerning Mr. Wissler's position with regard to the broader problems of American ethnology. In common with the great majority of his American colleagues, he believes in the unity of the New World culture. "Notwithstanding the great diversity we have found, there are, on every hand, the unmistakable signs of unity. The higher cultures of Mexico and Peru are, after all, merely the great centres where the fundamental elements in New World culture were full blown." He is also impressed by the "many indications of somatic homogeneity strongly suggesting unity of origin." Surely no morphologist would regard the Lagao Santa type (to which no reference is made) as belonging to the same race as the Bororo, or many other tribes. Following the line adopted by Boas, he suggests that "the longer-headed Algonkins and Patagonians are merely the result of greater marginal isolation rather than survivors of a previous long-headed population."

Research becomes paralysed if all irregularities are to be dismissed as fluctuations from a common mean. Probably no one will disagree with the statement that "no necessary relation exists between the known types of culture, linguistics, and somatology." The analysis of each of these must proceed on independent lines, and it must always be remembered that cultures and languages can be adopted or discarded. The diversity of linguistic stocks in America is an unexplained puzzle for those who maintain the essential unity of the American Indians. Certainly as regards somatology there is very good reason to believe in several distinct migrations of different racial elements from north-east Asia. What cultures they severally brought with them is another matter.

In referring to certain cultural traits mentioned by Rowland B. Dixon as common to America and the Pacific, Mr. Wissler says: "There is no great *a priori* improbability that some of these traits did reach the New World from the Pacific Islands. Satisfactory proof of such may yet be attained, but such discoveries would not account for New World culture as a whole. Then there are abundant data to show that the Polynesians are recent arrivals in the Pacific; in fact, Maya culture must have been in its dotage long before they were within striking distance of the American coast."

We have not yet heard the last word on the problems of the diffusion of culture which are now exercising the minds of many ethnologists; to these this most excellent book will serve at once as a stimulus and a challenge.

A. C. HADDON.

RADIOGRAPHY.

Radiography and Radio-therapeutics. By Dr. R. Knox. Part i., *Radiography.* Second edition. Pp. xxv+382+xx+plates lxxviii. (London: A. and C. Black, Ltd., 1917.) Price 30*s.* net.

NOTHING better illustrates the advance in medical radiology and the stimulus given thereto by the war than the appearance of a second edition of this work. Upon its production in 1915 Dr. Knox's book became the standard British book on the subject of X-rays, as regards their application diagnostically or as a therapeutic agent. In view of the large amount of new information available it has been thought advisable to issue the second edition in two parts, and part i., "Radiography," has now been completed.

Generally speaking, the lines laid down in the original work have been followed, new matter supplementing the old in the appropriate sections. When an entirely new subject comes up for consideration, such as the detection of gas in the tissues, a new sub-heading is made in the chapter to which it is germane. This will greatly facilitate for the reader the transition from the original volume to the new issue.

The main additions to the work appear to be in the chapters (which, we notice, are not numbered) devoted to the electro-technique of the subject, the localisation of foreign bodies, stereoscopy, and

diagnostic work upon the thorax and the alimentary system. In each of these sections there are considerable additions to the subject-matter of the first edition—present-day methods of dealing with war injuries receiving a good deal of attention by the author.

The illustrations, many of which are new, are very well reproduced, and reflect great credit upon the producers. We regret the omission of the bibliography; it is presumably intended to insert it in part ii., "Radio-therapeutics," but the size of the work warrants the division of the bibliography into two parts.

We notice that this book has been adopted by the U.S. Army and Navy Medical Departments. Whatever may be said as to the official recognition in this country of the significance of X-ray work, either on the diagnostic or the therapeutic side, and of the status of the medical radiologist, the appearance of this book leaves no doubt in one's mind that the study and practice of radiography are on a sound basis, an excellent foundation, in fact, for the structure of a British School of Radiology.

OUR BOOKSHELF.

The Gate of Remembrance: The Story of the Psychological Experiment which resulted in the Discovery of the Edgar Chapel at Glastonbury. By F. B. Bond. Pp. x+176. (Oxford: B. H. Blackwell, 1918.) Price 6*s.* net.

THIS little book furnishes an interesting record of a series of psychological investigations directed to elucidate certain hitherto unsolved questions in connection with the Glastonbury excavations. In 1907 Mr. F. B. Bond, in anticipation of his appointment to supervise the work, enlisted the aid of a friend, called "J. A.," both being members of the Psychical Research Society, and associated with the secretary in the inquiry. The object was to discover the site of the Edgar Chapel, which seems to have existed in the time of Queen Elizabeth, but which has now passed out of memory. Both the friends made a preliminary study of the monastic chronicles and other literature of the subject. They held numerous meetings, "J. A." grasping a pencil over a sheet of paper, and Mr. Bond resting his hand on that of his friend. By this method a number of scripts were recorded, some containing rudely drawn plans, purporting to be communications from one "Johannes Monachus," "Whyttinge, nuper Abbas," and others, who gave information by which, we are told, the position of the lost Edgar Chapel was determined.

It is obvious that Mr. Bond and "J. A." have compiled the record in perfect good faith, and they have pointed out errors of fact and style in the communications. They do not regard the communications as "the action of discarnate intelligences from the outside upon the physical or nervous organisation of the sitters." "J. A." is "disposed to concur with Mr. Bond in the view that the subconscious part of the mind may in its operation traverse the limitations of individual knowledge, either acting telepathically through contact with some larger field of memory, or as itself part of a larger unit of a more pervasive kind as regards time and space, conditions which would imply that the individual may have powers of self-expression far greater than those which are normally available through the brain-mechanism controlled by the will and logical faculties." This may be so, but others may prefer to attribute the manifestations to unconscious cerebration working on the authors' historical studies. Apart from its psychological interest, the excellent series of plans and sketches adds to the archæological value of the book.

The British Journal Photographic Almanac and Photographer's Daily Companion, 1918. Edited by George E. Brown. Fifty-seventh issue. Pp. 660. (London: Henry Greenwood and Co., Ltd.) Price 1*s.* 6*d.* net.

THE general character of this annual is so well preserved that it needs an actual comparison with the pre-war issues to discover that it is reduced to about half its normal size. Although the "Epitome of Progress" for last year is somewhat curtailed, this is compensated for in great measure by condensing the abstracts and giving references. There has been so much talk with regard to rendering this country independent of foreign factories, so far as some of the more costly chemical preparations are concerned, that one naturally seeks for evidence of progress in this direction. It is satisfactory to note that the Ilford Company is now able to supply certain pure dyes prepared under the direction of Prof. W. J. Pope, of Cambridge University. It mentions a "considerable number" useful for the making of colour filters of all kinds, stains for microscopy, etc., and it is claimed that they are superior to the pre-war German products. Among the latest introductions are pinacyanol and pinaverdol, now called sensitol red and sensitol green respectively; sensitol violet, which is an entirely new panchromatic sensitiser; and filter yellow A. These, with metol and amidol (made by the firm of Johnson and Sons), and various metol substitutes, the compositions of which are not stated, show that a good deal has already been done. Perhaps the second most notable item is the rise in the price of photographic plates. Before the war the popular one shilling a dozen for quarter-plates was increased by 25 per cent., and now, by successive steps, the shilling has risen to two shillings and ninepence.

Memento Oppermann à l'Usage des Ingénieurs, Architectes, Agents Voyers, Conducteurs de Travaux, Mécaniciens, Industriels, Entrepreneurs. Pp. 268. (Paris et Liège: Ch. Béranger.) Price 6 fr.

THIS is a pocket-book for engineers, surveyors, and architects, and contains the information usually given in similar works published in this

country. Only a few remarks are called for. The section on surveying includes a good description of the methods and instruments usually employed in the measurement of land, and gives specimen pages of field books. In the part dealing with weights and measures there are tables not only of the metric system, the use of which is now general throughout France, but also of various old French denominations, which, if not used at the present time in commerce or science, are at least often met with in legal documents. Particulars of the weights and measures of foreign countries are also given, and so far as regards the English system these are generally accurate. The compiler is not, however, aware that the metric carat of 200 mg. is the only legal unit of weight in this country for diamonds and precious stones, as he gives the equivalent of the obsolete English carat on p. 41. The troy weights mentioned on p. 44 are not, as there stated, used in this country by chemists; we have a special apothecaries' weight. On the whole, the work bears evidence of careful compilation, and is likely to prove useful to the professional men to whom it particularly appeals.

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.*]

Patents and Scientific Research.

IN connection with the excellent article on "Patents and Scientific Research" in NATURE of February 21, may I direct the attention of your readers to another article on the same subject published in *Science Progress* of January, 1914? Both articles must be read if any attempt is to be made to fit the patent system on to scientific research.

In my opinion, however, much the best way to encourage high intellectual effort of all kinds would be to establish a national pension fund for men whose work in any line has been of benefit to large numbers of the public without being remunerative to themselves, or, as sometimes happens, while being of actual pecuniary disadvantage to themselves. I have suggested this idea over and over again, but regret that I cannot get anyone to pay attention to it. For Britain, the present Civil List Pensions should be converted into such a pension scheme as I suggest. The pensions, which I anticipate would scarcely amount to more than 20,000*l.* a year altogether for Britain, ought to be allotted by a standing committee with a paid office—somewhat in the manner of the Nobel prizes. Of course, decision on rival merits of possible candidates may often be difficult, but the same difficulties now present themselves to all learned societies in allotting medals and other honours, and also to the Premier in allotting Civil List Pensions.

Yet another method is to admit the precedent of Jenner, who received 30,000*l.* on petitioning Parliament. I tried this method, as a test of the intelligence of the country, before the war (see *Science Progress*, October, 1915); but the present Premier, when he was Chancellor of the Exchequer, refused to allow my petition to go forward, although my lawyers assured me that it was a perfectly valid one.

At present the British nation is paying large sums of money to supply junior scientific workers with laboratory facilities and small salaries for doing pot-boiler scientific work in the hope of possibly making some discovery in the future, while it gives nothing whatever to those who have already done work of established and even universal value. I wonder why our countrymen find it so difficult to understand such simple ideas.

RONALD ROSS,
Editor of *Science Progress*.

36 Harley House, London, N.W.1, March 4.

Whale-meat in War Time.

AN announcement in the daily Press states that whale-meat furnished the principal article of food at a luncheon given in New York by the American Museum of Natural History to demonstrate the possibilities of whale-meat for home consumption, in order that the beef thus saved might be sent by America to relieve the scarcity prevailing among the Allies in Europe.

All who were privileged to partake of this luncheon must have gone away satisfied that the substitution of this meat for beef and mutton would entail no hardship, but, on the contrary, would prove a welcome addition to the bill of fare. This at any rate is the conclusion arrived at by members of the staff of the British Museum of Natural History, who have recently experimented with the flesh of a white-beaked dolphin stranded on the Suffolk coast.

Unfortunately, we can do little to assist in this saving, for the whales in our home-waters cannot be "fished," since neither ships nor men are available for the purpose. Similarly, lack of tonnage prevents importation from the Antarctic waters and elsewhere under cold storage.

It is to be hoped, however, that the fullest possible use will be made of the carcasses of the various species of Cetacea stranded around our coasts. Of course, no great quantity of meat would thus be obtained, but locally it should form a very welcome addition to the scanty meat rations now of necessity prevailing.

Whale-meat has no fat, but is encased in a thick layer of "blubber," which, when boiled down with water, yields a large quantity of clear, amber-coloured oil, just now very precious. It has, however, a slight and rather unpleasant odour, but it should not be difficult to eliminate this.

The dark red colour of whale-meat is likely to arouse prejudice against it. But if those who have opportunity will only make trial of its qualities as a food, they will find it scarcely distinguishable from beef, and quite as palatable. Such experiments may well create a demand for this meat after the war. This should lead to a revival of the now extinct Dundee whaling industry, remodelled after the methods followed by the Norwegians, in whose hands modern whaling now almost entirely rests. The difficulty of finding suitable gunners could easily be overcome by employing men trained in the Navy. Many new industries will arise among us after the war. This may well be among the number. It is ridiculous to suppose that we are unable to master the requirements of modern whaling; but, as matters now stand, British whaling companies have to depend for their principal officers on Norwegians. There is no reason why this state of things should continue.

W. P. PYCRAFT.

Aeronautics—History

THE LEGEND OF ALEXANDER AND HIS FLYING MACHINE.

BY the kind assistance of Prof. H. Fehr, of Geneva, and the help of M. Stuckelberg, professor of the history of art in the University of Bâle, we are able to give an additional photograph of the "Legend of Alexander," taken from the sculptured capital, in the choir of the cathedral of Bâle, on a Romanesque column of the twelfth century.

Guided by the previous photograph, given in NATURE of August 23 last, of the bas-relief on St. Mark's, Venice, we are able to identify the subject, in the words of "Love's Labour's Lost"—"My scutcheon plain declares that I am Alisander"—and make a comparison of the details in their close resemblance and attention to the description by the Pseudo-Callisthenes in his fabulous "Life of Alexander."

