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"To the solid ground
Of Nature trusts the mind which builds for aye."—WORDSWORTH.

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NOTICE.

For the convenience of readers of NATURE wishing to inspect books *published abroad* which have been reviewed in NATURE such volumes are kept for the period of six months at the publishing office of the journal. The books are retained for the purpose of examination free of charge. The display of books began with those reviewed in NATURE of January 7.

St. Martin's Street, London, W.C.

THURSDAY, OCTOBER 7, 1915.

PRACTICAL ENGINEERING.

(1) *Plain and Reinforced Concrete Arches.* By Prof. J. Melan. Authorised Translation by Prof. D. B. Steinman. Pp. x + 161. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1915.) 8*s.* 6*d.* net.

(2) *Masonry: A Short Text-book on Masonry Construction, including Descriptions of the Materials used, their Preparation and Arrangement in Structures.* By Prof. M. A. Howe. Pp. ix + 160. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1915.) Price 6*s.* 6*d.* net.

(3) *Railroad Field Manual for Civil Engineers.* By Prof. W. G. Raymond. Pp. vii + 386. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd, 1915.) 12*s.* 6*d.* net.

(4) *Working Data for Irrigation Engineers.* By E. A. Moritz. Pp. xiii + 395. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1915.) 17*s.* net.

(1) "PLAIN and Reinforced Concrete Arches" is an American translation by Dr. Steinman of a German treatise by Prof. J. Melan, who is an authority on structural design, and has invented a well-known system of reinforced arch construction. The treatise is thorough, accurate, and clear. After considering the theory of hinged and hingeless arches, the latter by both analytic and graphic methods, the effects of temperature, displacement of the abutments, and non-vertical loads are examined. Then come arches with elastic abutments, the results being applied to a treatment of arches continuous over several spans, on lofty piers. Reinforced arches are next considered, and there is a valuable chapter on the recalculation of the stresses in an arch ring by a more rigorous method after it has been provisionally designed. The calculations of arches, especially of reinforced arches, are laborious, and fully-worked-out examples of two actual bridges are given, the solutions being in one case by analytic, in the other by graphic, methods. There is a very useful chart for designing concrete sections with double reinforcement.

Prof. Melan has written several books on arched construction, and this one appears to be a condensed but fairly complete statement of the present state of arch theory. In investigating the critical conditions of loading for each arch section, the method of influence lines is used with great advantage. For abbreviating labour in provisional designing, easily applied simple approximate expressions are found. In many cases of double reinforcement the steel bars in compression are understrained. To obviate this, Prof. Melan has invented the method of putting them into an initial condition of thrust by loading them with part of the weight of the centring. The economy obtained is of value, and the method has been adopted abroad, though it is probably little known here. The treatise is very practical, if that can be said of a theoretical treatment of the subject, and can be strongly recommended to any engineer concerned in designing concrete arched bridges.

(2) "Masonry," by Prof. Howe, is an elementary, mainly descriptive account of stone masonry, brickwork, and concrete construction, not including reinforced concrete. Quarrying and manufacturing operations are briefly described, and the different kinds of brick and stone masonry, mass and block concrete, and tools used in different operations. The cement gun is described, used for giving a dense surface finish to mass concrete by blowing a cement grout against the surface.

(3) "The Railroad Field Manual," by Prof. Raymond, consists almost entirely of tables required in surveying and laying out curves. Its peculiarity is that the centesimal in place of the sexagesimal division of angles is adopted. The author remarks that, in practically every railway curve problem, it is necessary at some stage of the solution to transpose from minutes and seconds to decimals of a degree or *vice versâ*, and that it would require much less mental labour to lay out subchords if the transit were divided decimally, and, of course, if suitable trigonometrical tables were available. The tables seem to have been carefully arranged and to be accurate. Of course, if the author's method is to be used, the verniers on any transit made as at present would have to be altered to read hundredths of a degree, but this is not a very serious matter. Only experience can prove whether the economy of labour is sufficient to make the change desirable.

(4) "Working Data for Irrigation Engineers" consists in the main (*a*) of hydraulic diagrams and tables giving discharge of canals, pipes, orifices, and weirs; (*b*) of structural diagrams and tables giving earthwork quantities, bending moments on beams, tables for reinforced concrete and timber, etc. Large use is made of graphic diagrams. Some of the information is derived from the records of the U.S. Reclamation Service. The author is competent, and the book will be of service to irrigation engineers.

BOTANY AND GARDENING BOOKS.

(1) *Whitby Wild Flowers: A Complete Botanic List of the Flowers, Grasses, and Ferns of the Whitby District (including Levisham and Scarborough), with Notes on their History and Habitats.* By B. Reynolds. Pp. 60. (Whitby: Horne and Son, 1915.) Price 1*s.*

(2) *Field Book of American Trees and Shrubs: A Concise Description of the Character and Color of Species Common throughout the United States, together with Maps showing their General Distribution.* By F. S. Mathews. Pp. xvii+465. (New York and London: G. P. Putnam's Sons, n.d.) Price 7*s.* 6*d.* net.

(3) *Experimental Plant Physiology for Beginners.* By L. E. Cox. Pp. vii+111. (London: Longmans, Green and Co., 1915.) Price 2*s.* net.

(4) *Elementary Studies in Plant Life.* By Prof. F. E. Fritsch and Dr. E. J. Salisbury. Pp. xv+194. (London: G. Bell and Sons, Ltd., 1915.) Price 2*s.*

(5) *Climbing Plants.* By W. Watson. Pp. x+132. (London and Edinburgh: T. C. and E. C. Jack, n.d.) 2*s.* 6*d.* net.

(6) *Plant Life.* By C. A. Hall. Pp. xi+380. (London: A. and C. Black, Ltd., 1915.) Price 20*s.* net.

(1) THIS little book gives a useful list of the flowering plants of Whitby and its neighbourhood, including notes on the interesting alien forms which there, as elsewhere on our coasts, are endeavouring, often with success, to become naturalised. It aims also at interesting the holiday visitor in the attractive flora of the district, about half of the book being devoted to excursions in search of wild flowers with the author as pleasantly helpful and gossipy as a leader of such excursions should be. The arrangement of the book is somewhat loose and rambling, and misprints are somewhat numerous and occasionally a little puzzling, such as "Schlerochia" for "Sclerochloa."

(2) The author has packed into this book on American trees and shrubs an astonishing amount of information, with well-arranged and lucid descriptions and a wealth of illustrations both plain and coloured. The appendix contains numerous maps showing the distribution of a large number of species, three or four species being usually shown on each map, together with other useful charts (geological, soil, altitude, etc.). It is much to be wished that a book on similar lines were available dealing with British trees and shrubs, published at an equally moderate price, in such handy form, and with such excellent figures showing details necessary for identification of the species.

(3) This thoroughly practical little book, though limited in scope and dealing only with part of the subject of plant physiology, is about the best of its kind that we have seen. The directions for experimental work with simple materials and apparatus more than make up in clearness what they lack in novelty, and the beginner who works through the experiments will certainly have nothing to unlearn on proceeding to a more extended study of plant physiology. It seems a pity that some work on movement in plants, other than tropisms, was not included; even the beginner for whom the book is intended ought to know from experiment that plants can perform movements of greater agility than those involved in growth responses to such factors as gravity and one-sided illumination.

(4) This little book is apparently in the main a condensed and simplified version of the same authors' "Elementary Studies in Plant Life," and it presents the same excellent features—clearness of description, abundance of good illustrations, and a just appreciation of the importance of physiology and ecology in the study of the elements of botany. It would not be easy to find a book better suited to the needs of junior students.

(5) The name of Mr. William Watson on the title-page of a gardening book is a sufficient guarantee of the accuracy of its contents, and this handy volume on climbing plants is a most welcome addition to gardening literature. The claims and possibilities of climbers are admirably dealt with by Mr. W. Robinson in a wise and witty introduction, and the book certainly ought to stimulate interest in the culture of this somewhat neglected class of plants. No fewer than one hundred genera, many of them with several species, are dealt with by Mr. Watson in his usual precise and helpful manner; valuable hints are given as to the selection and cultivation of hardy, greenhouse, pergola, tree, and other climbers; the systematic notes are arranged in alphabetical order under the genera; and there are twenty-four excellent plates, eight of them coloured. These beautiful and wonderfully cheap "Present-day Gardening" volumes are worthy of a more durable kind of binding; few would grudge paying a little more if necessary in order to have something more substantial than the cardboard backs, which get badly rubbed and cracked in a short time even with careful use.

(6) The author's attempt at the compilation of a "popular botany" is somewhat more ambitious than usual in the case of such works, and certainly more successful so far as accuracy is concerned. We have little doubt that those who can

afford to buy a somewhat expensive book, and probably many will be willing to lay out twenty shillings on a handsome volume with fifty fine coloured plates, will agree that it serves admirably the twofold object of its existence, namely, usefulness to the amateur botanist and an easy introduction to the study of more technical works. The author has evidently selected from a tolerably good modern botanical text-book such parts as are amenable to popularisation and has presented the facts in a simple style, somewhat marred by an extensive use of unnecessary tags and phrases.

It would be easy to criticise various portions, but bearing in mind the difficulty of writing a thoroughly satisfactory book of this kind and the unpretentious objects aimed at by the author, it may be enough to say that it is one of the most attractive books of the kind we have seen. The coloured plates, from drawings by Mr. C. F. Newall, are remarkably fine, being accurate alike in colouring and in structural detail, but we should have liked to see a larger proportion of them devoted to the flowerless plants, especially as the considerable portion of the text dealing with these constitutes one of the best features of the book. The concluding chapter, dealing with ecology, is rather feeble, and will, we fear, give the uninformed reader a somewhat inadequate idea of the methods used and results obtained in this branch of botanical study; but we have not yet seen anything approaching a satisfactory "popular" account of what writers of books of this kind appear to have agreed to designate "the new botany," though as understood by them it is certainly neither new nor interesting, but merely a hotch-potch of "wonderful adaptations," or of obvious remarks about different kinds of plants growing in different kinds of positions, the reader being supposed to infer that until quite recently nobody ever noticed such astonishing facts as that moorland plants do not grow in salt marshes and *vice versâ*! F. C.

NEW METHODS AND OLD.

(1) *A Campaign Against Consumption: A Collection of Papers Relating to Tuberculosis.* By Dr. A. Ransome. Pp. viii+263. (Cambridge: At the University Press, 1915.) Price 10*s*. 6*d*. net.

(2) *A Chaplet of Herbs.* By F. Hine. Pp. xv+168. (London: G. Routledge and Sons, Ltd., n.d.) Price 2*s*. 6*d*. net.

(1) THE author, whose work relating to tuberculosis is well known, has done well to bring together the various papers he has contributed on the subject. The book is divided into four sections. The first, of a general character, deals with consumption, its causes and prevention, and the duties of the State in regard to tuberculosis. The second section discusses the conditions of infection in tuberculosis. Section iii. gives a summary of the author's researches on tuberculosis, such as treatment of pulmonary disease by means of intrapulmonary injections, media for the cultivation of the tubercle bacillus, etc. The last section is mainly statistical, and discusses such subjects as "The Public-house as a Source of Phthisis," "The Prospect of Abolishing Tuberculosis," and "Phthisis Rates."

Dr. Ransome considers that there is a fair prospect of abolishing tuberculosis, considering that the disease is steadily declining, which must be attributed to an inherent weakness of the microbe at the present time, and that we now possess potent weapons with which, when fully put into action, we may fairly hope to accomplish the final conquest of the foe. The author was optimistic enough in 1899 to suggest that another thirty years should see its vanishing point!

Altogether, much valuable matter has been brought together in this volume.