In the Bâle sculpture the throne of Alexander, placed on an ox-yoke, is seen reproduced more like a car-shaped boat, but the unbridled griffins (στομίων ἄτερ) are there. And Alexander holds the two sceptres—joy-sticks, in the language of the airman—baited with cakes instead of the rabbits shown at Venice, or the lumps of liver in the narrative of Pseudo-Callisthenes, where, we are told, the griffins were kept sharp-set for some time before a flight, in a manner known to the lion-tamer, and so followed the tasty bait of direction control whichever way it pointed.

The St. Mark's photograph has been reduced as a lantern slide by the kindness of the National Physical Laboratory. But when the slide was shown enlarged on the screen as the company was once assembling for a lecture to the Aeronautical Society, the members looked up on entrance, and looked away again without comment. Not one seemed to recognise it as the representation of a flying machine, the earliest known. It may be, then, that other versions of the legend are in existence in various cathedrals, but the meaning has been lost, and they are not recognised in relation to flight in the air.

So, too, it is possible that the capital at Bâle is regarded as representing some kind of progress over the water, or under it, from the boat-like shape of the car; and it was not recognised as intended to take to the air, because Pseudo-Callisthenes describes the machine as capable of being used as a submarine, as well as a flying machine; and this, too, is the account of Æthicus, quoted by Roger Bacon in "De Secretis Operibus Artis et Naturæ":—

Possunt etiam fieri instrumenta volandi, et homo sedens in medio instrumenti revolvens aliquod ingenium, per quod alæ artificialiter compositæ aerem verberent, ad modum avis volantis.

Possunt etiam fieri instrumenta ambulandi in mari et in fluviis ad fundum sine periculo corporali. Nam Alexander magnus his usus est, ut secreta maris videret, secundum quod Ethicus narrat astronomus.

Hæc autem facta sunt antiquitus, et nostris temporibus. Et certum est, præter instrumentum volandi quod non vidi, nec hominem qui vidisset cognovi, sed sapientem qui hoc artificium excogitavit explicite cognosco.

The romance of Callisthenes appears to have had a great vogue in the early and middle ages, and an allusion to it would be familiar to all; so an organised search should be undertaken in other cathedrals and churches of similar representations, not yet identified as on this one subject of flight,

Roman capital of the twelfth century in the choir of Bâle Cathedral.

in stained glass and tessellated pavement, as well as sculpture and bas-relief.

The book used at school has the powerful influence in moulding the mind, and providing association of ideas familiar to all. A quotation from a school book is sure of acceptation and comprehension.

Horace, in his ode on Archytas, mentions the flying machine among his mechanical achievements, if we may interpret so his "aerias tentasse domos—Tithonusque remotus in auras." But he mixes up Archytas and Archimedes in "numeroque carentis arenæ mensorem," both authors being in use in his schooldays for mathematical and cosmographical instruction. The curtain goes up on Antony and Cleopatra engaged in an amatory disputation on the Psammites Arenarius of Archimedes.

And here we, too, are quoting ourselves from the ode of Horace as familiar to all from schoolboy days.

Interpretations of this ode are various, but we may imagine Horace has arrived at the last stage on the Appian Way to the terminus at Brindisi, and employs the waiting time to visit the sights of Tarentum, where he comes across the tumulus of Archytas—"that old beast," he would call him in schoolboy terms, as the author of the text-book of arithmetic, geometry, harmonics, spherics. The epitaph then tells him the tomb is a cenotaph, and the real site of burial is away far to the north on the other sea, in a small memorial.

Another school author was Aratus, for instruction in astronomy, and so could be drawn on as familiar to all. Ovid is full of allusions from Aratus, and Cicero contemplated a translation into Latin verse. Aratus is quoted also by St. Paul as familiar to his audience, as Newton reminds us in the "Principia."

The mathematical fragments of Archytas, collected in "Mélanges Graux" (Paris, 1884), will trace his influence on the young minds of the Latin poets, Virgil, Ovid, Horace. They give the history of the problem of the two mean proportionals, generalisation of the Delian problem of the duplication of the cube, and incidental to angle trisection, among famous problems of antiquity, such as squaring the circle. And in his "Harmonics" Archytas was the first to direct attention to the harmonic progression shown in the divisions on the musical chord where it must be touched to give the successive overtone notes of frequency 1, 2, 3, etc. But the graphical and mechanical methods of Archytas drew down the scorn of Plato, pioneer of Rigour, as contaminating the purity of Geometry with material contact.

And what would Plato have said—originator of the sentiment, "Here's to Mathematics, and may they never be of use to anybody"—if he had foreseen the latest development of the harmless flying toy of Archytas, described with such prescience by the artist-mechanic in "Rasselas" (1759)?

> If men were all virtuous, I should with great alacrity teach them to fly. But what would be the security of the good, if the bad could at pleasure invade them from the sky? Against an army sailing through the clouds, neither walls, mountains, nor seas could afford security. A flight of northern savages might hover in the wind, and rush with irresistible violence upon the capital of a neighbour region.

G. GREENHILL.

METEOROLOGY IN NORWAY.[1]

THE volume before us, published in celebration of the fifty years' existence of the Norwegian Meteorological Institute, commences with brief sketches of the lives of Prof. Henrik Mohn and Director Aksel Steen, to both of whom the institute, to a large extent, owes its development. A very interesting account is given of the history of meteorology in Norway. Owing to the peculiar geographical position of the country, meteorology was early found to be of special importance, and observations were taken from the end of the seventeenth century; but it was not until the beginning of the nineteenth century that regular observations in the modern sense of the word were commenced. In 1811 Prof. Esmarck began them in Christiania, and in 1837 Prof. Hansteen took daily observations of pressure, temperature, wind direction and force, cloud amount, and appearance of the sky. A scheme was then put on foot for organising daily observations in the different parts of the country, but these gradually fell off, until in 1850, with the exception of the unbroken records at Christiania, meteorological work in Norway was almost at a standstill.

It was the great storm of 1854, which overtook the French and English fleets on the Crimean coasts, that gave a new impetus to meteorology in Europe, and in 1855 Le Verrier made proposals for an international weather service. Norway was greatly interested in the new movement, and in 1860 C. Nielsen, Director of Telegraphs in Norway, established five stations along the coast—Christiansund, Aalesund, Skudenes, Mandal, and Sandøsund—with the necessary instruments and staff. At these stations observations were made three times daily of pressure, temperature, humidity, wind, weather, and cloud. A short time later an inland station was established at Dombaas, and reports were exchanged between these stations and Sweden, and also, after a few years, with Paris.

The six stations were soon found to be insufficient for the proper development of meteorological work in Norway, and in 1865 it was resolved to erect a meteorological institute and to appoint a professor of meteorology. The institute was commenced, and in 1865 Henrik Mohn was appointed professor of meteorology and director of the Meteorological Institute. New instruments were installed at the existing stations, and on December 1, 1866, the Norwegian Meteorological Institute began its operations, with the co-operation of the six stations mentioned, and also of Bergen and Christiania.

Prof. Mohn's initiative soon resulted in great developments: the number of climatological sta-

[1] Meteorologien i Norge i 50 aar. (Christiania: Grøndahl and Sons.)

tions was rapidly increased; in 1871 there were fifty-five, in 1898 eighty. The collection of rainfall statistics also interested Prof. Mohn greatly, and by 1890 he had established nearly 100 stations, in 1895 the number reached about 300, and a few years later 500 stations reported rainfall to the institute.

The international exchange of telegrams was also developed. As early as 1869 telegrams were received from Great Britain; Denmark commenced in 1871, Sweden in 1873; Russia, Finland, Germany, and France began in 1892, and the Faröe Islands in 1907; Spitsbergen, Austria-Hungary, and Italy joined in 1912, followed in 1913 by Holland, Spain, Portugal, and Madeira.

Meanwhile the telegraphic reporting of observations from Norwegian stations was increased; by 1892 thirty-three stations reported by telegraph, while by 1914 the number had increased to sixty-nine.

Services of storm-warnings and forecasts were commenced early in the history of the institute. The reports and publications were organised and developed, and the volume gives diagrammatic representations of the growth of the institute's reporting stations, staff, budget, and library.

Aerology received much attention at the beginning of the present century; sounding balloons were sent up, and in 1909 pilot-balloon ascents were begun. In 1912 this part of the work was taken over by Prof. V. Bjerknes, and it is now carried on by the observatory at Aas.

Notes are given on the past and present members of the staff of the institute, and detailed descriptions of the growth and work of each of the three sections dealing with climatology, forecasting, and rainfall respectively. The establishment and work of the observatories at Aas, Bergen, and Haldde are described, and the book is illustrated by interesting photographs of the institute and observatories, and by reproductions of charts and diagrams.

NOTES.

THE letters that have appeared recently in the *Times* and in articles elsewhere on the effect of electric action on the growth of plants show a readiness to believe that almost any wonders may be wrought by electricity. Most scientific workers will agree with Prof. Armstrong and Sir James Crichton-Browne in their scepticism as to the proved value of electrical treatment as a general method of increasing crop production. It is asserted that by the electrical treatment of seeds increases of yield of 20 to 80 per cent. may be produced. The statement seems to refer to a commercial process in which, apparently, seeds are subjected to the combined action of electric currents and certain solutions; in the method electrolysis appears to play some part. The process seems based on the treatment known to physicians as "ionic medication," and used, for example, for the reduction of swollen joints. Treatment of seeds in this way appears to have no sound physiological basis, and no data derived from experiments carried out under critical conditions appear to be available, so that it is impossible to evaluate the method. No one who knows the difficulty of carrying out satisfactory agricultural experiments, and the ease with which a few favourable but illusory results can be obtained, is likely to accept the views of a few farmers as convincing evidence of the value of the process. The method of treatment of the growing plant with a high-tension discharge from overhead wires has been before the public for some years; it is certainly more promising, but it is generally admitted to be in a purely experimental stage.

SIR J. J. DOBBIE, Government Chemist, and principal of the Government laboratories, has been elected a member of the Athenæum Club under the rule of the club which empowers the annual election by the committee of a certain number of persons of distinguished eminence in science, literature, the arts, or for public service.

SUMMER-TIME began in France and Italy on March 10; it begins with us on March 24, and will begin in Holland on April 1. The dates on which summer-time ends are also different in different countries. However much "daylight saving" by alteration of clocks may be appreciated by the public, there can be no doubt that the varying dates adopted for the beginning and ending of the change of standard are most confusing, and will render it very difficult to determine the exact instant at which any records of observations of natural occurrences are made.

THE issue of the *Comptes rendus* of the Paris Academy of Sciences for January 28 contains a decree of the President of the Republic creating a new division under the title "Application de la Science à l'Industrie," which is to consist of six members, who are to enjoy the same privileges as the "Académiciens libres," without restriction as to residence. There is probably no more conservative scientific organisation in the world than the Académie des Sciences, and there could be no more significant sign of the changed conditions of the times than this action on the part of the French Government and the academy in thus seeking to bring science and industry into closer relationship.

IN connection with our note on the Air Force Medical Service in last week's issue, we may direct attention to the appointment of a Medical Administrative Committee. According to the *Lancet*, the Director-General of the Naval Medical Service is chairman. The other members are the Director-General of the Army Medical Service, Fleet-Surgeon R. C. Munday, Major C. B. Heald, Surgeon-General Rolleston, Dr. Henry Head, Mr. Raymond Johnson, Dr. Leonard Hill, and Sir Walter Fletcher. We observe with satisfaction that the scientific aspects of the problems will be likely to receive consideration. At the same time, the physiological representatives are small in number compared with the official and medical members, a fact to be regretted in view of the nature of the chief questions with which the Committee will have to deal. These questions require a wide knowledge of a great variety of physiological problems.

As the outcome of a conference held on November 7 last, at which there were present representatives of the Committee of the Privy Council for Scientific and Industrial Research and of the Department for the Development of Mineral Resources, besides many of the land- and mine-owners of Cornwall, a fund for research has been raised, and a Research Board has been appointed by the Committee of the Privy Council. The members of the Board are:—Sir Lionel Phillips, Bt. (chairman); Mr. J. G. Gilbert, Cornish Chamber of Mines; Sir Frank Heath, Department of Scientific and Industrial Research; Sir T. K. Rose, chairman of the Research Committee of the Board; Mr. Edgar Taylor,

Institution of Mining and Metallurgy; Mr. R. Arthur Thomas, Cornish Chamber of Mines; and Sir Richard Threlfall, Advisory Council for Scientific and Industrial Research; with Mr. A. Richardson as secretary (15 Great George Street, Westminster, S.W.1). The Board, after consultation with its Research Committee, has authorised extended lines of research with the view of increasing the recovery of metal in the treatment of ores.

IN his lecture on "Chemical Research in Relation to Industry" (Adelaide: G. Hassell and Son) Dr. Hargreaves says little that is new and nothing that is not true. The arguments he uses apply equally to us here and to our colleagues in the Antipodes. Dr. Hargreaves is Director of the Department of Chemistry of South Australia, which Department he describes as a connecting link between the industries and the pure man of science, and his lecture deals with two main topics: first, the need for closer co-operation between scientific men and business men; secondly, the need for paying chemists an adequate salary in order to get the right men. We are, in this country, face to face with the same two questions, and there is a grave risk that Great Britain as a whole will not realise their importance. There are indications that the scientific world here is now convinced on both these points, but the majority of business men keep aloof from science, and have been of late too busy with their own difficult problems to apply their minds to an investigation of matters outside their usual routine. Dr. Hargreaves's lecture is temperately written and contains some useful suggestions. It is to be hoped that a real effort will be made to interest the commercial men in this country in these problems of pressing and national importance, but present conditions make it difficult to start a crusade of the necessary dimensions.

MR. W. J. UGLOW WOOLCOCK, the registrar and secretary of the Pharmaceutical Society, has been appointed secretary of the Association of British Chemical Manufacturers.

MR. F. W. HODGE, head of the Bureau of American Ethnology of the Smithsonian Institution since 1905, has resigned, and has been succeeded by Dr. J. W. Fewkes, who has been on the Bureau's staff since 1895.

WE notice with regret the announcement of the death of Prof. E. W. Davis, dean of the College of Arts and Sciences and head of the Department of Mathematics of the University of Nebraska, at the age of sixty years.

THE death is announced, at the age of seventy-three years, at Dorchester, Mass., of Mr. Paul S. Yendell, known particularly by his studies of the light-curves and periods of variable stars of the Algol and short-period types.

WE learn from *Science* that Prof. Rollin D. Salisbury, head of the Department of Geography and dean of the Ogden Graduate School of Science at the University of Chicago, has been awarded the Helen Culver gold medal of the Geographic Society of Chicago. Prof. Salisbury was the first president of the society twenty years ago.

THE meeting of the Institution of Electrical Engineers on April 11 will be held at King's College, Strand, W.C.2, at 6 p.m., and will be a joint meeting with the electrical section of the Royal Society of Medicine. Papers will be read on the subject of "Medical Electricity," and there will be an exhibition of apparatus.

THE Röntgen Society has recently founded an annual lecture in memory of its first president, the late Prof. Silvanus P. Thompson. The first "Silvanus Thompson Memorial Lecture" will be delivered by Sir Ernest Rutherford at the next meeting of the society, to be held on Tuesday, April 9, at 8 p.m. The council will be pleased to welcome all interested, and applications for cards of admission should be made to the hon. secretary of the society, Dr. S. Russ, Middlesex Hospital, London, W.1. Further particulars will be announced in due course.

THE sudden death, on January 20 last, in his fifty-fifth year, of Dr. Rollin A. Harris, of the U.S. Coast and Geodetic Survey, is announced in *Science*. Dr. Harris entered the Tidal Division of the U.S. Coast and Geodetic Survey in 1890, and his "Manual of Tides" appeared in six parts between 1884 and 1907. In 1911 a monograph by him on "Arctic Tides" was published by the Survey. In addition, Dr. Harris was the author of numerous papers on the theory of functions with applications to physics, geodesy, and cartography.

WE much regret to learn of the death of Dr. Lewis Moysey, who was lost by the torpedoing of the hospital ship *Glenart Castle* on February 26. Dr. Moysey had only just joined the ship as one of its medical officers, and he was not among the survivors. Dr. Moysey, previous to the war, had long been in practice as a medical man at Nottingham. He was a very keen palæontologist, greatly interested in the rarer fossils of the coalfield around his home, and to the collection of such specimens in the field he had for many years devoted the scanty leisure of a busy professional life. He thus acquired an exceptionally fine series both of plant and animal remains, some of which he described in a number of papers, especially before the British Association, and others he placed in the hands of friends who were specialists in these departments. Only a few weeks before his death he handed over as gifts his entire collections, the plant remains to the University of Cambridge, and the animal fossils to the Geological Survey. Dr. Moysey possessed great charm of manner, and his loss will be much deplored among those interested in the palæontology of the older rocks.

WE regretfully record the death on February 6 of Capt. S. Gordon McDakin (retired), formerly of the Black Watch, but long resident in Dover, and there taking a leading interest in scientific affairs. During many years he presided over meetings of the Dover Sciences Society. His latest paper, on "Some Remarkable Mountains," was published in 1909 by the East Kent Scientific Society, which he also addressed on "Coast Erosion" and on "Fissure Flows of Lava." The former subject he brought before his home society, coupled with that of "Sea Temperature," and later on addressed it on the topic of "Shingle and Conglomerates in Reference to Local Deposits." That he was a trustworthy botanist is indicated by his papers on "Verification of Records of Flora" and "Verification of Botanical Records," the latter in partnership with the Rev. J. Taylor. At the initial constituent meeting of the South-Eastern Union of Scientific Societies in 1896 Capt. McDakin was one of the Dover delegates. His cheerful presence became welcome at every congress, generally in company with his wife, who encouraged him in his favourite pursuits. Science is apt sometimes to groan a little under its own weight of production. Capt. McDakin was therefore a useful type of man, content to inspire in his neighbours appreciation of scientific work, without appealing to the Press for any solid monument to himself.

AN Entomological Society of Spain has lately been founded, with its centre for the present at St. Saviour's College, Saragossa. Dr. Hermenegildo Gorría, of

Barcelona, is the president for 1918, and the Rev. R. P. Longinos Navás, S.J., the secretary. The society will deal with insects and the other arthropods usually studied with them from every point of view, both purely scientific and economic. Except from July to September, it will hold a monthly meeting for the reading and discussion of papers, and each meeting will be followed by the issue of a small *Boletín*. We have just received the first part of this publication (Nos. 1 and 2, January, 1918), which contains the rules of the society, the first list of members, and a portrait of the president. Following this preliminary matter there is the first instalment of a catalogue of the Coleoptera of Spain, by the Rev. José María de la Fuente. We congratulate our Spanish colleagues on the marked increase of activity in the pursuit of natural science in their country during recent years, and add our best wishes for the success of the important new society.

A COPY of the annual report for the year 1917 of the Philosophical Institute of Canterbury, New Zealand, has been received. During the year the presidential address on some questions of efficiency was given by Mr. L. Birks, and the following lectures were delivered:—Prof. H. B. Kirk, "The Fly Nuisance and its Control"; Prof. J. Hight, "Science and Economics"; and Prof. W. P. Evans, "Some Poison Gases." In April, by request of the local Commissioner of the National Efficiency Board, members of the council of the institute waited on him and discussed matters relative to national efficiency. Another question which has engaged the attention of the council is the proposal made by the "Scientific and Industrial Research Committee" of the New Zealand Institute to recommend the establishment of a national "Board of Science and Industry." The council criticised some features of the scheme, and trusts that the proposal will materialise, and that an institution of great national value will result. The sum of 110*l.* allotted by the New Zealand Institute to members of the Philosophical Institute was received. Considerable progress has been made in the investigation of the phosphate rocks of Canterbury by Messrs. R. Speight and L. J. Wild. Certain preliminary work has been done on the other investigations, viz. "The Deterioration of Apples in Cold Storage" and "The Electrical Prevention of Frosting in Orchards."

"AT a certain stage of social evolution," says Sir James Frazer in his article entitled "The Killing of the Khazar Kings," in the December (1917) issue of *Folklore*, "not a few races appear to have been in the habit of putting their kings to death, either at the end of a fixed term, or on the failure of the king's health and strength, or simply whenever a great public calamity, such as drought or famine, had befallen the country." Among tribes which have practised this remarkable form of limited monarchy must now be included the Khazars, or Khozars. For some 900 years this now almost forgotten tribe, from their home in the spurs of the Caucasus and along the western shore of the Caspian—called after them the Sea of the Khazars—played a great part in history on the European-Asian borderland. It is certainly remarkable that a people which had reached such a high level of civilisation and culture should have practised legalised regicide. But the evidence collected by Sir James Frazer from a very wide survey of medieval literature leaves no doubt on the matter. This survey of an almost unknown tribe is a contribution to anthropology of permanent value.

IN the *American Museum Journal* for December last Mr. Roy C. Andrews gives an admirable summary of the results of his expedition to Yunnan on behalf of the American Museum of Natural History. Herein he gives a valuable account of the habits of the goral and serow, of which but very little is known. These animals are rare in museum collections, so that he is not unnaturally proud of the fact that he has secured for his museum thirty-two gorals of at least two species, and seven serows of three species, forming a series the like of which is to be found in no other museum in the world. A large series of a shrew-like animal, of the genus Hylomys, extremely rare in collections, constituted the most striking of the additions to the smaller mammals made by the expedition. A number of remarkably fine photographs add immensely to the value of this contribution.

THE insect pest known as *Icerya purchasi*, originally a native of Australia, according to a report reprinted in the *Pioneer Mail* for November 24 from the *Agricultural Journal of India*, has now acquired a firm footing in Ceylon. It is especially destructive to citrus trees, but it may be found on other trees and plants, including the pomegranate, grape, rose, castor, mulberry, apple, peach, apricot, fig, walnut, willow, pepper, and potato. The adult female is about one-fifth of an inch in length and rather less in breadth, and is of a brown, reddish, or blackish colour, the body being overlaid by a large, white-fluted, cottony mass, in which the eggs are laid. In view of the great damage done to orange-groves in the United States, the Government sent a man of science to Australia, and the result was that a number of small red and black ladybird beetles (*Novius cardinalis*) were carried to California, where they speedily multiplied and dealt effectively with the Icerya. The Government of India is now undertaking inquiries to prevent the entry of the pest into that country.

OF the great memoir on "Hawaiian and Other Pacific Echini," begun in 1907 by Alexander Agassiz and H. Lyman Clark, three parts were published by the joint authors, and, with a fourth part by Dr. Clark, composed vol. xxxiv. of the Memoirs of the Museum of Comparative Zoology. Two further parts by Dr. Clark have now completed the work (Memoirs, vol. xlvi., Nos. 1 and 2). Of these, the former deals with the suborder Clypeastrina, or shield-urchins, and the systematic descriptions are preceded by a general discussion. Dr. R. T. Jackson has given reasons for the belief that the clypeastroids were derived from a group of regular urchins of which the Arbaciidæ are modern representatives. Dr. Clark, however, points out that, in the perforation of their tubercles and the structure of their pedicellariæ, they more closely resemble the Saleniidæ. The final part of the memoir consists of 200 pages and eighteen plates devoted to that large assemblage of much-modified urchins known as Spatangina, or heart-urchins. This is believed to include forms derived from at least two, and possibly four, distinct stocks. Dr. Clark does not, however, attempt to represent this in his classification. There is a discussion of the various structures used in classification, such as pedicellariæ and fascioles, but as regards the latter Dr. Clark does not make use of the important study published by B. Hoffmann in the *Palaeontologische Zeitschrift*, 1914. The present memoir adds one more to the valuable and admirably produced zoological publications arising out of the cruises of the U.S. Fish Commission steamer *Albatross*, and Dr. Lyman Clark is to be thanked and congratulated on completing his important share of the work.

A REPORT on the work of the Imperial Institute for South Africa, presented to the Committee for the Union of South Africa and Rhodesia at its last meeting, includes an interesting reference to the possible

utilisation of the waste bark of the wattle-tree, which is extensively cultivated in South and East Africa. The waste, from which the tanning constituent has been removed, can be utilised both here and in Natal, where tanning extract is at present being produced, for the manufacture of an excellent brown paper or millboard. The waste from tanyards in this country may thus be a source of remuneration, and in South Africa an important industry may be created where brown paper and millboard for packing purposes, especially for fresh fruit transport, are in great demand, and have to be imported for the purpose. The wood of the Acacia trees from which the bark has been taken can also be utilised for millboard. According to the report, arrangements are already being made for the use of spent wattle bark in this country by paper manufacturers.

A PAPER entitled "British Trade and the Metric System" was read by Mr. E. A. W. Phillips at a recent meeting of the Concrete Institute. Mr. Phillips proposes a system of weights and measures including, in addition to the more usual English denominations, a decimal scale based on a "British metre" of 39·6 in., the ton of 2240 lb., divided into ten sacks, or 1000 "British kilograms," and a cubic British metre of pure water divided into 1000 litres. It is mentioned that the proposed metre is the same length as the ancient Belgic yard, which the author calls the "Anglo-Saxon metre," and he states that this has existed in Britain since the third century at least. Five of these yards made the rod, pole, or perch used in land measure. Mr. Phillips raises the question of the possibility of making his proposed decimal system the international standard for trade, commerce, and engineering, and of restricting the metric system proper to purposes of pure science. As regards coinage, his proposals include the retention of the pound sterling of ten florins and the division of the florin into 100 imaginary cents of account, not coined, for use in decimal accounting and decimal quoting.