(2) This little volume of extracts is calculated to give leisure moments of real delight. The author has collected them from old herbals ranging from the eighth to the eighteenth century, and more particularly from those of the golden age of herbalists, 1450–1650. She has shown in her choice of extracts a sympathy and a humorous appreciation which are very attractive; a vein of laughter and delight runs through the book, with kindly charity and gentle raillery for the light-hearted, inconsequent old herbalist. In the introduction is an appreciation of the genuineness, and withal, the quackery, of the herbalists, their weakness for a far-fetched recipe, and their child-like trust in Mother-Earth, dear Dame-Nature.

Here are some extracts:—

"If anyone has over-eat himself, or drank too much; as feasts and pleasing company will lead the wisest into this mistake sometimes, Polypody is the best remedy. . . ."

"To make a woman shall not eat of anything yt is set on the table. . . . Take a little green Basil, and when ye dishes are brought to ye table put it underneath them. . . ."

Remedies for the green sickness and for "Chincough" (hiccough) are enlightening, and involve a pleasant use of alcohol; while thyme helps agues, hickup, lethargy, frensie, megrim, colick, convulsions, melancholy, and resists poison.

We have reason to be grateful for the names of flowers alone, cowslip or paigles, chickweed or gromel, and flag, gladen, or water-segg for the wild iris.

There is throughout the book a sense of pungent fragrance as of a bunch of herbs, and the "chaplet" is, as the quoted foreword claims, indeed "not short in savour."

R. & L. H.

OUR BOOKSHELF.

The Analysis of Non-Ferrous Alloys. By F. Ibbotson and L. Aitchison. Pp. vii+230. (London: Longmans, Green and Co., 1915.) Price 7s. 6d. net.

AT such a time as this, when there is a large demand for metals and metallic alloys of all descriptions, it is of the greatest importance that the manufacturers and users of these materials should have at their disposal rapid and accurate means of controlling the chemical composition of the goods they handle.

Until comparatively recently the "commercial" chemical analysis of non-ferrous alloys has received but little attention, at any rate from those most concerned, so that one has been forced to go for one's information to a series of widely scattered original papers in the various scientific and technical journals. A text-book embodying all the best of the information at present available is therefore exceedingly welcome.

The work under review may be divided broadly into three parts. The first part enters into a detailed description of the most recently devised apparatus for electrolytic analysis, and discusses the main theoretical considerations underlying the successful deposition of the metals.

The second part reviews the action of sulphuretted hydrogen on solutions of the metals under varied conditions of acidity, temperature, concentration, and time. Then follows an exhaustive description of the best methods for the estimation of the various metals in solutions of their salts.

The remainder of the book is devoted to the application of the foregoing methods to the analysis of brasses, bronzes, "white metals," and other alloys of industrial importance.

The value of the book is enhanced by a very complete bibliography. The book should prove of great value to works chemists and to the more advanced students in technical schools.

B. W. DRINKWATER.

Science of Dairying: a Text-book for the use of Secondary and Technical Schools. By W. A. G. Penlington. Pp. viii+260. (London: Macmillan and Co., Ltd., 1915.) Price 2s. 6d.

THIS volume covers a very wide range, and is intended to be used as a text-book of dairying in secondary and technical schools. It deals first with the composition and properties of milk, and gives particulars of the methods employed in the detection of adulteration. Two chapters are devoted to bacteria and the important part they play in dairying. A later chapter gives working details of the two best known rapid methods for the estimation of fat in milk. The first of these—the Babcock test—is not employed commercially in Great Britain, but is common in Australia, New Zealand, and Canada, whereas the second test—the Gerber—is universally practised in this country.

The principles, and outlines of the practice, of butter- and cheese-making are given in a clear and concise manner. The author then passes on to consider the physiology, feeding, care, etc., of the cow, and some of the common diseases to which she is subject. A chapter deals with arithmetical problems arising in dairy practice.

The book is written apparently for those who take up dairying more as a subject of examination than as an end in itself, and it is a little difficult to see to what class of English readers it will especially appeal. Without question, the educational value of such a work is considerable, but as dairying as a subject is not generally taught in the secondary schools in this country, the demand would appear to be limited to those attending a county dairy school, particularly those who are not following a systematic course of training. In the latter case the details are insufficient, but as introductory to the subject all students—whether short or long course—would benefit by a study of the book.

The Internal Combustion Engine: a Text-book for the Use of Students and Engineers. By H. E. Wimperis. New and revised edition. Pp. xvi+319. (London: Constable and Co., Ltd., 1915.) 6s. 6d. net.

SINCE the first edition of this book was published in 1908, there have been many important developments, both scientific and practical, in the internal combustion engine. These developments have necessitated many changes and additions in the present volume. The book is divided into three sections, the first of which treats of the theory of the subject. After describing the more elementary theorems in thermodynamics and the cycles employed, the author gives a very good account of the numerous experiments which have been made on explosions in closed vessels, and on temperatures inside the working cylinder. The second section deals with gas engines and gas producers, and includes information regarding the Humphrey gas pump, gas turbines, and Hopkinson's water-injection system. Methods of testing and of reducing test results are also given. The third section deals with oil and petrol engines and contains a good discussion on the Diesel engine, and on petrol engines for motor-cars and aircraft.

The illustrations are very good and clear. At the end of each chapter is given a number of excellent exercises, many of which have been taken from recent Cambridge examination papers. The book is very well adapted for the use of students, and has the merits of being moderate both in size and price.

Elementary Photo-micrography. By W. Bagshaw. Third edition. Pp. 143. (London: Iliffe and Sons, Ltd., 1915.) Price 2s. 6d. net.

SOME idea of the scope of this volume may be gathered from the fact that about ninety of its pages, which are not very large, are devoted more especially to photo-micrography, and rather more than thirty to photography—that is, developing and printing. The author takes it for "granted that the reader is already familiar with the use of the microscope," and also presumably that he is an amateur photographer, and seeks to show how the two may be brought together without the need for expensive appliances, and furnish results which, "though not perfect, are good and acceptable for nearly all purposes." He succeeds not only by precept but also by example, giving twenty-nine good reproductions of photo-micrographs taken by the simple means that he describes, using only objectives supplied with students' microscopes. These examples are illustrative of the methods dealt with in the text, and include magnifications from 2 up to 4000 diameters, the use of transmitted light, reflected light, a combination of the two, dark ground illumination, the use of polarised light, oblique illumination, illumination by flashlight, multiple-colour illumination, and a photograph on an autochrome plate. They are of excellent quality, including even a photograph of *Bacillus subtilis*, ×1000. But the *Amphipleura pellucida*, ×4000, shows that such simple methods will not serve for an extreme test, although taken by means of a one-twelfth immersion lens of 1·4 N.A. and an oiled-on condenser. By the way, such an objective and condenser scarcely come within the range of "students'" microscopical apparatus. In giving "pre-war" prices for chemicals, perhaps the author expresses his faith in an early return to peace conditions.

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.*]

The Masses of Heavenly Bodies and the Newtonian Constant.

IN a well-known treatise on physics we find the following statement:—"By the third law of Kepler we are led to the conclusion that the same value of G (the Newtonian constant of gravitation) applies to the sun and all planetary bodies." This conclusion appears to be fallacious, as we see by the following elementary considerations:—

(1) Take the case of Poynting's famous balance experiment for determining G. The attraction of the large mass M on the small mass m at distance d is

$$\text{couple} = G_M . Mma/d^2 = m'gl' \quad . \quad . \quad . \quad (1)$$

where m', l' are the mass of the balancing rider and its displacement necessary to counterpoise the gravitative pull of M on m.

Equation (1) gives G_M, for we know all the other factors. The suffix used here denotes that the "constant" G_M only applies to a mass if its temperature is that of M.

(2) The earth's attraction on mass m is

$$mg = G_E . Em/R^2. \quad . \quad . \quad . \quad . \quad (2)$$

where E, R are earth's mass and radius respectively.

Equation (2) gives us $G_E . E$. The earth's mean temperature may be, say, 4000° C., whereas that of M above is, say, 15° C. We have no experimental knowledge that the Newtonian "constant" is the same at 15° as at 4000°. Hence we cannot write $G_M = G_E$ and obtain from equation (2) the earth's mass. It is thus evident that the values commonly given for earth's mass and mean density are based on the unwarrantable assumption that $G_M = G_E$. Thus it is quite possible (for we have no evidence to the contrary) that $G_E = 2G_M$, in which case the earth's mean density would work out to be 2·76 instead of 5·52, as generally accepted.

(3) When we come to the case of the revolution of the earth and other planets round the sun, we have similar considerations to the above. Let two planets have mean radial distances d_1, d_2 and periodic times t_1, t_2, we obtain in the form of Kepler's third law

$$G_S . S = 4\pi^2(d_1^3/t_1^2) = 4\pi^2(d_2^3/t_2^2) = 4\pi^2 k,$$

where S = sun's mass and G_S the Newtonian constant for the sun's temperature, whence we obtain $G_S . S$; as we know Kepler's constant k. We do not know S alone, for we may not write $G_S = G_E = G_M$.

Thus we see that the masses and densities of all heavenly bodies, including the earth, are based on an assumption for which there is no experimental support, and which (considering the great range of temperature involved) is probably false.

In the case of the sun, the stars, and all the major planets the mean temperature is certainly as high as four figures, and in many cases probably five figures, on the Centigrade scale. It is thus inconceivable that any laboratory experiment will ever be made to determine the values G_S, G_P, or even G_E. But it is not unlikely that sure experimental evidence will be forthcoming as to the value of G, say, up to 500° C.

I have recently concluded a long research on the value of G up to 250° C., and I have found an increase in that "constant" of about 1 in 10^5 per 1° C. The full results I hope to publish shortly.

No doubt it has been for the sake of simplicity that astronomers and physicists have assumed constancy in G, and have thus obtained the accepted values for mass and density. But in reality these values (by analogy with the terminology of radiation) are not the mass and density, but the *effective-mass* and the *effective-density* respectively, and would only be true-mass and true-density if $G_S = G_E = G_M$, etc. If any temperature effect, such as is mentioned above, can be firmly established, then these terms ought to be adopted in the interests of accuracy.

So far, for simplicity, we have considered the temperature effect of gravity on the large mass only and have ignored any effect on the small mass. In equations (1) and (2) we have the small mass m at ordinary temperatures, say 15° C., so that we have not to consider temperature effect in connection with it. But in equation (3) the two planets in question may differ in temperature. Even then the equation is correct as it stands, supposing (*a*) the temperature effect on a mass considered as one member of a gravitative couple is identical with (*b*) its effect on mass considered as so much inertia; for these terms (*a*) and (*b*) occur on the left and right sides of the equation and cut out. But, on the other hand, if (*a*) is not identical with (*b*) the equation would have other factors. But neither in this case nor in the other can the equation (3) be made to prove the quoted statement with which this article begins.

Although the above considerations are theoretically of profound importance, they will obviously have no influence whatever on astronomical calculations; for in all such calculations the product of mass into Newtonian constant is used. Suppose in the case of the sun $G_S > G_M$ and let S, S′ be the true sun's mass and its present accepted value, then

$$G_S . S = G_M . S'.$$

In no calculation do we require S alone, but always product $G_S . S$, so that the false values for the sun of G_S and S do not lead to error.

P. E. SHAW.

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The Spectrum of X-Rays.

(1) KOSSEL (*Verh. d. D. Phys. Ges.*, 1914), discussing the previous measurements of the frequencies of the corresponding lines of the spectrum K and L characteristic for different elements, as well as of the limits of the respective bands of absorption, established certain numerical relations among them which Wagner (*Ann. der Physik*, 1915) confirmed in a more perfect way and even generalised. In addition, the extremely precise measures of Bragg and Pierce (*Phil. Mag.*, October, 1914) for the lines K_α, K_β, K_γ in the Ag, the Pd, and the Rh give additional confirmation.