A RECENT Technologic Paper (No. 103) of the U.S. Bureau of Standards deals with some typical cases of selective corrosion of 60 : 40 brass, or Muntz metal. The specimens described by the author, Mr. H. S. Rawdon, include bolts, sheathing, and condenser tubes. In all the cases examined, the selective corrosion takes the form of a removal of zinc from the β crystals, the α constituent not being attacked until a later stage. The corroded mass retains its external form, but consists only of spongy copper. A sharply defined boundary between the corroded portion and unaltered brass is always present, without any intervening zone of lower zinc content. Chemical action advances in the first instance along the boundaries of the crystal grains, and in the β crystals also along systems of intersecting planes, which may be twinning planes. Contact with a more strongly electro-negative metal has an accelerating influence, but none of the actual cases observed can be attributed to this cause. Experiments with grooved bars under tensile stress show that local increase of stress favours corrosion. Annealing has little effect. The results on the whole confirm those obtained by previous workers, but the photomicrographs illustrate very clearly the successive stages in the removal of zinc from alloys of this class.

THERE has been such a vast increase in the manufacture of organic nitro-compounds for the production of both dyes and explosives since the outbreak of war that the vexed question of the estimation of nitrogen therein has probably become acute. To the Journal of the Society of Chemical Industry of August 31 last Mr. A. P. Sachs contributes an account of what seems to be a highly successful method of effecting this estimation. The method depending on the reduction of the nitro-group with stannous chloride solution in an open flask and estimation of the excess of reducing agent with iodine was found to be unsatisfactory in the case of nitrated "solvent naphthas." The author finds, however, that if the nitro-compound is heated in a sealed tube with excess of stannous chloride solution (prepared by dissolving the dihydrated salt in twice its weight of 25 per cent. hydrochloric acid) at 120° for two hours, the tube being shaken every fifteen minutes, reduction is complete. The excess of stannous chloride is then determined by titration with decinormal iodine solution, using starch as indicator. It is of importance that exactly the same volume of stannous chloride solution should be used in all experiments and for the blank determination. Quoted analyses made by this method and by the combustion method on the same substances gave very concordant results.

AMONG forthcoming books of science we notice the following:—"The Future of Our Agriculture," H. W. Wolff (*P. S. King and Son, Ltd.*); "Dragons and Rain Gods, etc.," Prof. G. Elliot Smith (*Manchester University Press*); "Bibliography of the Geology and Eruptive Phenomena of the more Important Volcanoes of Southern Italy," the late Dr. H. J. Johnston-Lavis; "An Economic Geography of the British Empire," C. B. Thurston; "The New Regional Geographies, vol. iii., Europe and Africa," L. Brooks, and a new edition of "The Application of Hyperbolic Functions to Electrical Engineering Problems," A. E. Kennelly (*University of London Press, Ltd.*); "Problems of Reconstruction," papers read at the summer meeting held at the Hampstead Garden Suburb, August 3–17, 1917, with an introduction by the Marquess of Crewe; "Forestry Work," W. H. Whellans (*T. Fisher Unwin, Ltd.*); "The Year Book of Wireless Telegraphy and Telephony, including Map of the World showing Wireless Telegraph Stations, 1918" (*The Wireless Press, Ltd.*).

OUR ASTRONOMICAL COLUMN.

THE NEW WOLF PLANET.—An orbit of this body (which has been designated DB) has now been computed by Mr. G. Stracke, and its accuracy is confirmed by a recent Greenwich photograph:—

Perihelion passage 1918 January 3·617, G.M.T.

ω	347°	46′	15″	1918·0
Ω	110	54	1	
i	8	57	41	
ϕ	32	12	5	

Period 4·025 years
Perihelion distance 1·182
Aphelion ,, 3·879

The perihelion distance is very little greater than that of Eros, but the period and eccentricity are much larger. In some revolutions the planet will suffer considerable perturbations by Jupiter, but there will be no near approach in the coming revolution. The fact that the period is very close to four years implies that there will be another near approach to the earth at the next return, of which possibly advantage might be taken to make a determination of the solar parallax. The planet, however, is a little too faint for this purpose, being only of the tenth magnitude in the most favourable circumstances. Its diameter can scarcely be more than four miles.

The orbit is of much the same type as that of Albert, discovered in 1911, but never seen since that year. The present body has been much better observed than

Albert was, so it should be possible to secure its re-observation.

The recent observations of Encke's comet show that the time of perihelion passage will be 1918 March 24·295, G.M.T., which is only 0·018 day earlier than Mr. Viljev's predicted value. By the time this appears it will be too near the sun for observation, and on its emergence it will be visible only to southern observers.

ERRATUM.—In the note on the comet of 1802 last week, *for* "August to October last" *read* "August to October, 1802."

A STAR WITH A NOVA SPECTRUM.—Dr. Max Wolf has announced that a star of magnitude 8·5 showing a Nova spectrum was photographed at Heidelberg on February 4. In Circular No. 3 of the Marseilles Observatory, the position of the star is given by M. Millosevich as R.A. 7h. 22m. 47·98s., declination −6° 30′ 40·8″; on February 23 the magnitude of the star was 9·1.

THE SHORT-PERIOD VARIABLE RZ CEPHEI.—From extensive photographic observations which have been made at Dunsink, Messrs. Martin and Plummer have deduced a period of 0·308646 day for this interesting variable star (Monthly Notices, vol. lxxviii., p. 156). A maximum is indicated by the observations at J.D. 2421496·616, and the range of variation is from magnitude 9·5 to 10·16. The period, of about 7·4 hours, is among the shortest known. The light curve shows a more rapid rise to maximum than fall to minimum, and the descending arm shows well-marked secondary waves. The phases of the harmonics show remarkable accordance with those of other short-period variables, and also with those of some of the long-period variables which are included in Group II. of the classification given by Phillips. It would thus appear possible that a common process operates in variables differing as widely as RZ Cephei, and stars with a range of some ten magnitudes and periods of the order of a year, or even the sun with its period of eleven years.

THE RAMSAY MEMORIAL FUND.

THE Lord Mayor of London has issued a special appeal to the citizens of London for support to the Ramsay Memorial Fund. Towards the 100,000*l.* which the Executive Committee aims at raising, the sum of about 31,000*l.* has been subscribed. The Lord Mayor points out that London has benefited largely in the past through Sir William Ramsay's connection with the City, and that great industrial advantages will be derived from the successful institution of the proposed memorial laboratory of engineering chemistry. He hopes, therefore, that there will be a generous response to his appeal.

It will be remembered that the principal objects of the Executive Committee of the memorial fund are to establish: (*a*) Ramsay memorial research fellowships in chemistry, tenable at any suitable place possessed of adequate equipment, and (*b*) a Ramsay Memorial Laboratory of Engineering Chemistry in connection with University College, London. Subscriptions may be earmarked for either of these purposes, or may be left, as regards their allocation, to the discretion of the committee. The president of the Ramsay memorial is Mr. Asquith, whilst the vice-presidents include the Prime Minister, Mr. H. A. L. Fisher, Sir J. J. Thomson, Lord Rayleigh, the Earl of Rosebery, Lord Reay, and Lord Gainford of Headlam. Lord Rayleigh is chairman of the General Committee, Sir Hugh Bell of the Executive Committee. The hon. treasurers are Lord Glenconner and Prof. Norman Collie. On the Executive Committee appear the names of many of the most eminent representatives of British chemical science and industry.

It is earnestly to be hoped that all friends and admirers of Sir William Ramsay and all supporters and well-wishers of chemical science will subscribe to the memorial. The work which Sir William Ramsay did as a great teacher and investigator will remain for all time as an imperishable monument to his genius, enthusiasm, and tireless industry. In the centuries to come his name will stand out as one of the greatest discoverers in the long annals of science.

British chemical science has indeed reason to be proud of the great name which has long been, and ever will remain, one of its brightest ornaments. The proposed memorial will not only serve to honour the work and memory of Sir William Ramsay, but will also be of the greatest value for the cause which he had most at heart, namely, the advancement of chemical science. This object scarcely requires emphasising at the present time. The well-being, health, prosperity, and civilisation of nations are dependent on the never-ceasing advance and application of chemical facts and principles. For this purpose every nation requires a host of scientifically trained chemists. The more we possess of such men, the greater will be our chances not merely of prosperity and well-being, but also of survival in the great race of the immediate future. It is, therefore, of vital importance to provide young men of promise and ability with every opportunity of continuing and improving their chemical studies. The Ramsay memorial research fellowships will enable such young men to continue their training and experience in chemical research at that period of their lives when such opportunities are of the greatest importance for their future competency and success. The Ramsay Memorial Laboratory of Engineering Chemistry will provide young chemists with the opportunity of learning how to apply the principles of chemical science in technical practice. Many of our chemists have been unable to apply their knowledge and abilities to the greatest advantage for lack of suitable preparatory training in the theory of practice, which is, essentially, a just comprehension of the engineering and economic aspects of a chemical reaction or process. This is a matter of urgent and pressing importance for the future of British chemical industry. The committee of the Ramsay Memorial Fund hopes, in the ways indicated above, to be able, not only to honour the memory of a great man, but also to further the advancement of chemical science and chemical practice.

Memoranda describing the memorial scheme have recently been addressed respectively to the Governments of the Dominions, Colonies, and Dependencies of the Empire and to those of the principal Allied and neutral countries. Each Government is invited to consider the possibility of providing from State funds at least one capital sum of 6000*l.*, which will be sufficient to found and maintain in perpetuity one Ramsay memorial fellowship of the value of 250*l.* a year, with an expenses grant of 50*l.* a year. The fellowship, it is proposed, will be tenable at any place in the United Kingdom possessed of the necessary equipment by a fully trained chemist from the Dominion, Colony, Dependency, or foreign State concerned. For Dominions like Canada and India one fellowship might scarcely be adequate; and it is hoped that some Governments will see their way to found, not one, but a group of fellowships.

The scheme is making good progress in countries outside Great Britain, and it is hoped that a substantial sum will be received from such countries. The Ramsay Memorial Committee has already appointed the following representatives outside Great Britain: Prof. Baskerville in America; Prof. Masson in Australia;

Prof. Inglis in New Zealand; Señor Augusto Villanueva in Chile; Prof. Guye in Switzerland; and Prof. H. Kamerlingh Onnes in Holland.

Subscriptions should be sent either to the Lord Mayor at the Mansion House, or to the Hon. Treasurer, Ramsay Memorial Fund, University College, Gower Street, London, W.C.1.

AURORA AND MAGNETIC STORM OF MARCH 7–8.

THE auroral display of Thursday last attracted much attention, partly because it coincided with an air-raid upon London. The northern sky was lighted up with a crimson glow both before and during the raid, which started shortly after 11 p.m.; and the appearance was thought by an observer at Folkestone to be due to a distant fire. Sir Napier Shaw informs us that the Meteorological Office has received reports of aurora observations from Lerwick, Stornoway, Eskdalemuir, Donaghadee, Liverpool, Clacton, and Southend. He has favoured us with the following account, by Dr. C. Chree, of the large magnetic disturbance recorded at the Kew Observatory between 9 p.m. on Thursday and 5 a.m. on the following morning. Mr. A. Lander has sent us photographic traces of movements in declination recorded at Canterbury during Thursday and Friday. Thursday's trace was remarkably even until shortly after 9 p.m., when the magnetic storm began. It is possible that the disturbance was a repetition, after three 27-day intervals, of the large magnetic storm of December 16–17, 1917. There was a very considerable disturbance on January 12 at the end of the first 27-day interval, and a minor disturbance at the end of the intermediate interval in February.

Dr. Chree writes: "A magnetic storm of no great duration, but very considerable amplitude, was recorded at Kew Observatory on the night, March 7–8, 1918. It began with a 'sudden commencement' at about 9h. 10m. p.m. on March 7. The largest movements occurred in the early morning of March 8, between midnight and 5 a.m., but smaller oscillations persisted for some time after the latter hour. The 'sudden commencement' was especially prominent in horizontal force (H); after a small, sudden fall there was a sharp rise of fully 60γ. The corresponding movements in declination (D) consisted of an oscillation of about 4′, the first movement being to the west. The range shown on the D trace was about 51′, the extreme easterly and westerly positions being reached at 2.20 a.m. and 4.16 a.m. respectively on March 8. Between 1.11 a.m. and 2.20 a.m. of the same day there was a movement of 36′ to the east. The range on the H trace was about 240γ. A very rapid downward movement commenced about 2.3 a.m. on March 8, the fall during the next thirty minutes amounting to fully 185γ. After 5 a.m. on the same day there were only short-period oscillations in H of moderate size; but up to 10 a.m. the element remained depressed by fully 70γ as compared with its value on the previous day before the storm."

MILITARY AERONAUTICS.