From among these relations, attention is specially directed to the one obtained by generalising the second law of Kossel—

$$L_\alpha = K_\beta - K_\alpha, \text{ viz., } (1)\ M_\alpha = L_\gamma - L_\alpha$$

In these equations each term expresses the frequency of the lines. With its help we can foresee the frequencies of the principal lines of the spectrum of the M characteristic if L_γ and L_α are known.

If we admit Bohr's model for the atom as modified by Kossel—that is to say, supposing that in the transit of an electron from one ring to another a quantum is emitted, the frequency of which is determined by Bohr's formula, the radiation M will correspond to the transit of an electron from the fourth to the third ring, and the corresponding frequency,

$$\nu = \nu_0\left(\frac{1}{3^2} - \frac{1}{4^2}\right)\left(N - a\right)^2 = 1.59 \times 10^{14}(N - a)^2$$

will be emitted.

To demonstrate the exactness of this prediction, I have calculated the values of ν contained in the following table by means of the formula (1), starting from the values of L_α and L_γ given by Moseley, Rutherford, and Andrade. The last row contains the values of ν obtained from the formula—

$$(2)\ \nu = 1.39 \times 10^{14}(N - 21.8)^2$$

deduced by graphic interpolation, where N is the atomic number of the element.

	N	ν cal. by (1)	ν cal. by (2)
Pd	46	81×10^{15}	82×10^{15}
Ce	58	189	182
Eu	63	245	236
Ta	73	364	365
Pt	78	438	440
Au	79	452	455
Radium B ...	82	501	505

As can be seen, the formula (2), of similar type to those found by Moseley for K_α and L_α, shows well enough the change of M_α with N, and besides the constant $1 \cdot 39 \times 10^{14}$ coincides with the theoretical value $1 \cdot 59 \times 10^{14}$, between the limits to be expected on account of the method of calculation. No data are at present available to test this hypothesis. The spectrum M is most likely to be observed in heavy elements and in the radio-active bodies.

(2) In the numerical relations obtained by Kossel and Wagner, there does not appear the groups L_{A_2}, L_β, and L_δ of the spectrum L, nor does there seem any simple way of introducing them in another series of formula involving the frequency of the K radiations. This suggests the possibility of the spectrum being composed of two distinct parts, which might be illustrated by supposing that two rings are situated in distinct planes, from one of which (the one corresponding to L_2) no electron can pass to the ring K. The correctness of this hypothesis could be tested by investigating experimentally the lines of the L spectrum that accompany the spectrum K—a study that does not seem impossible.

It is logical to suppose that this group L_2 should be accompanied by others, M_2, N_2, . . . in the exterior spectrum, and even that in these should appear some new ones—M_3, N_3 . . . N_4 . . . In this way it would be easy to understand how the spectrum gets more and more complicated from the X-ray spectrum to the visible, and even the existence of the well-known series in the light spectrum.

B. CABRERA.

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Studies of the Cotton Plant.

I SHOULD be sorry if any reader of NATURE were to be prejudiced against perusal of my book on applied plant physiology, called "The Development and Properties of Raw Cotton," by thinking that I had attempted to write on the systematic botany of Gossypium. Yet this impression might easily obtain, since your reviewer devotes exactly two-thirds of his review to a few pages of my first chapter, the title of which, "The Development of Pedigree," is alone sufficient to indicate that it was not intended for biologists.

Still, technological treatment is no excuse for inaccuracy, even as enthusiasm for herbaria is no excuse for such a phrase as "peripatetic Mendelian crossbreeding of undetermined stocks." Therefore I would direct your reviewer's attention to the fact that my description of Gossypiæ as a sub-order (instead of a tribe) is taken from an accepted authority on systematy.

He states that "the results and evidences of systematic botany" with regard to cotton have been before us for a long while; the Hindi weed-cotton to which he purposely refers is a sad example of the result. I regret being obliged to mention it, but he misspells it as "Hindu" weed, and then objects strongly to my leaving it with such a loose designation. Now, in the first place, this name is on record in Sir George Watt's standard monograph of the genus, and is therefore as definite as any other. Possibly more definite, for though the specimen used for that determination came from a pure strain, Sir G. Watt called it "a ferine hybrid possessed of a strain of *G. vitifolium*." Only by enlisting the aid of "peripatetic" Mendelism can one justify the apparent contradiction, but nothing *a priori* can excuse the inclusion of this Hindi weed in the "fuzzy-seeded cottons" during the primary division of the genus in that monograph. There is no cotton which has a more naked seed than Hindi.

It is clear that I took too much upon myself in attempting to persuade the growers and spinners of cotton—in the first dozen pages of the book—that the systematic botany of cotton had some definite meaning. Nor did I think that any reviewer would be so ruthless as to drag my little jest (about scientific names appearing to be "merely useless duplicates of easier names") out of its context to pelt me.

W. LAWRENCE BALLS.

Little Shelford, Cambridge, September 16.

MR. LAWRENCE BALLS's objections to my review of his book, "The Development and Properties of Raw Cotton," which appeared in NATURE of August 26, call for a reply from me.

I feel quite sure Mr. Balls need have no fear that my remarks will be viewed, by even the most casual reader, as the criticisms of a work that had attempted to deal with the systematic botany of Gossypium. But Mr. Balls's anxiety that that great sin should not be attributed to him, exposes himself to the charge of deliberate disregard for both the methods and results of the systematist. It is a fact that I specially devoted a considerable part of my remarks to what I regard as the weak side of Mr. Balls's book, and I repeat it is a very weak side, which, though contained in one chapter mainly, dominates his entire studies of the cotton plant. But with equal deliberation, however, I recognised and even extolled the meritorious features of the book, which are undoubtedly very great.

The implication that I read only certain portions of Mr. Balls's book is quite uncalled for. As a matter of fact, I read every word. It was only because I appreciated and even admired the book that I felt it incumbent to express my mind unhesitatingly. It was in no spirit of carping that I gave special attention to its shortcomings. The issue at stake is very great indeed; namely, the development of the cotton staple, a problem of Imperial interest in the agriculture and industry of our Empire. I cannot help repeating, therefore, that for Mr. Balls to attempt to justify Mendelian cross-breeeding of undetermined stocks (and even pedigree selection of such stocks) of Gossypium is not only a blemish but a serious blunder, both in his book and his work. With culture experiments accuracy, in the starting point (more especially with stocks that of necessity involve several species and numerous varieties and races), is more essential than even care in subsequent treatment. We have heard far too much of the assumption that successful stocks can be produced in the laboratory or the experimental plot, in utter disregard of systematic botany.

The sneer that has been thereby cast on herbaria work is uncalled for, and merits the severest condemnation. Such an attitude may enlist the sympathy of the ignorant, but can secure no advancement in the object in view. The question of the future supply of cotton to the British looms is too serious a matter to justify any half-measures. The history of cotton is full of fads and fancies. Extravagant and wasteful experiments have taken the place of rational development. We have failed because we have not followed nature with sufficient closeness. We require the earnest endeavours of the experimental physiologist to be combined in the closest association with the most extended and searching investigations of the systematist. Either alone must of necessity be useless.

Mr. Lawrence Balls informs us that his description of "Gossypiæ" as a sub-order (instead of a tribe) had been taken from "an accepted authority on systematy." He might have favoured us with the name of the author in question. I have searched through a fairly extensive botanical library and failed to discover the authority to whom he may be alluding. Bentham and Hooker, in their "Genera Plantarum," place Gossypium in the tribe Hibisceæ (which Mr. Balls renders as Hibiscæ), but they make no mention of a sub-order "Gossypiæ" (? Gossypeæ). These are no doubt trivial criticisms and are made only in the spirit of "Hindu" and "Hindi." But admitting the "accepted authority on systematy," is there any advantage in setting on one side the universally accepted authorities on British botany?

I am afraid Mr. Lawrence Balls simply tries to obscure the main issue, raised in my review, by citing an example of careless orthography; the "Hindu" and "Hindi-weed" already mentioned. Is it necessary to explain that the word "Hindu" denotes the people or the religion, while "Hindi" and "Hindustani" indicate the languages of certain portions of India? These are their most general acceptations, but neither could, strictly speaking, be used as the name of a plant, more especially when *that* plant never could have come from India. The person who first used that name, in its Egyptian signification, was very possibly a follower of the school that seems to hold the view that accuracy in systematic botany was an unpardonable offence. De Candolle, long years ago, told us that the aim of science was not to make names, but to use names to distinguish plants. Does "Hindi-weed" isolate a certain cotton plant from all others? If it does not, it is a vulgar name that should find no place in a scientific publication.

Sir George Watt's "Wild and Cultivated Cotton Plants of the World" (to which Mr. Balls refers us) mentions Hindi-weed as being possibly a recessive hybrid of the *Moqui* of Arizona, or perhaps rather of the *N'dargua* cotton of Senegal. It is not advanced as a name that can be accepted as distinguishing a definite plant. But Mr. Balls himself is quoted by Sir George (*loc. cit.*, p. 182) as holding that Hindi-weed "hybridises with the others and the Mendelian splitting forms from the cross are very common, and also go under the name of 'Hindi,' though they are usually very tall, up to three metres. 'Hindi' itself is about one metre high, and except in its seed reminds me of American Uplands." We are thus told, by an advocate of non-systematic studies, that "Hindi-weed" may assume numerous forms and conditions until a certain example of it might have to be spoken of as not being Hindi-weed. Thus that vulgar Egyptian name is by no means as "definite as any other," though Mr. Balls in another passage assures us that it is. It is a loose, popular name that could never be taken seriously as the name of a cotton plant. The issue raised by Mr. Balls as to the Hindi-weed having a naked seed, while he seems to affirm that Sir George Watt "during the primary division of the genus" places it with fuzzy-seeded forms (a passage I have failed to discover) is, however, outside the scope of a review of Mr. Balls's book.

Lastly, I admit that Mr. Balls's jest of scientific names being merely useless duplicates of easier names was not only feeble (as he now admits it to have been) but highly misleading and utterly out of place.

THE REVIEWER.

THE KARAKORAM EXPEDITION.

THE account of Cav. Dr. F. de Filippi's expedition of 1914–15 to the eastern portion of the Karakoram range, briefly noticed in NATURE of August 5, has now been published in the *Geographical Journal* (vol. xlvi., No. 2), with a selection from the beautiful photographs taken by Capt. Antilli, to whom this part of the varied and important work undertaken by the expedition was entrusted, together with a report of the interesting discussion which followed the reading of the paper. By the kind permission of the Royal Geographical Society we are now enabled to reproduce two of the views exhibited at the meeting on June 14, illustrating the characters and surroundings of the Remo glacier, which in some respects appears to resemble the great ice streams of the Arctic regions rather than those of the usual Himalayan type.

In general the Himalayan glacier, like that of the Alps, is confined to a single drainage system, and is separated from its neighbours by an ice-free ridge. But here we see the Remo not only spilling over the saddles which surround its upper basin, into the valley of the neighbouring Siachen glacier, but actually sending a tongue across the main watershed dividing the Indus drainage from that of Central Asia (Fig. 1). Again, the fact noticed by Dr. de Filippi, that the front of the Remo glacier is almost free from moraine matter, is without parallel among the larger glaciers of the Himalaya, where one may often clamber for miles beyond the snout over heaped-up masses of débris, and scarcely detect a vestige of the ice beneath. The moderate dimensions of the mountains that rise above the Remo glacier, as compared with its breadth, no doubt account for its immaculate appearance, so vividly described in the paper (Fig. 2).