THE recent night raids on Paris by squadrons of Gotha machines brings the question of defence against such raids before us, and adds much interest to an article by Lieut. Jean-Abel Lefranc, who, writing in the *Revue Scientifique*, gives an excellent review of the development of German bombing machines, of which the latest type is the Gotha. He also surveys the various methods of defence that have been adopted, particularly against night raids. His article is full of interesting details, of which it is only possible to quote a few, and to recommend those who are interested to read the original in the *Revue Scientifique* for February 16. A detailed description of the Gotha machine is given, the overall weight being quoted as 84,000 lb., and the weight of bombs carried as about half a ton. The speed is given as ninety miles per hour, and the height to which the machine can rise after discharging its bombs is 20,000 ft. M. Lefranc also states that the Gotha is likely to be replaced by a "Gotha Riesenflugzeug," having four motors, and a span of about 130 ft. The "large Friedrichshafen Gotha" which was captured in one of the Paris raids can scarcely be one of these later machines, as it only had two motors of 250 h.p. each. The extreme difficulties of accurate bombing by night are commented upon, and the writer thinks that the demoralisation of industry is a more important result of night raids than the actual damage done. With regard to defence, camouflage, anti-aircraft guns, and attack by fighting machines are discussed, but M. Lefranc considers that all these methods are very ineffective, and that the best method of defence is to attack and destroy so far as possible the enemy's aviation centres. Commenting on extreme measures, such as total abolition of artificial lighting at night, he thinks they are a vain sacrifice to public opinion, and may even be a detriment to the Services. M. Lefranc concludes his well-written article with a picture of the bombing machine of the near future, pointing out that a machine of 1000 h.p., carrying two tons of explosives, is within the reach of modern design.

The *National Geographic Magazine* for February, published by the National Geographic Society, of Washington, U.S.A., should be read by all who are interested in the development of aviation and in the part which America is playing in the struggle for aerial supremacy. The whole of this attractive issue is devoted to matters of aeronautical interest, and the photographs which illustrate the articles are especially good. Three of the articles deal directly with American activity, and are entitled "America's Part in the Allies' Mastery of the Air," "Building America's Air Army," and "The Future of the Airplane." The second of these merits special attention, and is beautifully illustrated by no fewer than forty-three photographs. The first section deals with the actual construction of American machines, and the manufacture of their parts is described in some detail. Some really magnificent photographs follow, showing machines in flight and views obtained from aeroplanes, and the article concludes with a description of the training of aviators and the tests which they must pass before being pronounced expert pilots. The magazine also contains a number of descriptive articles giving the experiences of aviators in various countries, which make very interesting reading, but which it is impossible adequately to summarise in a short notice such as the present.

THE PRODUCTION OF FUEL OIL AND COAL-GAS.

MUCH attention has been devoted recently to developing the home production of fuel oil, the needs of the Navy and difficulties of transport rendering this imperative. Several well-informed articles have appeared in the Press, and the subject was dealt with in NATURE of February 28 (p. 506). Opinion is divided among experts as to the probability of finding petroleum in any quantity in this country, but Lord Cowdray, who has been so closely associated with the remarkable developments of the Mexican and other

fields, has expressed the view that the prospects are distinctly promising, and has backed his opinion by making alternative offers on behalf of his firm to the Government, either to place the services of the firm's expert staffs at its disposal for the period of the war, free of cost, or to drill at the firm's own expense subject to certain areas being reserved to them. He estimated that this offer committed his firm to a probable expenditure of 500,000*l*. It is obvious that the first step should be to prove or disprove the existence of oil in paying quantities, under such regulations that national interests in any oil discovered are properly safeguarded. Details as to royalties, conditions of production, etc., can well wait for future settlement. The alternative to natural oil is production by distillation processes. For some years about three million tons of oil-shale have been produced in Scotland and retorted, but other oil-yielding minerals, such as coal, cannel-coal, and blackband ironstone, are possible sources. Large quantities of cannel are available, much of which is left in the mine or thrown on the dump as unsuitable for fuel, on account of its high ash content, which is seldom below 10 per cent. One ton of high-quality cannel may yield more than forty gallons of oil; the average yield may be taken as twenty gallons per ton; of this some 50–60 per cent. would be fuel oil. Such oils more nearly approach the natural petroleum products in composition than do the ordinary coal products, and also furnish good yields of valuable paraffin wax. An announcement appeared in the *Times* (March 8), bearing the impress of official origin, that tests on cannel in existing gasworks retorts have given satisfactory results, with extraordinarily high yields of fuel oil and ammonia. It is to be hoped that this foreshadows early production, since little extra retorting and collecting plant will be required.

Modern developments in gasworks construction and practice were described by Mr. Alwyne Meade in a paper read at the Institution of Civil Engineers on March 5. It appears that in spite of modern improvements, the introduction of scientific control, and the lavish installation of labour-saving machinery, coal-gas costs approximately as much to manufacture as it did thirty years ago. The expense of modern manufacture is solely attributed to the abnormal rise in the cost of coal and transport, while during the past three years the wages paid to employees have, in common with other industries, undergone considerable augmentation. Mr. Meade stated that the advances made in the practical application of the theory of heat interchange have resulted in an enormous saving of sensible heat. Whereas twenty years ago 28 lb. of coke were necessary for the carbonisation of 100 lb. of coal, to-day, with the modern continuous vertical retort, only 11½ lb. are required for dealing with the same quantity of coal. Attention was directed to present-day attempts to effect carbonisation on ideal lines by the continuous admission of a small quantity of coal to the retort, and the simultaneous extraction of an equal bulk of coke. The continuous vertical retort has been designed for this purpose, but Mr. Meade holds the opinion that as regards the results of carbonisation the horizontal retort is still able to hold its own in many respects. An advantage of the vertical retort is that it affords facilities for steaming the coal charge; thus, within limits, water-gas may be produced simultaneously with the evolution of coal-gas. Recent results indicate that by introducing the principle of "steaming," it is possible to increase the B.Th.U. produced per ton of coal from 6⅓ millions to nearly 8 millions, with a corresponding reduction in the quality of the gas amounting to only some 20 B.Th.U. per cubic foot. The coal reserves of this country are trifling compared with those of America and the Central Empires, from which it will be appreciated that there is no time to be lost in developing to the utmost advantage the natural gift upon which England's pre-eminence as a nation depends.

TECHNICAL INSTRUCTION IN SWITZERLAND.

IN the *Revue Scientifique* for November 3, 1917, there appears an interesting article by M. C. Perregaux on the progress of technical instruction in Switzerland. It is the second of two articles, the first of which dealt with the establishment, equipment, and work of the renowned Federal Polytechnic of Zurich, with its eleven divisions of applied science, and of the State-recognised School of Engineering at Lausanne, both of which are devoted to the training of the highest class of professional technicians. The present article deals with the aims and work of an intermediate class of schools known as "Technicums," and intended, each according to local industrial requirements, for the training of men aspiring to positions of industrial responsibility as foremen and managers. Six such schools come under review, namely, in German Switzerland: Winterthur, Berthoud, and Bienne; in French Switzerland: Geneva, Locle, and Fribourg.

In addition to these six day institutions, there are also in Switzerland 13 museums of industrial art, 164 schools of commerce, 27 trade schools for boys, 22 trade schools for girls, 342 special (fortbildung) schools for boys, and 720 for girls; in all 1294 institutions of a special or trade character devoted to the industrial well-being of Swiss citizens, an extraordinarily effective provision for a country of three and a half millions denied in large measure the possession of natural mineral resources and wholly dependent for the industrial and commercial well-being of its people upon facilities for a sound scientific and technical training based upon an efficient system, universally accessible, of elementary and secondary education.

It was in 1883 that the Swiss Confederation decided to aid by means of grants, and also to supervise, the existing meagre means of trade instruction in certain instances, and in 1884 gave a subsidy of 40,000 francs to forty-three institutions, with a total expenditure of 440,000 francs, but so rapid has been the development of these institutions that in 1904 they had increased to 318, with an expenditure of 3,940,000 francs, towards which the subventions from the State amounted to 1,080,000 francs; and there were in 1916 1294 such institutions supervised and aided by the State. The six "Technikums" under consideration form a link between the trade schools (Gewerbeschulen), so-called, and the training given in the Federal Polytechnic at Zurich or the Engineering School at Lausanne.

The activity of Germany, and especially of the neighbouring State of Württemberg, in the provision of technical instruction seriously alarmed the Confederation, since it had the possibility of displacing certain Swiss industries, and it led therefore to the initiation of measures calculated to avert the peril. The chief of these "Technikums," which vary in type and seek to adapt themselves to regional conditions, is at Winterthur, some thirteen miles from Zurich, founded in 1874. The other five have been established since 1890, three of them since the beginning of the century.

The course of instruction in Winterthur covers six semesters, and includes architecture, mechanical and electrical engineering, roads and bridges, chemistry, commerce, and railway work. Students on entrance must have had a secondary-school course and be not less than fifteen years of age. The staff comprises forty

professors with fourteen assistant lecturers, and the students in all departments were 556 in 1916. The fees for instruction are 30 francs for each semester, together with certain special fees, and foreigners are charged treble fees. The six schools have a total of 2427 students, and are fully equipped with laboratories for experimental instruction. On leaving these schools the students enter the Union of Swiss Technicians, which association now counts its members by thousands and has for its organ the *Swiss Technical Review*, which publishes much good original work. Altogether these institutions have proved a great success and have been of material benefit in training a large body of men for the industries, many of whom have afterwards qualified for high industrial or administrative positions at home or abroad.

GRAVITATION AND THE PRINCIPLE OF RELATIVITY,[1] II.

WE have to admit, then, that a world-line can be bent by the proximity of other world-lines. It can also be bent, as you see, by the proximity of my thumb. The suggestion arises, May not the two modes of bending be essentially the same? The bending by my thumb (a mathematical transformation of space and time) is in a sense spurious; the world-line is pursuing a course which is straight relative to the *original* material. Or we may perhaps best put it this way—the world-line still continues to take the shortest path between two points, only it reckons distance according to the length that would be occupied in the unstretched state of the bladder. It is suggested that the deflection of a world-line by gravitation is of the same nature; from each world-line a state of distortion radiates, as if from a badly puckered seam, and any other world-line takes the shortest course through this distorted region, which would immediately become straight if the strain could be undone. The same rule —of shortest distance as measured in the undistorted state—is to hold in all cases. This is a mode of reasoning which has often been fruitful in scientific generalisations. A magnetic needle turns towards the end of a bar-magnet; it also turns towards a spot near the pole of the earth; hence the suggestion that the earth is a magnet. We assume the essential identity of the two modes of deflecting the needle. It is a daring step to apply the analogy and assume the essential identity of the two ways of deflecting world-lines; but at any rate we shall make this assumption and see what comes of it.

You will see that according to this view the earth moves in a curved orbit, not because the sun exerts any direct pull, but because the earth is trying to find the shortest way through a space and time which have been tangled up by an influence radiating from the sun. We can continue to describe this indirect influence of the sun on the earth's motion as a "force"; but, assuming that it makes itself felt as a modification or strain of space and time, we are able to bring the discussion of the laws of this force into line with the discussion of the laws of space and time, *i.e.* the laws of geometry. Needless to say, we could not determine a physical law like the law of gravitation by geometrical reasoning without making some assumption.

I am afraid that to talk of a force as being a distortion of space and time must at first appear to you hopeless jargon. But it must be remembered first that we are not concerned with any metaphysical space and time. We mean by space and time simply a scaffolding that we construct as the result of our measures; and if anything queer happens to our measuring apparatus, the scaffolding may easily go crooked. Taking our everyday conception of space, we should say that this room is at rest; we have been told that it is being carried round the earth once a day, but in practical life we never pay any attention to that. The space that we naturally use is thus different from, and it is not difficult to show that it is distorted as compared with, the more fundamental astronomical space in which this room is travelling at a great velocity. So our scaffolding is crooked. But, it may be asked, in what way can this distortion of our space-scaffolding be regarded as a force? The answer is quite simple. We perceive it as a force, and that is the only way in which we do perceive it. We do not perceive that this room is being carried round by the earth's rotation, but we perceive a certain force—the earth's centrifugal force. It is rather difficult to demonstrate this force, because gravitation predominates overwhelmingly; but if gravity were annihilated we should have to be tied down to the floor to prevent our flying up to the ceiling, and we should certainly feel ourselves pulled by a very vigorous centrifugal force. That is our only perception of the crookedness of our scaffolding.

We often call the centrifugal force an "unreal" force, meaning that it arises simply from a transformation of the framework of reference. Can we feel confident that gravitation is in any sense more "real"? In effect they are so much alike that even in scientific work we speak of them in one breath. What is called the value of gravity in London, 981·17 cm./sec.^{2}, is really made up partly of the true attraction of the earth and partly of the centrifugal force. It is not considered worth while to make any distinction. Surely, then, it is not a great stretch of the imagination to regard gravitation as of the same nature as centrifugal force, being merely our perception of the crookedness of the scaffolding that we have chosen.