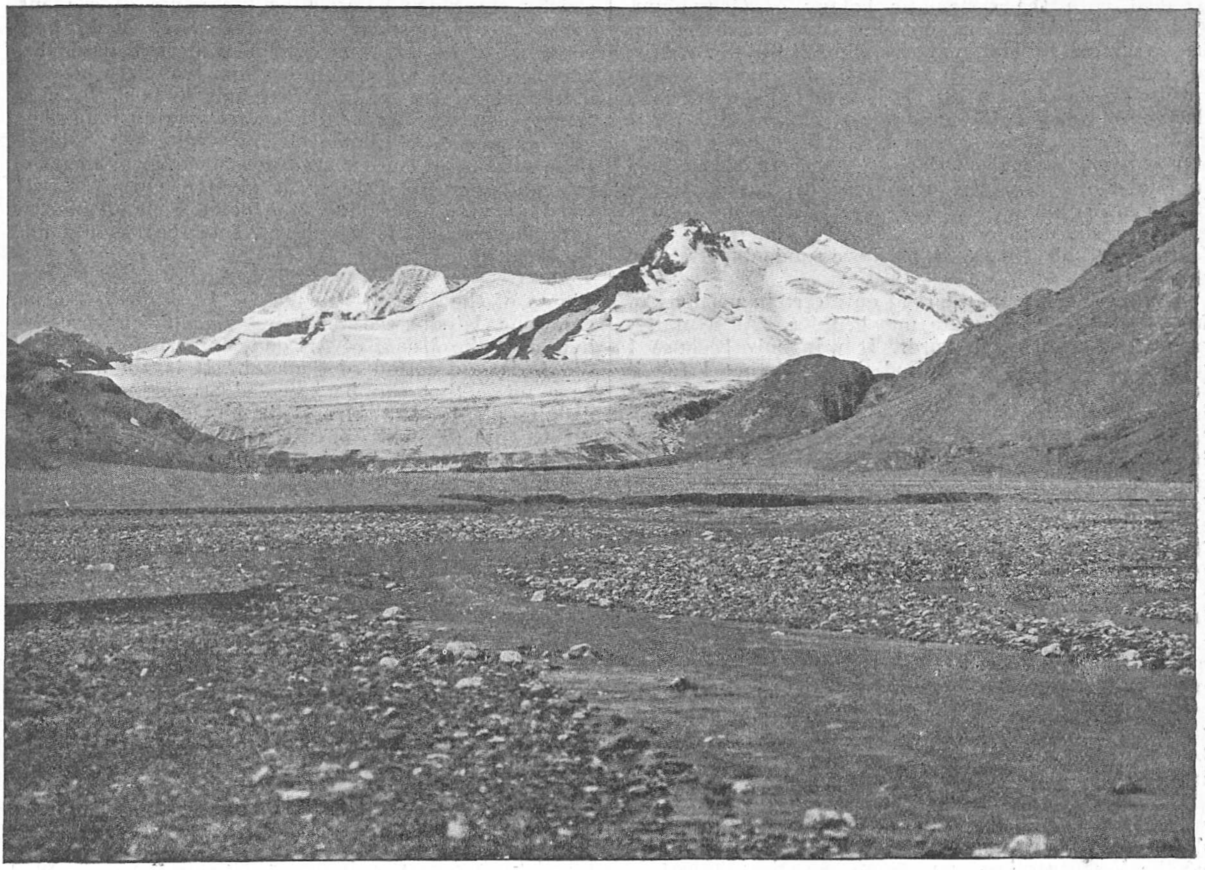

FIG. 1.—Sources of the River Yarkand. From the *Geographical Journal*, August.

The difference in aspect between the surroundings of the Remo glacier and those of the glaciers further west and in Sikkim, a point raised by the President at the close of the discussion, is perhaps to be explained in part by the geological structure of the district. The line of division between the crystalline rocks constituting the main axis of the Himalaya and the softer slates, shales, and limestones of Palæozoic and Mesozoic age which succeed them on the north, is shown on Lydekker's geological map of Kashmir (Memoirs, Geological Survey of India, vol. xxii.) as passing diagonally across the Karakoram range to the west of the Siachen glacier; and in the last note made by Stoliczka, two days before his death, he records the presence at the Karakoram pass of shales and limestones of Triassic and Liassic age. Thus the material from which the magnificent pinnacles of the western Karakoram, or the precipices of Kinchinjunga, have been carved out is lacking in the eastern extension of the range. Moreover, the absence of a deep gorge in close proximity to the crest of the range, like that of the Indus further west, or of the Tista in Sikkim, lessens the transporting power of the tributary torrents, and causes the hills to become smothered in a mantle of their own débris, so that, as Stoliczka remarks, "it becomes almost an exception to observe a rock *in situ*," and the scenery becomes correspondingly tame.

The occasion of the reading of Dr. de Filippi's paper was memorable in more respects than one. Not only was an opportunity afforded, and happily utilised by the President of the Society, of expressing the cordiality of our relations with Italy, whether we are engaged together in peaceful exploration or in the more serious business of war, but also by the participation in the discussion of the father of Himalayan exploration in that region, Col. Godwin-Austen, and of another pioneer in Central Asian discovery, Sir F. Younghusband.

T. H. D. L.

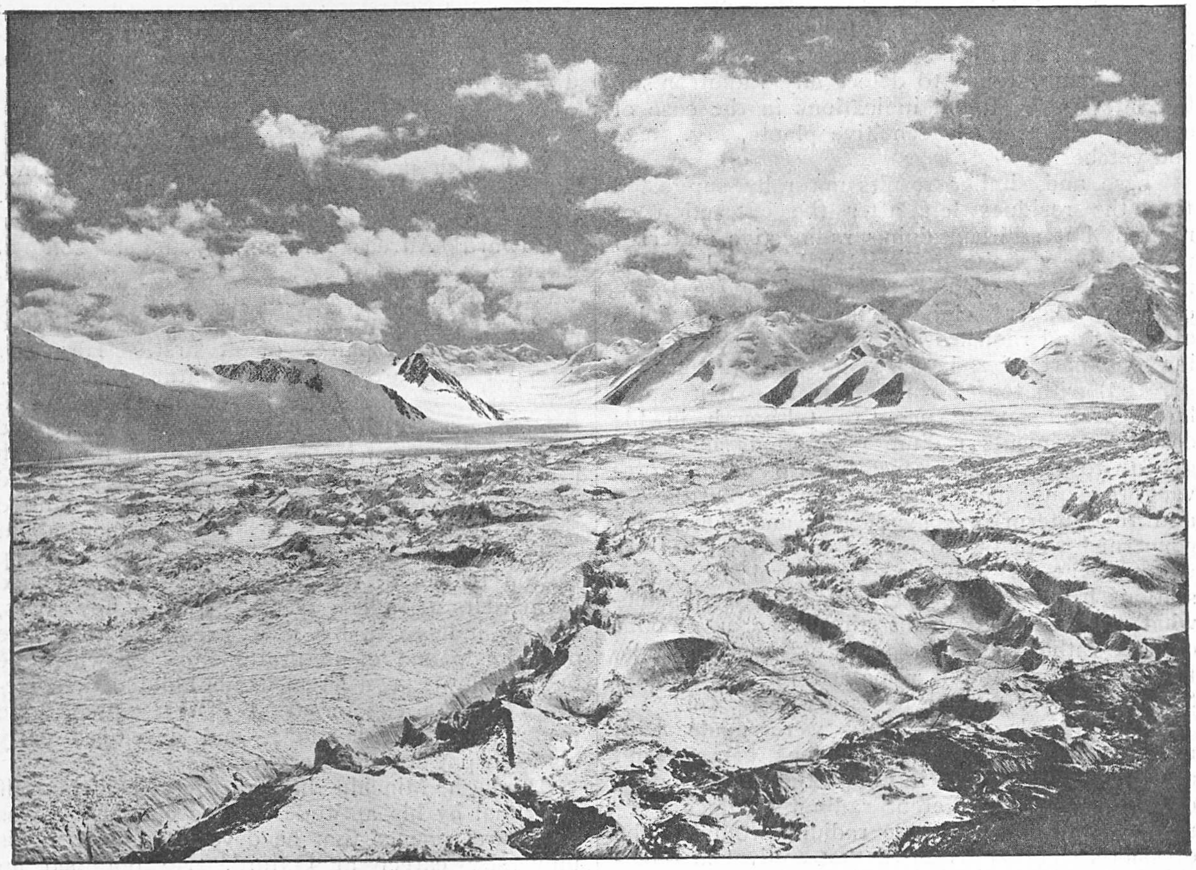

FIG. 2.—Middle portion of Remo Glacier, Northern Branch. From the *Geographical Journal*, August.

THE EFFECT OF RADIUM ON THE GROWTH OF PLANTS.

AMONG the many remarkable properties of radium it was perhaps natural to expect that it might have some definite effect on plants, and even, under suitable conditions, cause sufficient increase in the amount of growth to justify its use in horticulture and agriculture. The early observations of Dixon and Wigham[1] at Dublin, however, did not seem very promising: 100 seeds of cress (*Lepidium sativum*) were uniformly distributed over an even surface of moist quartz sand, and after germination had taken place a sealed tube containing 5 mgms. of radium bromide was set 1 cm. above the central seed. The seedlings grew up, but without any curvature indicating positive or negative "radiotropism," and the only noticeable effect was a slight depression of growth in those within 1 cm. radius of the tube. As stronger preparations of radium became available more definite retardations and inhibitions were observed: thus Gager, in an elaborate report,[2] noted a more or less complete inhibition in cell activities in younger and especially embryonic tissues, with few exceptions. The action of radium through the soil, however, was different; germination and growth were both accelerated, and the plants furthest away were stimulated most. Acqua[3] found that different plants, and even different organs of the same plant, were differently affected, the root system in general responding more markedly than the aerial parts,

[1] Proc. Roy. Soc. Dublin, 1904, x., 178–192.
[2] Mem. New York Bot. Gard., 1908.
[3] *Ann. Bot.* (Rome), 1910, viii., 223–238.

and in his experiments being arrested in their development.

The intensity of the radiation is important, and G. Fabre,[4] using *Linum catharticum* as test plant, was able to obtain increased development and germination of seedlings by working with emanations up to 1·5 microcuries per 2 litres of air, and to retard development by using emanations of 40 microcuries per litre of air. H. Molisch[5] obtained a like result: young plants of vetches, beans, sunflower, etc., were stimulated in growth by weak emanations, but checked or entirely stopped by stronger ones. He further claimed that the "rest period" could be broken by the radium emanation, and forced lilac into bloom in November by attaching pipettes containing small quantities of radium chloride to the terminal buds.[6] In his earlier experiments he, like Dixon and Wigham, failed to detect any radiotropism, but later on he found indications in the case of certain heliotropically sensitive plants, *e.g.*, oats and vetches.[7]

These and similar results naturally suggested that the residues left after the extraction of radium, but still containing radioactive material, might have definite manurial value, and it was not long before definite statements were forthcoming. Baker[8] claimed that increased yields of wheat and radishes had been obtained by mixing one part of radioactive material (2 mg. ra. per ton) with ten of soil. It is true that Stoklasa's[9] results were negative (although in his other experiments radium emanations increased growth to a marked extent), but this did not prevent the introduction of radioactive fertilisers, and the enterprising syndicates and companies concerned were by no means loth to push their wares. The staffs of the agricultural experiment stations being busy people and, moreover, somewhat sceptical about plant stimulation on account of some rather sad failures, did not generally take the matter up, and it remained for Mr. Martin Sutton to carry out the necessary tests.

Mr. Sutton's experiments were made with radishes, tomatoes, potatoes, onions, carrots, and marrows, some grown in pots, others in plots out of doors. Eight different radium residues were used, in addition to pure radium bromide; the dressings were so arranged that equivalent quantities of radium were given in each case (1/4000 mgm. radium bromide to 15 lbs. of soil in the pots; 2½ times this amount per square yard to the plots). Controls were set up, including a set treated with the other substances present in the residues, designed to ascertain whether those had any effect.

The results have just been issued by Mr. Sutton. Going carefully through them, one is forced to the conclusion that the radioactive materials have been ineffective. In no case is there any clear evidence of increased growth. Even the pure radium bromide seems to have done nothing. We are therefore left with an apparent discrepancy. The work of the physiologists, assuming it to be sound, certainly indicated that radium emanation is capable of stimulating certain cell activities. Mr. Sutton's results show that such stimulus, if it exists at all, does not affect the final growth of the plant. The discrepancy is not a new one, it is periodically confronting the agricultural investigator. Thus Dr. Winifred Brenchley, at Rothamsted, has failed to obtain increases in growth by supplying plants with inorganic poisons which have been supposed to stimulate certain cell functions in suitable dilutions. The result opens up the prospect of an interesting discussion, but it also shows the danger of arguing from a simple physiological observation to a complex phenomenon like the growth of a plant in soil.

E. J. RUSSELL.

4 *Compt. Rend. Soc. Biol.* (Paris), 1911, lxx., 187–188.
5 *Umschau*, 1913. xvii., 95–98.
6 *Oesterr. Gart. Ztg.*, 1912. vii., 197–202.
7 *Sitzber. k. akad. wiss.* (Vienna), 1911, cxx., 305–318.
8 *Journ. Roy. Soc. Arts*, 1913. lxii., 70–78.
9 *Chem. Ztg.*, 1914, xxxviii., 841–844.

PROF. E. A. MINCHIN, F.R.S.

IT is with profound regret that we announce the death, on September 30, at Selsey, of Prof. E. A. Minchin, F.R.S.

Edward Alfred Minchin, younger son of Charles N. Minchin by his wife Mary J. Lugard, was born in 1866. From his birth he suffered from a constitutional weakness, and indeed his life was despaired of at first. He grew stronger with age, yet the premature close of his career was no doubt due to the physical disabilities against which he had so bravely struggled to the very end. Unable to share in the rough life of the ordinary schoolboy, he was educated privately, and then for a short time at the United Service College, Westward Ho! When about fourteen years of age he went to the Bishop Cotton School at Bangalore after having joined his parents in India. Here he lived happy years, free to indulge to his heart's content that love of animals and of natural history of which he had already shown signs in his childhood, sometimes to the consternation of his nurse. He made valuable collections, and developed early his keen powers of observation.

Although Minchin had distinguished himself at school by his aptitude for the classics, it was to natural science that he devoted himself in his university career at Oxford. He obtained an exhibition at Keble College, and took his degree in 1890 with first-class honours in zoology. Shortly afterwards he was awarded the University Scholarship at Naples, and then the Radcliffe Travelling Fellowship. In 1893 he was elected Fellow of Merton College. He was thus enabled to travel abroad to pursue his researches in foreign marine zoological stations, and to work in the laboratories of Prof. Bütschli, in Heidelberg, and Prof. R. Hertwig, in Munich. For several years assistant to Sir Ray Lankester and demonstrator in comparative anatomy at Oxford, he afterwards became lecturer in biology at Guy's Hospital, but soon succeeded Weldon in the Jodrell chair of zoology at University College, London, in 1899.

When, seven years later, a new chair of protozoology was founded in the University of London, Minchin was naturally chosen to fill the post, and undertook the direction of the new department of protozoology at the Lister Institute of Preventive Medicine in Chelsea. Here, to some extent freed from routine work and administrative worries, he pursued his researches with untiring industry, and reached those brilliant results which have made his name famous among protozoologists the world over. In 1910 he was awarded the Trail Medal, and in 1911 was elected a Fellow of the Royal Society. He married Florence Maud Fontain in 1903.

Even as an undergraduate Minchin made his mark as a student of singular ability and originality. His first scientific paper, "On a New Organ in Periplaneta" (*Quart. Journ. Microsc. Science,* vol. xxix., 1888), and a short note on the embryos of Aurelia (*Proc. Zool. Soc.*, 1889), were published before he had taken his degree. Shortly after, he gave the first intelligible account of the working of the extraordinary Cuvierian organs of Holothuria.

But space will allow us here to mention only a few of Prof. Minchin's numerous and valuable contributions to zoological science. He was a specialist in the best sense of the word, deliberately restricting the field of his researches in order to probe the more deeply into the mystery of life. The Porifera and the Protozoa were his favourite groups.

A series of papers, published from 1892 to 1898, on the structure, development, and classification of Calcareous Sponges placed Minchin at once in the first rank of zoological investigators. He was struck with the importance of studying specimens living under natural conditions or preserved in perfectly fresh state. An expert swimmer and diver, he loved to observe his sponges on the rocky coasts of Plymouth, Roscoff, Banyuls, and Naples. He was thus able to solve many of the problems which had baffled the efforts of his predecessors, and to correct not a few of their mistakes. These studies culminated in a masterly and beautifully illustrated memoir on the development of the spicules of the Clathrinidæ (*Quart. Journ. Microsc. Science,* vol. xl.), a triumph of technical skill over the difficulties encountered in dealing with minute histological details. It is typical of all his work: neat and methodical in preparation, accurate and thorough in execution, clear and convincing in presentation. To reach the high standard of accuracy he aimed at, Minchin worked with extraordinary patience and care; no pains were spared, no detail however small was neglected, every refinement of method brought into use. His mastery of technique was indeed remarkable, and great was his ingenuity in devising improvements in the instruments used and routine followed in his investigations.

In later years he devoted more and more of his time to the study of the Protozoa, especially of the parasitic forms. The same skill and care which had yielded such successful results in the study of the Porifera soon won for Minchin a high reputation among protozoologists. In 1905 he spent some time in Uganda on the Royal Society's Sleeping Sickness Commission. From that time his work was confined almost entirely to the elucidation of the life-history of the Trypanosomes. For years he devoted himself to this difficult problem, and the memoir brought out, in conjunction with Mr. J. D. Thomson, last January (*Quart. Journ. Microsc. Science,* vol. lx.), describing in every detail the life-history of *Trypanosoma lewisii* in the rat-flea, will remain a lasting memorial to Minchin's boundless industry and perseverance. Some idea of the magnitude of the work may be gathered from the fact that more than 1600 fleas were dissected and examined in the course of these researches. Among the important discoveries there described may be mentioned the occurrence of an intracellular stage passed through by the Trypanosome in the stomach of its host. Incidentally, Minchin contributed valuable information concerning the life-history and structure of the tsetse-fly and the flea.

It was not, however, by his original researches alone that he advanced zoological science. He wrote many excellent articles in the "Encyclopædia Britannica" and elsewhere, and text-books of the highest merit. The parts he contributed to Lankester's "Treatise on Zoology," dealing with the Porifera and the Sporozoa, are models of clear description and sound judgment based on wide zoological experience and a thorough knowledge of the literature. The later "Introduction to the Study of the Protozoa" is by far the best text-book yet written on the subject in English, or perhaps in any language, and will long remain a standard work.

Minchin had a wholesome horror of hurried or slipshod work, of anything which savoured of sensationalism or self-advertisement. He was always ready to give of his best, whether in his writings or his lectures, whether to his friends or his pupils. As a teacher he was particularly successful at the Lister Institute, where he welcomed and encouraged any who wished to engage in research. There also he lectured and gave practical instruction to students, many of whom were medical men from India and the tropics.

Minchin was a man of cultured intellect and wide interests, with a keen appreciation of the beauties of ancient and modern literature. His published works and his presidential addresses to the Quekett Microscopical Club are distinguished not only for the matter they contain, but also for the admirable form in which it is presented. Nowhere, perhaps, is this better seen than in his last scientific contribution, the presidential address to Section D of the British Association at Manchester. Unfortunately he was prevented from reading it himself by the illness which was so soon to carry him off.

The sudden ending of his scientific career will be deeply felt in the zoological world, not only in England, but also abroad, and especially perhaps in France, where his merits were quickly appreciated. Minchin's great modesty and his gentle and unassuming character endeared him to his many intimate friends and pupils. His personal charm was greatly enhanced by a keen sense of humour; he delighted in a good story. In conversation Minchin was gifted with a happy turn of phrase. His friend, Mr. Heron-Allen, with whom he spent his last days, tells us that in answer to a quotation from O. W. Holmes, that "Life, as we call it, is nothing but the edge of the boundless ocean of existence where it comes on soundings," Minchin replied, "And death, as we call it, is nothing but the unfathomed deeps of the ocean of existence where we lose the sounding plumb."

DR. T. ALBRECHT.

We deeply regret to announce the death, on August 31, at seventy-two years of age, of Dr. Theodor Albrecht, departmental chief in the Royal Prussian Geodetic Institute, Potsdam, and chief of the International Bureau for Investigating Latitude Variation since its inception in 1898. By his death, geodesy loses a painstaking and conscientious worker, who laboured zealously to unravel a complicated problem, and to carry forward the investigations so brilliantly inaugurated by the late Dr. Chandler. For many years he occupied himself with the study of the minute changes in the position of the earth's axis, and by his office had been mainly responsible for the methods of observation applied, and the trustworthiness of the results derived.

Prof. Fergola, as is well known, urged the necessity of attacking this question of latitude variation by a uniform and systematic method of observation under international control, so far back as 1883, but it was not until twelve years later that any progress was made, when Profs. Forster and Helmert, supported by the hopeful researches of Chandler, were able to bring the far-reaching scheme to fruition. From that time onward, Albrecht was identified with this plan, to which he gave untiring devotion. Even before his appointment as director, he had signalled his interest in these researches by dicussing the motion of the pole in the interval 1890–95, from observations made at some dozen observatories in Europe and America. Since then Dr. Albrecht issued reports with praiseworthy regularity, and his diagrams showing the excursions of the pole have been models of clearness. Under his superintendence the bureau justified itself by its diligent, patient labour and skill in handling minute details. Criticism has not been wanting, but probably there was little room for originality or brilliancy of treatment.

The late director performed a useful work in keeping an interesting problem before the scientific world, and though in these days there must be great difficulty in maintaining an international bureau, supported by the varying subsidies of many nations, amounting in all, we believe, to about 3000*l.* per annum, it would be a matter of regret if any breach of continuity in the conduct of the bureau should result.

NOTES.

At the recent meeting in Manchester, the General Committee of the British Association unanimously adopted the following resolution, which has been forwarded to the Prime Minister, the Chancellor of the Exchequer, and the Presidents of the Board of Education and of Agriculture and Fisheries:—"That the British Association for the Advancement of Science, believing that the higher education of the nation is of supreme importance in the present crisis of our history, trusts that his Majesty's Government will, by continuing its financial support, maintain the efficiency of teaching and research in the universities and university colleges of the United Kingdom."

The urgent need for a wise economy in every department of public and private life is recognised by every patriot anxious to see the war brought to a successful end. A timely protest in the Press from Sir James Yoxall, M.P., against unintelligent and wrongly directed economy deserves notice. At no time in the country's history has it been more necessary that every effort should be made to make our system of education efficient and thorough, so that when military conflict gives place to industrial competition we may be able to hold our own with the central European States. Yet Sir James Yoxall has to direct attention to attempts to save money at the expense of the education of the nation's children. "Supplies of books, stationery, and other needed school appliances are being lessened in amount or reduced in quality; plans are laid for abolishing evening classes and schools; and there is evidence of a wide general slackening in educational provision." Some local education authorities have contemplated reducing the salaries of teachers. "The Amalgamated Association of Operative Cotton Spinners, operatives themselves, and many of them parents, are asking that children may go into the mills to work full time at the age of thirteen. Agricultural people demand 'half-time' for children of eleven; and so does the Cotton Spinners' Trade Union, I understand." Such unwise economy must be discouraged everywhere, and it is the duty of every influential person to do his part to prevent any deterioration in the work of our schools and colleges, because upon it our country's welfare ultimately depends.

Mr. E. W. Swanton has been elected president of the British Mycological Society.