If gravity and centrifugal force are manifestations of the same underlying condition, it must be possible to reduce them to the same laws; but we must express the laws in a manner which will render them comparable. There is a convenient form of Newton's law, which was given by Laplace and is well known to mathematicians, which describes how the intensity at any point is related to the intensity at surrounding points—or, according to our interpretation, how the distortion of space at any point fits on to the distortion at surrounding points. It is evidently an attempt to express the general laws of the strains in space and time which occur in Nature. If we are correct in our assumption that gravitation involves *nothing more* than strain of space-time,[2] so that its law expresses merely the relation between adjacent strains which holds by some natural necessity, clearly the strains which give the centrifugal force must obey the same general law. Here a very interesting point arises. We cannot reconcile the Newtonian law of gravitation with this condition. Newton's law and the law of centrifugal force are contradictory.

To put the matter another way, if we determine the strains by Newton's law, we get results closely agreeing with observation, provided Minkowski's space-time is used; but if we avail ourselves of our right to use a transformed space-time, the results no longer agree with observation. That means that Newton's law involves something which is not fully represented by strains, and so does not agree with our assumption. We must abandon either our assumption, or the famous law which has been accepted for more than

[1] Discourse delivered at the Royal Institution on Friday, February 1, by Prof. A. S. Eddington, F.R.S. Continued from p. 17.

[2] The idea is that matter represents a seam or nucleus of strain, and the strains at other points link themselves on according to laws inherent in the *continuum* and quite independent of the matter. The matter starts the strain, but does not *control* it as it goes outwards.

200 years, and find a new law of gravitation which will fall in with our requirements.

This amended law has been found by Einstein. It appears to be the only possible law that meets our requirements, and in the limited applications which come under practical observation is sufficiently close to the old law that has served so well. In practical applications the two laws are indistinguishable, except for one or two crucial phenomena to which reference will be made later. But in gravitational fields far stronger than any of which we have experience, and for bodies moving with velocities much greater than those of the planets, the difference would be considerable.

This idea of the distortion of space as the *modus operandi* of gravitation has led to a practical result—a new law of gravitation. It is not brought in as a hypothetical explanation of gravitation; if Einstein's theory is true, it is simply of the nature of an experimental fact.

If we draw a circle on a sheet of paper and measure the ratio of the circumference to the diameter, the result gives, if the experiment is performed accurately enough, the well-known number π, which has been calculated to 707 places of decimals. Now place a heavy particle at or near the centre and repeat the experiment; the ratio will be not exactly equal to π, but a little less. The experiment has not been performed, and is not likely to be performed, because the difference to be looked for is so small; but, if Einstein's theory is correct, that must be the result. The space around the heavy particle does not obey ordinary geometry; it is non-Euclidean. The change in its properties is not metaphysical, but something which, with sufficient care, could be measured. You can keep to Euclidean space if you like, and say that the measuring-rod has contracted or expanded according as it is placed radially or transversely to the gravitational force. That is all very well if the effect is small, but in a very intense gravitational field it would lead to ridiculous results like those we noticed in connection with the Michelson-Morley experiment—everything expanding or contracting as it changed position, and no one aware of any change going on. I think we have learnt our lesson that it is better to be content with the space of experience, whether it turns out to be Euclidean or not, and to leave to the mathematician the transformation of the phenomena into a space with more ideal properties.

This consequence of the new law of gravitation, though theoretically observable, is not likely to be put to any practical test either now or in the immediate future. But there are other consequences which just come within the range of refined observation, and so give an immediate practical importance to the new theory, which has indeed scored one very striking success. If we could isolate the sun and a single planet, then under the Newtonian law of gravitation the planet would revolve in an ellipse, repeating the same orbit indefinitely. Under the new law this is not quite true; the orbit is nearly an ellipse, but it does not exactly close up, and in the next revolution the planet describes a new ellipse in a slightly advanced position. In other words, the elliptic orbit slowly turns round in the same direction in which the planet is moving, so that after the lapse of many centuries the orbit will point in a different direction. The rate at which the orbit turns depends on the speed of motion of the planet in its orbit, so we naturally turn to the fastest moving planets, Mercury, Venus, and the earth, to see if the effect can be detected. Mercury moves at thirty miles a second, Venus at twenty-two, the earth at eighteen and a half. But there is a difficulty about Venus and the earth. Their orbits are nearly circular, and you cannot tell in which direction a circle is pointing. Mercury combines the favourable conditions of a high speed and a satisfactorily elongated orbit the direction of which at any time can be measured with considerable precision. It is found by observation that the orbit of Mercury is advancing at the rate of 574 seconds of arc a century. This is in great measure due to the attraction of the other planets, which are pulling the orbit out of shape and changing its position. The amount of this influence can be calculated very accurately, and amounts to 532 seconds per century. There is thus a difference of forty-two seconds a century unaccounted for; and this has for long been known as one of the most celebrated discordances between observation and gravitational theory in astronomy. It is thirty times greater than the probable error which we should expect from uncertainties in the observations and theory. There are other puzzling discordances, especially in connection with the motion of the moon; but the conditions in that case are more complicated, and I scarcely think they offer so direct a challenge to gravitational theory. Now Einstein's theory predicts that there will be a rotation of the orbit of Mercury additional to that produced by the action of the planets; and it predicts the exact amount—namely, that in one revolution of the planet the orbit will advance by a fraction of a revolution equal to three times the square of the ratio of the velocity of the planet to the velocity of light. We can work that out, and we find that the advance should be forty-three seconds a century—just about the amount required. Thus, whilst the Newtonian law leaves a discordance of more than forty seconds, Einstein's law agrees with observation to within a second or so.

Of course this superiority would be discounted if we could find some other application where the old Newtonian law had proved the better. But that has not happened. In all other cases the two laws agree so nearly that it has not been possible to discriminate between them by observation. The new law corrects the old where the old failed, and refrains from spoiling any agreement that already exists. The next best chance of applying the new theory is in the advance of the orbit of Mars; here Einstein's new law "gilds refined gold" by slightly improving an agreement which was already sufficiently good—a "wasteful and ridiculous excess," which is at any rate not unfavourable to the new theory.

There is another possibility of testing Einstein's theory, which it is hoped to carry out at the first opportunity. This relates to the action of gravitation on a ray of light. It is now known that electromagnetic energy possesses the property of inertia or mass, and probably the whole of the mass of ordinary matter is due to the electromagnetic energy which it contains. Light is a form of electromagnetic energy, and therefore must have mass—a conclusion which has been found true experimentally, because light falling on any object exerts a pressure just as a jet of water would. We ordinarily measure mass in pounds, and it is quite proper to speak of "a pound of light," just as we speak of a pound of tobacco. In case anyone should be thinking of going to an electric light company to buy a pound of light, I had better warn you that it is a rather expensive commodity. They usually prefer to sell it by a mysterious measure of their own, called the Board of Trade unit, and charge at least 3*d*. a unit. At that rate I calculate that they would let you have a pound of light for 141,615,000*l*. Fortunately, we get most of our light free of charge, and the sun showers down on the earth 160 tons daily. It is just as well we are not asked to pay for it.

But although light has mass, it does not follow that light has weight. Ordinarily, mass and weight are associated in a constant proportion, but whether this

is so in the case of light can be settled only by experiment—by weighing light. It seems that it should be just possible to do this. If a beam of light passes an object which exerts a gravitational attraction, then, if it really has weight, it must drop a little towards the object. Its path will be bent just as the trajectory of a rifle bullet is curved owing to the weight of the bullet. The velocity of light is so great that there is only one body in the solar system powerful enough to make an appreciable bend in its path, namely, the sun. If we could see a star close up to the edge of the sun, a ray of light coming from the star would bend under its own weight, and the star would be seen slightly displaced from its true position. During a total eclipse stars have occasionally been photographed fairly close to the sun, and with care it should be possible to observe this effect. There is a magnificent opportunity next year when a total eclipse of the sun takes place right in the midst of a field of bright stars. This is the best opportunity for some generations, and it is hoped to send out expeditions to the line of totality to weigh light according to this method.

In any case, great interest must attach to an attempt to settle whether or not light has weight. But there is an additional importance, because it can be made a means of confirming or disproving Einstein's theory. On Einstein's theory light must certainly have weight, because mass and weight are viewed by it as two aspects of the same thing; but his theory predicts a deflection twice as great as we should otherwise expect. Apart from surprises, there seem to be three possible results:—(1) A deflection amounting to 1·75″ at the limb of the sun, which would confirm Einstein's theory; (2) a deflection of 0·83″ at the limb of the sun, which would overthrow Einstein's theory, but establish that light was subject to gravity; (3) no deflection, which would show that light, though possessing mass, has no weight, and hence that Newton's law of proportionality between mass and gravitation has broken down in another unexpected direction.

The purpose of Einstein's new theory has often been misunderstood, and it has been criticised as an attempt to explain gravitation. The theory does *not* offer any explanation of gravitation; that lies quite outside its scope, and it does not even hint at a possible mechanism. It is true that we have introduced a definite hypothesis as to the relation between gravitation and a distortion of space; but if that explains anything, it explains not gravitation, but space, *i.e.* the scaffolding constructed from our measures. Perhaps the position reached may be made clearer by another analogy. Let us picture the particle which describes a world-line as hurdle-racer in a field thickly strewn with hurdles. The particle in passing from point to point always takes the path of least effort, crossing the fewest possible hurdles; if the hurdles are uniformly distributed, corresponding with undistorted Minkowskian space, this will, of course, be a straight line. If the field is now distorted by a mathematical transformation such as an earthquake so that the hurdles become packed in some parts and spread out in others, the path of least effort will no longer be a straight line; but it is not difficult to see that it passes over precisely the same hurdles as before, only in their new positions. The gravitational field due to a particle corresponds with a more fundamental rearrangement of the hurdles, as though someone had taken them up and replanted them according to a law which expresses the law of gravitation. Any other particle passing through this part of the field follows the guiding rule of least effort, and curves its path, if necessary, so as to jump the fewest hurdles. Now, we have usually been under the impression that when we measured distances by physical experiments we were surveying the *field*, and the results could be plotted on a map; but it is now realised that we cannot do that. The field itself has nothing to do with our measurements; all we do is to count hurdles. If the only cause of irregularity of the hurdles were earthquakes (mathematical transformations), that would not make much difference, because we could still plot our counts of hurdles consistently as distances on a map; and the map would represent the original condition of the field with the hurdles uniformly spaced. But the more far-reaching rearrangement of hurdles by the gravitational field forces us to recognise that we are dealing with counts of hurdles and not with distances; because if we plot our measures on a map they will not close up. The number of hurdles in the circumference of a circle[3] will not be π times the number in the diameter; and when we try to draw on a map a circle the circumference of which is less than π times its diameter, we get into difficulties—at least in Euclidean space. This analogy brings out the point that the theory is an explanation of the real nature of our measures rather than of gravitation. We offer no explanation why the particle always takes the path of least effort—perhaps, if we may judge by our own feelings, that is so natural as to require no explanation. More seriously, we know that in consequence of the undulatory theory of light, a ray traversing a heterogeneous medium always takes the path of least time; and one can scarcely resist a vague impression that the course of a material particle may be the ray of an undulation in five dimensions. What concerns gravitation more especially is that we have offered no explanation of the linkages by which the hurdles rearrange themselves on a definite plan when disturbed by the presence of a gravitating particle; that is a point on which a mechanical theory of gravitation ought to throw light.

From the constant of gravitation, together with the other fundamental constants of Nature—the velocity of light and the quantum of action—it is possible to form a new fundamental unit of length. This unit is 7×10^{-28} cm. It seems to be inevitable that this length must play some fundamental part in any complete interpretation of gravitation. (For example, in Osborne Reynolds's theory of matter this length appears as the mean free-path of the granules of his medium.) In recent years great progress has been made in knowledge of the excessively minute; but until we can appreciate details of structure down to the quadrillionth or quintillionth of a centimetre, the most sublime of all the forces of Nature remains outside the purview of the theories of physics.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The syndicate appointed to consider the Previous examination has issued its report. The recommendations involve changes which, if passed by the Senate, will greatly alter the present character of the examination. The syndicate advises the discontinuance of Greek as a compulsory subject, and recommends that every candidate shall be required to take at least one paper in natural science. It proposes that the examination should be in three parts: (1) Languages; (2) mathematics and natural science; (3) English subjects. In part (1) it is recommended that Latin should continue to be a compulsory subject, and that a candidate should be required to take one other foreign language, namely, Greek, French, German, or Spanish.