The Thomas Hawksley Lecture of the Institution of Mechanical Engineers will be delivered on Friday, October 29, by Dr. Dugald Clerk; the subject will be, "The World's Sources of Fuel and Motive Power."

A preliminary meeting to discuss the formation of a proposed Society for the Study of Geological Physics will be held at the rooms of the Geological Society of London, Burlington House, W., on Thursday, October 14, at 3.30 p.m. The chair will be taken by Prof. Benjamin Moore.

The issue of *Science* for September 17 announces the death of Prof. Karl E. Guthe, professor of physics in the University of Michigan and dean of the

Graduate School; and of Prof. J. H. Van Amringe, dean of Columbia College, and professor of mathematics until his retirement five years ago after a service of fifty years.

THE Rome correspondent of the *Morning Post* states that in consequence of comments on his Germanophil attitude, the Marquis Cappelli has resigned the presidency of the Royal Geographical Society of Italy, and the resignation has been accepted. As the Marquis Cappelli is also president of the International Agricultural Institute, the question is being asked whether he will now retain that position.

THE director of the Meteorological Office reports that information has been received from the seismological observatory at Eskdalemuir, Langholm, Scotland, of the record of a large earthquake which occurred at 7 a.m. G.M.T. on Sunday, October 3. The computed position of the epicentre is between Colorado, U.S.A., and the Island of Guadelupe, off the coast of California.

WE learn from the *Pioneer Mail* that the programme of the Board of Scientific Advice for India during the year 1915–16 includes the following work of the various scientific departments:—The meteorological department will continue observational work with pilot balloons at various stations, and will also do some experimental work on vertical air currents at Agra. In the astronomical department a new spectroheliograph is under construction, which it is hoped will be completed during the year. Five Omori seismographs, two at Simla, two at Calcutta, and one at Bombay, the Milne seismograph at Kodaikanal, and several instruments of local manufacture at Bombay, will be kept in use during the year for scientific research work. Geological surveys will be continued in Bombay, Central India, Rajputana, the Central Provinces, Burma, and Kashmir. In connection with the botanical survey of the country, the curator of the herbarium and the systematic assistants will work up, with a view to publication, the material of the past year's exploration in Southern India, and the material presented by contributors not belonging to the department for field work. It is proposed to continue the exploration of Travancore by the curator of the herbarium and an officer of the department. This field work will be of practical use in connection with the flora of Madras now under preparation. In the industrial section of the Indian Museum plant breeding and plant improvement work will be continued on wheat, tobacco, gram, fibre plants, indigo and oilseeds; and fruit entomology will include general investigations of crop pests, and especially of the pests of rice, sugar-cane and cotton, fruit trees, and stored grain. Under the head of agriculture, the following are among the lines of work in progress:—The combination of irrigation and drainage in the growing of rice; the study of the inheritance of the more important characters of dairy cattle by crossing; the building up of milk pedigree in cattle by selection.

THE Rev. Cyrus Byington, born in 1793, served for fifty years as a missionary among the Choctaw Indians, and died full of years and honour in 1868. He translated into Choctaw several books of the Old and New Testaments, and compiled a grammar of the language. His chief work was a Choctaw-English Dictionary, which he left in manuscript without final revision. This has now been done by Mr. J. R. Swanton with the assistance of Mr. H. S. Halbert, who spent many years among the Choctaws, became familiar with their language, and is an enthusiastic student of everything relating to the past history and present culture of the tribe. The dictionary, which has now been published as Bulletin 46 of the Bureau of American Ethnology, will be welcomed by all students of the languages of the American Indian tribes.

IN *Man* for October, Mr. T. E. Peet discusses the types of megalithic monuments found in the peninsula of Sinai, which are interesting in connection with the question of rude stone monuments in the Mediterranean basin, and also in view of a possible relation between their builders and the early Egyptians. The monuments consist of beehive tombs, rock circles, and hut circles. Much further investigation is needful before their origin and relations can be fixed with certainty. Mr. Peet, who writes with commendable caution, thinks that the evidence does not satisfactorily prove their connection with Egypt. As regards the Mediterranean relations, he remarks that the more specialised features of the true megalithic system—dolmens, the use of really large stones, and the combination of large orthostatic slabs and corbelled courses of masonry, as found in Malta and Sardinia—do not exist. Possibly further investigation may provide examples of these features, but at present we lack evidence to connect Sinai with the Mediterranean megalithic area.

IN the Journal of the College of Agriculture of the Imperial University, Sapporo, Japan (vol. vi., pt. vii.), Mr. J. Yamare discusses the inheritance of "notched" ears in Ayrshire cattle. This marked abnormality recognised in American herds of the breed is due to a Mendelian dominant factor, but it is of interest to find that heterozygote individuals show the "notching" only in a greatly reduced condition.

STUDENTS of the Dragonflies will welcome Mr. Clarence H. Kennedy's "Notes on the Life-history and Ecology of the Odonata of Washington and Oregon" (Proc. U.S. Nat. Mus., vol. xlix, pp. 259-345). The habits of the insects when pairing and egg-laying are described, and structural details of the nymphs and of the imagos at different ages are made clear by means of an excellent set of illustrations.

DR. A. E. CAMERON has spent a year in New Jersey as a research fellow of the Victoria University, Manchester, and gives some of the results of his studies in an article on potato spraying and dusting, published in the Bulletin of Entomological Research (vol. vi., part i.). It is established that Bordeaux mixture with arsenate, in addition to its effect as a fungicide, kills the beetle-enemies of the potato crop. Dr. Cameron directs especial attention to the profitable co-operation found in the United States between scientific experts, farmers, and chemical manufacturers, and wishes that similar conditions might be brought about in this country.

THE trustees of the British Museum have issued an account of the Nemertine Worms collected on the *Terra Nova* Antarctic Expedition (Nat. Hist. Report, Zoology, vol. ii., No. 5), by Mr. H. A. Baylis. The number of species is small, and most of them are represented by few examples, but the author in his systematic and anatomical descriptions and drawings has made the most of the material at his disposal. Worms from Antarctic localities described by other naturalists as species of Cerebratulus and Eupolia, are all referred to M'Intosh's Kerguelen species *Lineus corrugatus*, which, on this view, has an extensive circumpolar range.

A VALUABLE account of the penguins of South Georgia, by Mr. R. C. Murphy, has been published, in the form of a bulletin (vol. ii., No. 2) by the Brooklyn Institute of Arts and Sciences. The charge of wanton slaughter, which the author makes against the crew of the *Daisy*, a sealing brig which he accompanied for the purpose of studying the penguin rookeries, makes painful reading. It would seem that the doom of the king penguin, so far as South Georgia is concerned, is sealed. In addition to his studies of this bird, Mr. Murphy gives some lengthy notes on the Gentoo penguin (*Pygoscelis papua*). Since so much has already been written on these birds, more than Mr. Murphy seems to be aware of, judging from his references to the literature of this subject, it is not surprising to find that the author has nothing new of importance to record. In one particular he has missed a fine opportunity. We have heard much of the central "pouch" and of the "flap of skin" under which the king penguin incubates its egg, and later broods its young, but so far no really careful, or accurate, description of this structure has yet been given. Mr. Murphy has done nothing to help forward the solution of this matter.

THE Geological Survey of Great Britain describes the mainland portions of Sheets 330 and 331 in a memoir by H. J. O. White on "The Geology of the Country near Lymington and Portsmouth" (1915, price 1*s*. 6*d*.). The district includes the admirably fossiliferous strata of Bracklesham and the Oligocene beds of Brockenhurst, where a band occurs in the Headon series that is more purely marine than its representative in the Isle of Wight. It is stated that the drowned valley of the Solent and the inlets near Portsmouth generally have been considerably enlarged by marine erosion.

THE United States National Museum has received from a marine Miocene formation in California the greater part of the skull of the rare Sirenian Desmostylus, which shows that in several respects this is one of the most primitive genera of its order. The snout is not bent downwards so much as in modern sirenians, and the nostrils are comparatively small and far forwards The new specimen is described in detail by Dr. O. P. Hay in the Proceedings of the United States National Museum, No. 2113, and reference is also made to an allied species found on the opposite coast of the Pacific in Japan.

THE difficulty of restoring extinct reptiles, even when nearly complete skeletons are known, is well illustrated by the armoured dinosaur Stegosaurus, described by Mr. C. W. Gilmore in a recent part of the Proceedings of the United States National Museum (No. 2110). When Marsh first found the greater part of a skeleton of this reptile, he supposed that its large plates of bony armour were arranged as a ridge along the middle of the back; subsequent authors recognised that the plates were not median, and regarded them as forming a paired series; Mr. Gilmore now concludes that the plates were neither median nor paired, but must have formed two alternating series along the middle of the back. He also thinks that the largest plates were above the root of the tail, not above the pelvis, and thus he feels obliged to make the trunk shorter than in previous restorations. A readjustment of the head gives to Stegosaurus the appearance of a browsing animal.

THE *American Journal of Science* for September, 1915 (vol. xl., No. 237), contains two papers of special geological interest. W. M. Davis gives the results of his studies, during 1914, of the coral-reefs of the Pacific, and strongly supports the theory put forward by C. Darwin "when he was twenty-five years old and before he had ever seen a true coral-reef." W. H. Twenhofel discusses the making of black shale, such as that in which graptolites abound. He shows, from a remarkable instance on the Esthonian coast, described by several Russian writers, that black slimes are not necessarily deposits of deep water, but may fill up coastal shallows. The blackness is in this case due to hydrocarbons of vegetable origin; the absence of tides, and a cool temperate climate are favouring conditions. "Sulphur gas" is present, and the author believes that animal remains would ultimately be pyritised in such an environment. Anærobic bacteria probably play a large part in the production of the slime. The muds of the Black Sea are contrasted with these shore-deposits.

THE August number of *The Royal Engineers' Journal* (vol. xxii., No. 2) contains a lengthy summary of General Maitrot's study of the strategical relations of France and Germany. The original appeared in French in a third edition this year as "Nos Frontières de l'Est et du Nord," and while in the main it deals with military considerations, contains a valuable study of the geography of the western theatre of war. Major W. A. J. O'Meara's summary is accompanied by several useful maps from the original publication. Events have proved the accuracy of General Maitrot's estimate of the value of the geographical factor in the plan of campaign.

INVESTIGATIONS of ocean currents around Australia have been made by floats thrown overboard from various vessels. A chart indicating the drift of fifty of those which have been recovered from the end of 1909 to the middle of 1914 has been published by the Commonwealth Government. Most noticeable is the

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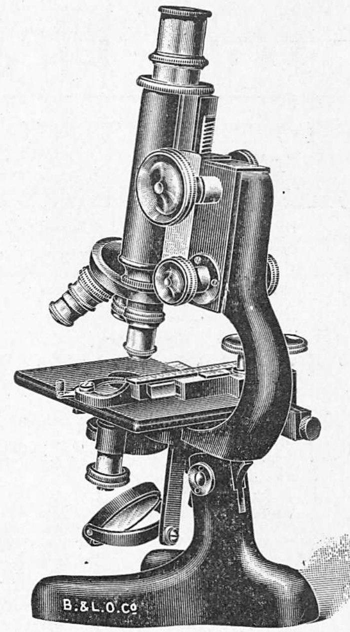

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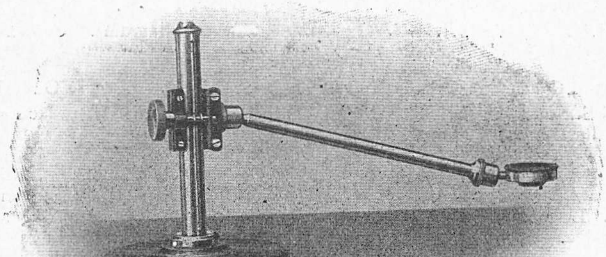

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E.N.E. course of those set adrift in the forties in contrast to the general E.S.E. track of those from the thirties south of Australia. As most of the floats were cast up on relatively unfrequented shores where they may have lain a considerable time before discovery, it is impossible to form any estimate of their rate of travel. Nor can any conclusions be drawn from the absence of floats on a coast, as, for example, the western coast of the south island of New Zealand, where none have been found; this may be due to that coast being less frequented than the western coast of the north island, where many were picked up.

THE rainfall in Australia in 1914 is shown in a series of charts prepared by Mr. H. A. Hunt, and issued by the Commonwealth Government. The year was noticeable for its drought, and in South Australia, the Riverina, western Victoria, and much of Tasmania it was the driest year on record. These conditions resulted in a failure of the crops over the greater part of the wheat belt, with a production only some 30 per cent. of the previous season. Tasmania suffered least of all parts of the wheat belt, but in other parts of southern Australia the deficiency of rain in the cool part of the year averaged from 25 per cent. to 72 per cent. These conditions were related to anti-cyclones of great intensity, which kept south of their normal track across Australia, and moved very slowly, with the result that the "Antarctic" disturbances failed to reach Australia to any great extent. The weakness and failure of the winter rains were partly counterbalanced in the warmer months by unusually strong monsoons. In western Australia, Victoria, central and southern New South Wales in November and December, these rains were far above the average. On the whole, the drought of 1914 was not so widespread as the droughts of 1888 and 1902, but was locally more intense. Queensland and tropical Australia largely escaped.

IN the *Tôhoku Mathematical Journal* (viii., 1) Mr. Kihizi Yanagihara, in a note entitled "A Theorem on Surface," offers a proof of the statement that if one surface always cuts a second surface in a plane curve or several simply closed plane curves, then the first surface must be a sphere.

IN a paper on "General Expression for Stress Components" (Proceedings of the Tokyo Mathematical Physical Society, viii., 2 (1915)), Mr. Senien Yokota considers the problem of an infinite plate containing a circular hole in which a plug can be inserted, or having complete or partial contact with its periphery. The plate is supposed to be under a uniform tension in a fixed direction. It would appear that whether the plug is loose or just fits the hole, the maximum tangential tension on the periphery of the hole is three times the tension applied to the plate. This result is no doubt of interest in connection with the problem of rivets.

IT is remarkable that while aeroplanes the engines of which have been disabled by shrapnel can pursue their erratic paths to earth without any prospect of having their equations of motion solved, mathematicians are still covering pages of formulæ with attempts to solve the problem of three (hypothetical) bodies. We have before us a paper by Prof. T. Levi Civita on "The Reduction of the Problem of Three Bodies" (Venice: Carlo Ferrari, 1915; reprinted from the *Atti del R. Istituto Veneto,* lxxiv., 2, pp. 907–939), and Mr. D. Buchanan discusses a new isosceles solution in the Transactions of the American Mathematical Society, xvi., 3, pp. 259–274. We can only hope that these and other writers on this problem will speedily bring their investigations to such a state of perfection as to render it impossible to discover anything further on the subject. When this is done, they will find aeroplanes clamouring for a little attention.

IN response to numerous requests for information as to the melting points of the chemical elements, the Bureau of Standards at Washington has issued a table of melting points according to the most trustworthy data. The following are the melting points on the thermodynamic scale used by the bureau as standard temperatures in the standardisation of thermometers and pyrometers: Mercury −38·9°, tin 231·9°, cadmium 320·9°, lead 327·4°, zinc 419·4°, antimony 630·0°, aluminium 658·7°, silver 960·5, gold 1063·0°, copper 1083·0°, nickel 1452°, iron 1530°, palladium 1549°, platinum 1755°, tungsten 3000°. At temperatures of 1000° the uncertainty is of the order 0·1°, at platinum 5°, and at tungsten 100° C. A further table of other standard temperatures is given in which the following are included: normal boiling point of oxygen −183·0°, sublimation of carbon dioxide in an inert liquid −78·5°, normal boiling points of water 100°, naphthalene 217·96°, benzophenone 305·9°, sulphur 444·6°, freezing point of sodium chloride 801° C.

THERE is an interesting description with photographs in *Engineering* for October 1 of what is in many respects the most remarkable old steam engine in existence. This is a Newcomen engine used at the Farme Colliery, Rutherglen, near Glasgow. The valve gear is of the simplest possible kind, and is worked by hand, just as was the case with the original Newcomen engine. The engine is used for winding, and draws a cage up in 35 seconds, making 16 revolutions while doing so. The cylinder has a diameter of 2 ft. 8¼ in., and the stroke is 5 ft. 6 in. The mean pressure is 7·35 lb. per sq. in., and the boiler pressure is 3 lb. per sq. in. The maximum indicated horse-power is 27.

IN addition to the works referred to in the last two numbers of NATURE, the following forthcoming books of science are announced:—In *Agriculture*—The Spirit of the Soil: An Authorised Exposition of the Theories and Results evolving from Prof. Bottomley's Inoculation of Soil by Means of Bacteria, G. D. Knox, illustrated (Constable and Co., Ltd.); Poultry Husbandry, E. Brown, illustrated (E. Arnold). In *Anthropology and Archaeology*—Savage Man of Central Africa, Dr. A. L. Cureau (T. Fisher Unwin, Ltd.). In *Biology*—The Hill Birds of Scotland, S. Gordon, illustrated; Thirty-five Years in the New Forest, Hon. G. Lascelles, illustrated (E. Arnold); Trout Fly-Fishing in

America, C. Z. Southard, illustrated; The Rambles of a Canadian Naturalist, S. T. Wood, illustrated (J. M. Dent and Sons, Ltd.); Bramble-Bees, J. H. Fabre (Hodder and Stoughton); Bird Behaviour, F. Finn; Insect Artisans and their Work, E. Step (Hutchinson and Co.); The Book of the Wilderness and Jungle, F. G. Aflalo; Wild Animals of Yesterday and To-Day, F. Finn; The Common Beetles of our Countryside, W. E. Sharp (S. W. Partridge and Co.); Wonders of Animal Life, W. S. Berridge (Simpkin and Co., Ltd.). In *Geography and Travel*—By Forest Ways in New Zealand, F. A. Roberts, illustrated (Heath, Cranton and Co., Ltd.); Java: Past and Present, D. Campbell, 2 vols., illustrated (Heinemann); How to Read Ordnance Maps, J. F. Unstead; Philip's Human Geographies, H. Fairgrieve and E. Young (G. Philip and Son, Ltd.); With Scott: the Silver Lining, T. G. Taylor, illustrated (Smith, Elder and Co.). In *Geology*—Earth-Lays: Geological and other Moods, C. Tolly (J. M. Dent and Sons, Ltd.). In *Mathematical and Physical Science*—Text-Book of Navigation and Nautical Astronomy, Capt. A. P. W. Williamson, new edition, illustrated (John Hogg). In *Medical Science*—Mosquito Control in Panama: the Eradication of Malaria and Yellow Fever in Cuba and Panama, J. A. Le Prince and A. J. Orenstein (G. P. Putnam's Sons). In *Technology*—Handbook of Technical Instruction for Wireless Telegraphists, J. C. Hawkhead and H. M. Dowsett, new edition, illustrated (The Wireless Press, Ltd.). In *Miscellaneous*—The Limitations of Science, Prof. L. T. More (Constable and Co., Ltd.); Social Progress and the Darwinian Theory, G. W. Nasmyth; Darwin and the Humanities, Prof. J. Mark Baldwin (G. P. Putnam's Sons).

OUR ASTRONOMICAL COLUMN.

Measures of Jupiter.—Numerous visual and photographic measures of the diameter of this planet have been made by the Rev. Father S. Chevalier, S.J., of the Zô-Sé Observatory, during 1912–13 (*Mem. Soc. Spett. Ital.*, July, 1915). The Gautier micrometer used in the visual work provides for the measures being made by bringing two strips of platinum tangential to the limbs of the planet, either (i) internally, *i.e.* with both strips seen in front of the disc, or (ii) externally, both strips beyond the disc. The two sets of measures thus obtained were of closely similar accuracy. In the photographic work very many separate exposures were made on each plate, affording material for a considerable body of measures. The exposures were graded in seven groups according to intensity, and measures on only four of these sets were used in taking the means. The discarded groups were those in which the images were considered either too small through under-exposure or enlarged by irradiation. The mean results may be summarised as follows:—

	Polar diam.	Equat. diam.
Visual measures ...	35·37″	38·16″
Photographic measures	35·20″	37·99″

The value of the aplatissement derived from both sets is practically identical, its reciprocal being 13·6, indicating a decidedly greater flattening than hitherto ascribed to this planet. Thus in one of the most important memoirs recently published (Lau, *Ast. Nach.*, No. 4673) the diameters are given as 35·4″ and 37·6″, yielding 17 as the reciprocal of the ellipticity.

The Rotation Period of Certain Jovian Markings.—Jupiter is now well situated for observation, and Mr. W. F. Denning, in the Journal of the Royal Astronomical Society of Canada (September), indicates some directions in which useful work may be done. The subject of the paper is the rotation period of the great red spot and of the hollow in the southern equatorial belt. The yearly values of the rotation period are tabulated for the eighty-four years, 1831–1914 (inclusive). Waiving the debatable point involved in the formation of this sequence, the period has varied between 9h. 55m. 33·3s. (1831) and 9h. 55m. 41·7s. (1898). Special attention is directed to the very marked acceleration since 1910. The mean period of rotation for about 74,170 rotations comes out at 9h. 55m. 36·9s. After such a weighty determination one hesitates to mention a value based on twenty-nine rotations, but M. Chevalier's recent photographic measures are worthy of note (*Mem. Spett. Ital.*, vol. iv., September 2, p. 113). The point measured was the western extremity of the south tropical disturbance, and the period deduced 9h. 55m. 10·4s. ±0·7s., a faster movement than Mr. Denning assigns to the dusky south tropical disturbance (9h. 55m. 20s. approx.). The question of co-ordinating the visual and photographic observations would no doubt in happier times have led to extensive polemics.

R. Coronæ Borealis.—This irregular variable has been manifesting light-changes during the past summer (see this column, August 19). We now learn from the Monthly Register of the Society of Practical Astronomy that in Bulletin No. 585 Harvard College Observatory, August 14, 1915, Prof. E. C. Pickering states that attention had been directed to its diminution in brightness by Mr. Eaton, and Mr. Bancroft found its magnitude 6·8 on July 24 and 6·9 on the 25th; whilst at Harvard, on August 13, its magnitude was only 7·7 (Mr. Campbell).

A 10-inch Diffraction Grating.—A short paper by Prof. A. A. Michelson on the ruling and performance of a giant diffraction grating (*Proc. Amer. Phil. Soc.*, No. 217, p. 137) affords most inspiring reading. Rowland's gratings accomplished so much, yet the interferometer, the echelon, and the plane parallel plate brought such undreamed-of resolving powers into practical employ that it might well have been imagined that the grating had had its day. Michelson, the pioneer of the newer methods, realised early their disadvantages, and twelve years ago set about constructing a perfect screw 20 ins. in length, with the hope of some day ruling a grating 14 ins. long. Mechanicians will delight in the ingenious devices which have brought realisation within reach, and even encourage the undertaking of a 20-in. grating. Thus for correcting the screw an interferometer method was adapted enabling measurement to within 1×10^{-6} of an inch. An auto-collimating method of straightening the guiding ways ensured rectilinear motions within one second of arc. The grating carriage was nearly floated in mercury. Longitudinal movement of the screw was geometrically eliminated by allowing its spherically rounded end to bear against an optically plane surface of diamond fitted with adjustments to secure normality to the axis of the screw. Periodic errors could be corrected by using a worm-wheel to rotate the screw, and those of higher order were eliminated by a mysterious "correcting device." So long ago as 1910 a $6\frac{1}{2}$-in. grating had been produced and was employed by Messrs. Gale and Lemon in a research demanding resolving powers rivalling those of interference spectroscopes; now a ruled surface $9\frac{3}{8}$ in. $\times 2\frac{7}{8}$ in., having 11,700 lines per inch, has been achieved and tested in a spectrograph of the Littrow form with an 8-in. 20-ft. Brashear lens. The theoretical resolving power in the sixth order is 660,000, and 600,000 has actually been attained on a negative from which was prepared the illustration accompanying the paper.