[3] A circle would naturally be defined as a curve such that the number of hurdles (counted along the path of least effort) between any point on it and a fixed point called the centre is constant. To make the vague analogy more definite, we may suppose that the hurdles are pivoted, and swing round automatically to face the jumper; he is not allowed to dodge them, *i.e.* to introduce into his path sinuosities comparable with the lengths of the hurdles

In part (2) it is proposed that six papers should be set (two in mathematics and four in natural science subjects—experimental science, physical geography, biology, botany), of which a candidate would be required to take three, one, at least, of these being a mathematical paper, and no candidate would be allowed to take both biology and botany.

LIVERPOOL.—The University of Liverpool has recently received a gift of 2000*l.* from Mrs. and Miss Holt as a contribution towards the cost of equipment of the new department of geology. Prof. Boswell is to be congratulated upon the excellent beginning that academic geology is able to make at Liverpool in consequence of this gift. Moreover, the new department has been enriched by the presentation of valuable collections of books, maps, and geological specimens. Among the specimens are included the collections of rocks, minerals, and fossils made by the late G. H. Morton (together with his manuscript catalogue), the collections of the late Dr. R. C. Ricketts and Joseph Lomas, besides other smaller miscellaneous collections. The departmental library of geology includes a large series of periodicals, both British and foreign, the publications of the local British geological societies being of especial interest. The late T. Mellard Reade's large collection of geological pamphlets finds an appropriate home in the department, and a valuable gift of books and periodicals from the library of the late R. H. Tiddeman has recently been presented by his widow. Furthermore, for some years past Prof. W. A. Herdman has been collecting together an important series of maps and periodicals in anticipation of the establishment of the School of Geology.

OXFORD.—An anonymous donor has sent 500*l.* to Sir William Schlich towards the fund for the permanent endowment of the professorship of forestry.

In a Convocation held on March 12 the degree of D.Sc., *honoris causa*, was conferred upon Prof. W. C. M'Intosh, for many years professor of natural history in the University of St. Andrews.

SOME interesting details are given in *La Nature* for February 9 concerning the present activity of the University of Grenoble. As is well known, Grenoble is situated practically in the centre of the hydro-electric industry of France, and much of the work of the Polytechnic Institute connected with the University has a bearing on the branches of science which are concerned in the new industries arising from the use of hydro-electric energy. The polytechnic comprises (1) a higher electrotechnic college for the training of electrical engineers, electrometallurgists, and electrochemists; (2) an elementary school of electrotechnics; (3) a mechanical and electrical testing laboratory for commercial tests; (4) a school for training engineers for the paper trade; (5) a laboratory for tests and analyses connected with the paper trade; and (6) an electrometallurgical and electrochemical test station, and a model plant of 1000 h.p. A chair of electrochemistry and electrometallurgy has also been created. It is stated that the polytechnic is also open to receive students from foreign countries.

PARTICULARS given in the issue of the U.S. *Monthly Weather Review* for June of last year concerning meteorological courses for aeronautical engineers have been published at Washington as a separate pamphlet. The National Advisory Committee for Aeronautics, co-operating with the United States War Department, arranged in May, 1917, with a number of leading universities and schools for courses designed specially to further the education and training of aviators. These courses, technically known as "Ground Schools in Military Aeronautics," include such subjects as elementary meteorology, astronomy, engineering, internal-combustion engines, and so on, and are now being offered at Massachusetts Institute of Technology in co-operation with Harvard University, Princeton University, Cornell University, Ohio State University, University of Illinois, University of Texas, and the University of California. Prof. R. DeC. Ward is giving the course in meteorology at the Massachusetts Institute of Technology, and also a more extended course forming part of the requirements leading to the degree of aeronautical engineer. The syllabus of work includes, in addition to the general principles of meteorology, a study of atmospheric conditions affecting aviation, forecasts of wind velocity and direction aloft, and favourable and unfavourable weather for flying.

THE governing body of the Manchester School of Technology has decided to change the name to Manchester College of Technology. The progress of the college fully justifies the change in name, which at the same time will remove a possible misconception as to the nature and scope of the activities of the institution. In the two years immediately before the war the number of matriculated students in the college increased by 50 per cent., and though the war has drawn away more than two-thirds of its students, to-day there are actually more undergraduates than there were in 1911–12. The proportion of evening students doing the most advanced work doubled itself between 1913 and 1916; and even to-day, after two years of the Military Service Acts, the proportion is 60 per cent. greater than it was in 1911–12. To enable the college to attract and retain experts of first-rate ability whose services are in great demand by industrial concerns, the governing body is now offering professorial salaries up to 1000*l.* or 1200*l.* a year, with permission to undertake private consulting work under suitable conditions. According to official data, the annual expenditure of the college is now about equal to that of the University of Sheffield, and is half as large again as that of the University of Bristol. But perhaps the greatest change of all is in the quantity of the research work undertaken. This result is in part due to the fact that the governing body now offers annually several research scholarships, each of the value of 100*l.* a year. Moreover, lecturers are appointed not only to teach, but also to research; they understand that their advancement largely depends upon their research. Co-operative researches in which the practical experience of individual manufacturers is combined with the wider but less specialised knowledge of members of the college are increasing in number.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 28.—Sir J. J. Thomson, president, in the chair.—Hon. R. J. **Strutt**: Scattering of light by dust-free air, with artificial reproduction of the blue sky. (1) By proper arrangement of the experimental conditions, it is possible to observe the scattering of light by pure air, free of dust, in a small-scale laboratory experiment. (2) Similar results can be obtained with other gases. Hydrogen gives much less scattering than air, oxygen about the same, carbon dioxide decidedly more. (3) The scattered light in air and in all the other gases is blue—the blue of the sky—illustrating very directly the theory that attributes the blue of the sky to scattering by the molecules of air. Tyndall obtained the blue by means of fine-grained fogs, precipitated from organic vapours. This was a valuable contribution, but his fogs were, of course, both chemically and physically very different from dust-free air. (4) The scattered light is almost com-

pletely polarised.—Dr. J. R. **Airey**: The Lommel-Weber Ω function and its application to the problem of electric waves on a thin anchor ring.—W. **Harrison**: Investigations on textile fibres. (1) Dry fibres, when subjected to stress, exhibit a kind of plasticity in which the strains produced remain when the stress is removed, but are accompanied by corresponding internal stresses. (2) Fibres deformed in the above manner return to their original shape when placed in cold water. (3) Fibres in contact with cold water are elastic; strains produced by the application of stress disappear when that stress is removed, more quickly with some fibres than with others. (4) In boiling water fibres are plastic, and the application of stress produces permanent deformation with no corresponding internal stresses in the case of wool and only slight stresses with other fibres. (5) The double refraction exhibited by the natural fibres is due to the presence of internal stresses. (6) The swelling produced by treatment of cotton fibres with solutions of sodium hydrate and of wool fibres with sulphuric acid is due to the internal stresses naturally present in those fibres. (7) The internal stresses present in natural fibres appear to originate in the moulding of the fibres during growth and in their subsequent drying, and can be imitated experimentally with artificial fibres.—W. L. **Cowley** and H. **Levy**: Critical loading of struts and structures. This paper is concerned with the elastic stability of structures composed of members under compression, and treats problems relating to the strength of such a construction as a beam under end thrusts and supported at intermediate points. The investigation shows that failure does not necessarily occur when one of the bays is of Euler's lowest critical length. In this instance, however, the two equations of three moments involving this bay take an indeterminate form and must be replaced by two other equations which can easily be derived. The structure will not fail, in general, through the bending moments becoming excessive, even if several of the bays are of Euler's critical length, provided at least one bay is not of that length.

Geological Society, February 15.—Annual general meeting.—Dr. A. Harker, president, in the chair.—The **President**: Anniversary address. The present position and outlook of the study of metamorphism were discussed. For the first time it seems possible to approach the subject of metamorphism systematically from the genetic point of view. For the geologist this implies the critical study, not only of the great tracts of crystalline schists and gneisses, but equally of metamorphic aureoles, of pneumatolysis and other contact-effects, and of the phenomena, mechanical and mineralogical, related to faults and overthrusts. It implies, moreover, the recognition that these are all parts of one general problem, that of the reconstruction of rocks under varying conditions of temperature and stress. This problem is complicated by the fact that perfect adjustment of chemical equilibrium cannot be assumed, either in the rocks prior to metamorphism, or during the process of metamorphism itself. The most fundamental characteristic of metamorphism was considered, namely, that recrystallisation takes place in a solid environment, and so may be profoundly affected by the existence of shearing stress. Stress of this type arises from the crystal growth itself, and is called into play by external forces. The automatic adjustment of the internally created stress to neutralise that provoked from without affords the key to all structures of the nature of foliation. The mineralogical peculiarities characteristic of the crystalline schists must find their explanation in kindred considerations; for it can be shown that the chemistry of bodies under shearing stress differs in important respects from the chemistry of unstressed bodies. The result is seen in the appearance of a certain class of "stress-minerals" where the dynamic element has figured largely in metamorphism, while in the same circumstances the formation of minerals of another class seems to have been inhibited. The conditions governing metamorphism are temperature and shearing stress, with uniform pressure as a factor of less general importance. If the orogenic forces are sufficient to maintain shearing stress everywhere at its maximum, the stress itself becomes a function of temperature, since this determines the elastic limit, and the principal conditions of metamorphism come to depend upon a single variable. This degree of simplification, however, is not to be expected universally.

February 20.—G. W. Lamplugh, president, in the chair.—Prof. W. M. **Davis**: The geological aspects of the coral-reef problem. A voyage in the Pacific, in 1914, enabled the author to collect new evidence bearing upon this question, and to make observations that have influenced him in his support of Darwin's theory. All theories that postulate a fixed relation between reef-formation and ocean-level are disproved, and are inapplicable to the case of atolls. Reef-upgrowth is intimately associated with submergence wherever the matter can be tested. The solution of the coral-reef problem turns, at present, upon some means of discriminating between a submergence caused by subsidence, and a submergence caused by a general rise of the ocean-level due either to the uplift of the ocean-floor beyond the coral-reef region, or to the melting of the Pleistocene ice-sheets. Reasons to regard changes in ocean-level as of secondary importance are presented, and the submergence demanded by self-encircled islands is attributed to local subsidence, in accordance with the views of Darwin and Dana. It is concluded that fringing-reefs do not mark stationary or rising islands so generally as Darwin supposed. With regard to elevated reefs, the impossibility of explaining their features by regarding them as having been stationary while the ocean-surface was lowered is demonstrated, and it is held that they must be due to local and diverse uplift affecting the islands themselves, following on epochs of subsidence which were the epochs of reef-formation. The theory that such reefs were formed during pauses in the elevation and emergence is considered to be seriously defective, and is contrary to Darwin's views.

Zoological Society, February 19.—Dr. A. Smith Woodward, vice-president, in the chair.—L. A. **Lantz**: A collection of reptiles made in Transcaspia and now in the Zoological Museum of Moscow University.—Prof. E. W. **MacBride**: Recent investigations into the development of the sea-urchin (*Echinocardium cordatum*).

Physical Society, February 22.—Prof. C. H. Lees, president, in the chair.—T. **Smith**: A note on the use of approximate methods in obtaining constructional data for telescope objectives. The paper discusses the reason why satisfactory telescope objectives are obtained by neglecting thicknesses and solving for freedom from first-order aberrations. It is shown that the introduction of thicknesses into such an objective without any alteration in the curvatures of the surfaces yields a lens corrected for aberration for a zone which is a constant fraction of the full aperture obtainable. For objectives of the usual type this zone is very approximately the one that would be selected for correction to obtain the most favourable balance between first- and second-order aberrations. It follows that objectives calculated from first-order formulæ in which thicknesses are neglected do not require trigonometrical verification or correction unless the conditions are very

abnormal.—Dr. H. S. **Allen**: A suggestion as to the origin of special series. The paper gives a development of an idea put forward in an earlier paper, describing an atomic model with a magnetic core. It is assumed that the principle of the constancy of angular momentum may be applied to the *total* angular momentum of the electron, and a certain part of the core bearing a special relation to the electron. On the lines of Bohr's theory this leads to an expression for the oscillation frequency, which is similar to Rydberg's formula, and contains a constant which is the same for all elements. The "phase" μ of a "sequence" is regarded as proportional to the angular momentum of a definite portion of the core. In observed series the phases of the two sequences are not equal to one another; consequently, whatever interpretation be given to the phase, the two types of state concerned must be in some way different from one another. When the magnetic field of the core is taken into account, a formula is obtained which is identical with that of Ritz. An explanation of the series of enhanced lines in spark spectra is also suggested.

CAMBRIDGE.

Philosophical Society, February 4.—Prof. Marr, president, in the chair.—Major P. A. **MacMahon**: Certain integral equations.—G. H. **Hardy**: (1) Sir George Stokes and the concept of uniform convergence. (2) Note on Mr. Ramanujan's paper entitled "Some Definite Integrals."—G. N. **Watson**: Asymptotic expansions of hypergeometric functions.—S. **Ramanujan**: (1) Certain trigonometrical sums and their applications in the theory of numbers. (2) Some definite integrals.

February 18.—Prof. Marr, president, in the chair.—Prof. S. **Gardiner** and Prof. **Nuttall**: Fish-freezing. The authors advocate the creation of a vast store of frozen herrings against times of scarcity, instead of the herrings being pickled and exported. The value of fish as food is weight for weight about the same as meat, containing the same constituents.—P. **Lake**: Shell deposits formed by the flood of January, 1918. During the flood of January 20 a remarkable and extensive deposit of shells was laid down by the Cam on the towpath near the railway bridge below Cambridge. Most of the shells belonged to the genus Limnæa, but other genera, both land and fresh-water, also occurred. The freedom from silt of much of the deposit suggests that even a muddy river may form a limestone as pure as the fresh-water limestones of the Purbeck series.—G. **Matthai**: (1) Reactions to stimuli in corals. The series of movements which take place in the soft parts of colonies in response to chemical and tactile stimuli are of the nature of amœboid or streaming movement of protoplasm, the soft parts themselves appearing to serve as the medium for the conduction of stimuli. (2) Is the Madreporarian skeleton an extraprotoplasmic secretion of the Polyps? In 1899 Bourne supported von Koch's view that the Madreporarian skeleton is formed as an extraprotoplasmic secretion of the calicoblastic layer of ectoderm, and entirely disagreed with von Heider's suggestion that it is the result of the deposition of carbonate of lime within calicoblasts. The organic matrix revealed on slow decalcification of thin sections of Coralla, and regarded by Bourne as due to the disintegration of calicoblasts, is probably part of the living calicoblastic sheet in which calcareous matter has been laid down, as otherwise it is difficult to understand how the manifold skeletal types of the Madreporaria can have arisen. Skeletal formation in the Madreporaria would then be homologous to spicule formation in the Alcyonaria—*i.e.* intraprotoplasmic.—H. H. **Brindley**: Notes on certain parasites, food, and capture by birds of *Forficula auricularia*. There seems no ground for attributing male dimorphism in earwigs to infection by gregarines. Though earwigs are always spoken of as garden pests, there appear to be but scanty records of the plants they prefer. During last August and September a large number kept in captivity in the zoological laboratory were given three kinds of plants together for several days at a time to ascertain the favourites, with the following results:—Vegetable marrow leaves much eaten; horseradish leaves very little; Michaelmas daisy leaves and flowers not at all; beetroot leaves much eaten; phlox flowers also; dwarf bean leaves but little; white rose and blue Anchusa petals much attacked, their leaves neglected; golden rod leaves eaten, but flowers untouched; yellow Œnothera petals much eaten, pods untouched; white Japanese anemone flowers somewhat nibbled, leaves untouched; raspberry leaves not eaten, but the hairy undersides a most favourite hiding place; cabbage leaves very thoroughly gnawed; rhubarb leaves a good deal; scarlet-runner flowers, pods, and foliage untouched. Plum fruit was readily attacked, but apples and potatoes in their skins remained untouched even when no other food was given for a week. When cut across both were eaten, potato much more than apple. Newstead (*Supp. Journ. Board of Agric.*, December, 1908) reports the presence of earwigs in the alimentary canal of only ten out of 128 species of British birds the food of which was examined. Theobald and McGowan (*loc. cit.*, May, 1916), investigating the food of the starling month by month during 1912–14, found 353 earwigs in 748 birds. An analysis of their records reveals that more earwigs were taken from October to March than from April to September, though most male earwigs die and the females are hibernating during the latter period. This fact is puzzling, though it may be that the starling is driven to search for buried earwigs in the absence of other insect food. Stone curlew and sparrows have been found to eat earwigs, but there is no doubt that this insect is little molested by wild birds. Domestic fowls eat it readily.

PARIS.

Academy of Sciences, February 4.—M. Paul Painlevé in the chair.—The president announced the death, on February 2, of M. E. Yung, correspondant for the section of anatomy and zoology.—E. **Ariès**: Formula giving the pressure of the saturated vapour of a monatomic liquid. A formula derived from an equation of state given in a previous communication is applied to the cases of crypton, xenon, and argon. A comparison of the calculated and observed figures shows good agreement, with the exception of one temperature for argon, for which an error of experiment is suggested as the cause of the deviation.—G. A. **Boulenger**: The oldest Characinidæ, and its signification from the point of view of the present distribution of this family.—P. **Barbarin**: The dilemma of J. Bolyai.—P. **Fatou**: Functional equations and the properties of certain boundaries.—A. **Denjoy**: The curves of M. Jordan.—D. **Pompeiu**: A definition of holomorphic functions.—R. de Montessus de **Ballore**: Skew quartics of the first series.—A. **Mailhe** and F. de **Godon**: A new catalytic method for the formation of nitriles. Ammonia and the vapours of an aldehyde are passed over thoria at about 430° C., when hydrogen is evolved and a nitrile produced, according to the equation

$$R.CHO + NH_3 = R.CN + H_2O + H_2.$$

*iso*Amyl nitrile, *iso*butyl nitrile, propionitrile, benzonitrile, and anisonitrile have been prepared by this reaction.—L. **Gentil**, M. **Lugeon**, and L. **Joleaud**: The geology of the Sebou basin (Morocco).—Mlle. Y. **Dehorne**: The analogies of the branched form in the polypes constructing reefs at the present time with the stromatopores of the secondary strata.—A. **Guilliermond**: Plasmolysis of the epidermal cells of

the leaf of *Iris germanica*. The epidermal cells of the leaf of this Iris form an exceptionally favourable object for the cytological study of plasmolysis. The effects produced by solutions of sugar and of common salt of various concentrations are detailed.—H. **Colin**: The genesis of inulin in plants. Studies on inulin formation and migration in chicory, dahlia, and Jerusalem artichoke.—J. **Gautrelet** and E. **Le Moignic**: Contribution to the physiological study of the antityphoid vaccines in aqueous solution. An experimental study on the dog of the changes in the blood-pressure caused by the injection of various typhoid and paratyphoid vaccines.—MM. **Tuffier** and **Desmarres**: Studies on the cicatrisation of wounds.

BOOKS RECEIVED.

Originality: A Popular Study of the Creative Mind. By T. S. Knowlson. Pp. xvi+304. (London: T. W. Laurie, Ltd.) 15*s*. net.

The Spleen and Anæmia. By Prof. R. M. Pearce, with the assistance of Dr. E. B. Krumbhaar and Prof. C. H. Frazier. Pp. x+419. (Philadelphia and London: J. B. Lippincott Co.) 21*s*. net.

Principles and Practice of Milk Hygiene. By Prof. L. A. Klein. Pp. x+329. (Philadelphia and London: J. B. Lippincott Co.) 12*s*. 6*d*. net.

Annual Reports on the Progress of Chemistry for 1917. Issued by the Chemical Society. Vol. xiv. Pp. ix+264. (London: Gurney and Jackson.) 4*s*. 6*d*. net.

Lectures on the Principles of Symmetry and its Application in all Natural Sciences. By Prof. F. M. Jaeger. Pp. xii+333. (Amsterdam: "Elsevier" Publishing Co.)

Mathematics for Engineers. Part i., including Elementary and Higher Algebra, Mensuration and Graphs, and Plane Trigonometry. By W. N. Rose. Pp. xiv+510. (London: Chapman and Hall, Ltd.) 8*s*. 6*d*. net.

British Birds. Written and illustrated by A. Thorburn. Supplementary Part. Pp. 11. (Longmans and Co.) 6*s*. net.

DIARY OF SOCIETIES.

THURSDAY, MARCH 14.

ROYAL SOCIETY, at 4.30.—An Expansion of the Point-Potential: A. W. Conway.—The Lunar and Solar Diurnal Variations of Water Level in a Well at Kew Observatory, Richmond: E. G. Bilham.

ROYAL SOCIETY OF ARTS, at 4.30.—English Commerce with India, 1608–1658: William Foster.

INSTITUTE OF METALS, at 4.—The Relationship between Hardness and Constitution in the Copper-rich Aluminium-Copper Alloys: J. Neill Greenwood.—Aluminium-Bronze Die Casting: H. Whittaker and H. Rix.—On Grain Size: Dr. G. H. Gulliver.—Lead-Tin-Antimony Alloys: Owen W. Ellis.—An Investigation on Unsound Castings of Admiralty Bronze (88:10:2): Cause and Remedy: Prof. H. C. H. Carpenter and Miss C. F. Elam.

MATHEMATICAL SOCIETY, at 5.—The Representation of a Number as the Sum of any Number of Squares: G. H. Hardy.—A Problem in the Theory of Numbers: G. N. Watson.

OPTICAL SOCIETY (Imperial College of Science and Technology), at 8.—The Detection of Ghosts in Prisms: T. Smith.

FRIDAY, MARCH 15.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—Employment of Women in Munition Factories: Miss O. E. Monkhouse and Ben. H. Morgan.

SATURDAY, MARCH 16.

ROYAL INSTITUTION, at 3.—Problems in Atomic Structure: Sir J. J. Thomson.

MONDAY, MARCH 18.

ROYAL GEOGRAPHICAL SOCIETY, at 5.—The Possibility of Aerial Reconnaissance in the Himalaya: Dr. A. M. Kellas.

ARISTOTELIAN SOCIETY, at 8.—Realism and Politics: J. W. Scott.

TUESDAY, MARCH 19.

ROYAL INSTITUTION, at 3.—The Climatic Adaptation of Black and White Men: Dr. Leonard Hill.

ROYAL STATISTICAL SOCIETY, at 5.15.—The Bases of Local Taxation in England: E. J. Harper.

ZOOLOGICAL SOCIETY, at 5.30.

INSTITUTION OF CIVIL ENGINEERS, at 5.30.—*Further Discussion*: Modern Developments in Gasworks Construction and Practice: A. Meade.—*Paper*: The Derwent Valley Waterworks: E. Sandeman.

INSTITUTION OF PETROLEUM TECHNOLOGISTS, at 8.—The Russian Petroleum Industry and its Prospects: D. Ghambashidze.

MINERALOGICAL SOCIETY, at 5.30.—Graphical Operations with Four Independent Variables: Prof. E. S. Federov.—Lattice-like Inclusions in Calcite from North Burgess, Ontario: R. P. D. Graham.—On Linear Rock-diagrams: Dr. J. W. Evans.

WEDNESDAY, MARCH 20.

ROYAL SOCIETY OF ARTS, at 4.30.—The Food Situation in Germany: P. Shuttlewood.

GEOLOGICAL SOCIETY, at 5.30.

INSTITUTION OF NAVAL ARCHITECTS, at 11 a.m.—Address by the President: The Earl of Durham, K.G.—Standard Cargo Ships: Sir George Carter.—The Most Suitable Sizes and Speeds for General Cargo Steamers: J. Anderson.

ROYAL METEOROLOGICAL SOCIETY, at 5.—The Measurement of Atmospheric Pollution: Dr. J. S. Owens.

THURSDAY, MARCH 21.

INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—The Mechanical Design and Specification of the Turbo-alternator Rotor: Dr. S. F. Barclay.

INSTITUTION OF MINING AND METALLURGY, at 5.30.—Annual General Meeting.

INSTITUTION OF NAVAL ARCHITECTS, at 11 a.m.—Problems of the Future in the Design and Construction of Merchant Ships: W. S. Abell.—Research in Marine Engineering: A. E. Seaton.—The Effect of the Longitudinal Motion of a Ship on its Statical Transverse Stability: G. S. Baker and Miss E. M. Keary.—At 3 p.m.—The Iron Carbon Equilibrium Diagram and its Practical Usefulness: Prof. H. C. H. Carpenter.—Stress Distribution in Bolts and Nuts: C. E. Stromeyer.

LINNEAN SOCIETY, at 5.—The Shoulder-girdle of a Dicynodont Reptile from South Africa: E. S. Goodrich.—Fossil Charas from Oligocene Beds: J. Groves.—Malayan Form of *Chlorococcum humicola* (Nacq.), Rabenh.: Miss B. Muriel Bristol.

FRIDAY, MARCH 22.

ROYAL INSTITUTION, at 5.30.—Radiation from System of Electrons: Sir J. J. Thomson.

INSTITUTION OF NAVAL ARCHITECTS, at 11 a.m.—A Preliminary Survey of the Possibilities of Reinforced Concrete as a Material for Ship Construction: Major M. Denny.—Reinforced Concrete Vessels: W. Pollock.—Design and Construction of a Self-propelled Reinforced Concrete Seagoing Cargo Steamer building in Great Britain: T. G. O. Thurston.—An Investigation of the Shearing Force and Bending Moment acting on the Structure of a Ship including Dynamic Effects: A. M. Robb.—At 3 p.m.—Air Supply to Boiler Rooms: R. W. Allen.

SATURDAY, MARCH 23.

ROYAL INSTITUTION, at 3.—Problems in Atomic Structure: Sir J. J Thomson.

CONTENTS.

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.