THE SOLAR PHYSICS OBSERVATORY, CAMBRIDGE.—We have received a copy of the second annual report of the director relating to the year April 1, 1914, to March 31, 1915. Disadvantageous conditions arising out of the war have imposed serious limitations on the output of work, and have also retarded the installation of equipment. Mr. Baxandall has made considerable progress in working out the details of the chemistry stellar spectra for the projected atlas. The green regions of the spectra of α Cygni, α Canis Minoris, α Persei, and α Canis Majoris have been reduced, and the results are being prepared for publication. Spectra of several bright stars have been photographed in the course of adjusting the new spectrograph used with the 15-in. Huggin's refractor. Solar work has evidently been prosecuted both with zeal and success. The observers with the South Kensington spectroheliograph are especially to be congratulated on having secured spectroheliograms of the sun's limb on no fewer than 110 days. The solar eclipse expedition to Theodosia in the Crimea was very unfortunately foiled by clouds, and this is doubly regrettable as the eclipse provided some novel spectroscopic features. Successful photographs of sun-spot spectra have been secured with the McClean solar instruments. In the laboratory a powerful spectrograph of the Littrow type has been improvised, using a 6-in. plane grating and a 6-in. Cooke photovisual lens, and thus the 21-ft. concave grating detained at Odessa will scarcely be missed.

LONG-DISTANCE WIRELESS TELEPHONY.

THE announcement that the United States Navy Department has successfully experimented with a wireless telephone from Arlington, Virginia, to Mare Island, California, is chiefly interesting on account of the distance covered—2500 miles. If this success can be maintained in all conditions it will mark a notable achievement and one upon which the naval authorities in the United States may be complimented, because of the many years of steady and silent work which they have devoted to the subject.

There is nothing inherently impossible in long-distance wireless telephony, and from the scientific point of view there is no reason why it should not be carried on over even greater distances than that recorded above, but there are practical difficulties in regard to the construction of a microphone transmitter capable of passing large high-frequency currents, and in the production of the necessary persistent oscillations. In ordinary telephony, the current going through the microphone is quite small, and so long as the power to be dealt with is small, it is easily possible to obtain a microphone capable of dealing with the amount of energy while giving good articulation. But when a power measured in kilowatts has to be dealt with it is another matter. By using many microphones in parallel; by cooling the carbon granules with gas or immersing them in oil, and a host of similar devices, inventors have sought to produce one capable of dealing for protracted periods with a heavy current; but either they have not been entirely successful in this, or articulation has suffered. It is therefore desirable to await a full official account of the experiments carried out by the United States Navy Department before expressing an opinion upon the results. This is all the more necessary because of the great difficulty of judging the success of long-distance and other experiments merely by "reading."

It is extraordinary, in practice, to observe the marked difference between the distance at which speech is audible and the distance to which it is truly intelligible. The faint overtones and small nuances upon which intelligible speech depends are, at best, all too lightly impressed on the ever-varying curve of intensity sent out; and if they are smothered up or glossed over by a coarse microphone, a distant receiving station where the signals are weak gets only the bare fundamental tones stripped of all meaning. It is very easy to be deceived in this, and when well-known words are uttered, the ear glibly supplies the missing sounds.

EXPERIMENTS ON HOMING.[1]

PROF. J. B. WATSON and Dr. K. S. Lashley have made some important experiments at Bird Key, in the Tortugas, on the homing capacity of the noddy tern (*Anous stolidus*) and the sooty tern (*Sterna fuliginosa*), which breed there in large numbers. The island is peculiarly suitable for the purpose, since it marks the northern limit of the migration of these two tropical terns (so that if the birds are experimentally transported further north they find themselves in regions which they have not previously visited); moreover, on the westward side there is only the open water of the Gulf of Mexico until the shore-line of Texas is reached, Galveston being 855 statute miles distant. "This strip of open water proves a magnificent route for homing experiments." The authors caught terns at their nesting-places, put individual marks of paint on their head and neck, tied a small tag recording the date, locality, and marking round the neck, fixed a larger duplicate tag beside the nest, transported the birds in large cages to a distance, liberated them, and watched for their return. The general result is of great interest:—"The noddy and sooty terns can return from distances up to 1000 miles in the absence of all landmarks, at least so far as the term landmark is understood at present."

Some details of this careful piece of work may be noted, for they are very instructive. From Galveston (855 miles away) three birds returned out of ten, taking from about six to about twelve days; two noddies liberated at 720 miles both returned, taking between eleven and seventeen days; out of ten birds liberated at 585 miles eight returned, taking from about four to about eight days; out of four noddies and four sooties liberated in open water 461 statute miles away, two noddies returned in three days; of twelve taken north to Mobile, only one returned, taking about seven days; two noddies and two sooties carried in a state-room to Havana and released in the harbour there early in the morning of July 11, returned to Bird Key on the 12th, the distance in a straight line being about 108 statute miles; of three noddies and two sooties liberated off Cape Hatteras (850 miles to the north), both of the latter and at least one of the former species returned after several days. "The alongshore route, which is the one in all probability chosen by the birds on their return, since they were gone several nights, is approximately 1081 statute miles." (It seems that the birds almost never rest on the water, unless they happen to find pieces of driftwood or the like.) The records show that the terns often take as long for short distances as for long distances, and that a return from the open sea outside of all landmarks is just as practicable as a return from a coast.

By a series of exceedingly careful experiments Dr.

[1] Papers from the Department of Marine Biology of the Carnegie Institution at Washington. Vol. vii., "Homing and Related Activities of Birds." By J. B. Watson and K. S. Lashley. Pp. 1–104+7 plates+9 figs. (Washington: The Carnegie Institution, 1915.)

Lashley has shown that the problems of proximate orientation are relatively simple and straightforward. On the island of Bird Key the terns make their adjustment to the nest, mate, young, etc., on a basis largely of visual habits. Kinæsthetic habits are also involved, but to a less extent. On dark nights the sooty tern hovers over the crowded nesting area, giving out his call; he is answered by his mate and young, and is thus guided to the nest. Dr. Lashley found no evidence of any remarkable or unusual sensitiveness, or of the functioning of any hypothetical sense-organ.

As to the more difficult problem of distant orientation, the authors consider and dismiss various suggestions: that the birds follow water-currents; that they get their bearings by ascending to a great height; that they have special visual acuteness, *e.g.* to infra-luminous rays; or that they have special tactual or olfactory sensitiveness in the nasal cavities. The experimental thoroughness with which the spectral sensitivity and the functioning of the nasal chamber are dealt with is worthy of imitation. The authors are unwilling to suggest at present the assumption of any new and mysterious sense; they rightly prefer to continue to experiment. They suggest various experiments, *e.g.* on the sensory equipment of homing pigeons, and they conclude:—"We are far from being without hope that future studies may yield results which will enable us to solve the riddle which has been propounded to scientific men of all ages, but as yet never satisfactorily answered."

THE INSTITUTE OF METALS.

AT the meeting of the Institute of Metals held in London on September 17, a number of interesting papers were read and discussed. Amongst these were the following:—"Specifications for Alloys for High-speed Superheated Steam Turbine Blading," by W. B. Parker. In this paper the author confines his attention to a consideration of the non-ferrous alloys which are used for turbine blading. He gives a clear description of the physical and chemical properties which are essential for this purpose, and discusses in detail the causes of the wearing and corrosion of the blades. It is pointed out that although non-ferrous alloys have the advantage of being non-rusting, they do not possess a good proportional limit which is capable of being retained for long periods when exposed at the temperature of highly superheated steam. This fact has so far prevented the use of non-ferrous alloys for this particular purpose, and steel alloys are invariably utilised. The proportional limit should remain, for temperatures between 100° and 450° C., within 10 per cent. of its value at the ordinary temperature. Investigation is, therefore, needed, in order to find either (1) a non-ferrous alloy which will almost indefinitely retain its hardness up to a temperature of 450° C., or (2) a steel which will fulfil the above requirements and also be non-rusting. Anyone conducting research along these lines will find Mr. Parker's paper extremely valuable.

"The Constitution of Brasses Containing Small Percentages of Tin," by Dr. Hudson and R. M. Jones. This paper deals with the constitution of the ternary alloys containing from 50 to 70 per cent. of copper and 0·5 per cent. of tin. The ranges in which the various constituents can exist, at temperatures below the lowest thermal critical points of the alloys, have been determined, and the results are embodied in a constitution diagram. Most of the alloys fall into one of the two following groups: (1) Those in which the tin is held in solid solution, and consequently possess the normal structure of the copper-zinc series, and (2) those in which a constituent is present, which is similar to the δ of the copper-tin alloys.

"A Thermostat for Moderate and High Temperatures." The authors of this paper, J. L. Haughton and D. Hanson, describe a simple and much-needed apparatus which they have designed for keeping constant temperatures for long periods. The records illustrated in the paper show that the apparatus is highly satisfactory. By using fused silica in the place of glass it is hoped that the effective range of temperature will be considerably extended.

"Metallic Crystal Twinning by Direct Mechanical Strain." In this paper Prof. C. A. Edwards gives evidence which proves that certain metallic crystals are twinned when subjected to mechanical deformation without the intermediate operation of annealing. In the case of tin the twinning is very marked, even at the temperature of liquid air. Diagrams are shown to illustrate the possible mechanism of twinning, and from a consideration of these it is concluded that amorphous layers are produced on the twinning planes.

"The Micro-chemistry of Corrosion," by Dr. Desch and H. Hyman. The corrosion of gun-metals has been examined by the electrolytic method. The presence of tin decreases the rate of corrosion by forming a layer of basic salts which act as a protective coating on the metallic surface. Coarsening the structure by annealing increases the corrosion. A pure alpha alloy is more readily acted upon than one which contains the eutectoid, but the presence of the beta, obtained by quenching, has very little effect.

ON THE FUNCTIONS OF THE CEREBRUM.[1]

THE first of these papers is a study of thirty-eight cases of insanity (dementia præcox, general paralysis, arteriosclerotic dementia, and senile dementia) and their autopsies. It is pointed out that entirely different symptoms (hallucinations, delusions, loss of memory, disordered conduct) may occur in different patients, although the associated cortical atrophy may occur in precisely the same areas; also that the same symptoms may occur in different patients in whom the cortical atrophy is subsequently found to be in different areas. The author, however, ignores the fact that different *layers* of the cerebral cortex are affected in the different diseases.

The second paper is the result of an experimental study of cerebral localisation in monkeys. It is there pointed out that any given cortical motor centre (the leg area, for example) differs in size and shape in different animals of the same species, in the two hemispheres of the same animal, and even in the same hemisphere at different times. For instance, it is found that the arm can sometimes be stimulated from a spot in the middle of the leg area, sometimes not. From these data Dr. Franz draws conclusions as to certain possible connections between neurons. We are quite prepared to go even as far as this with him; but when he offers these neural arrangements as an explanation of "the variations of behaviour of different animals and of the same animal at different times to the same form of stimulation," we must join issue. Not so much that Dr. Franz's suggestions are incorrect from a neurological point of view

[1] (1) "Symptomatological Differences Associated with Similar Cerebral Lesions in the Insane." (2) "Variations in Distribution of the Motor Centres." By Shepherd Ivory Franz. (Princeton, N.J.: *Psychological Review* Co.)

as that they are insufficient to satisfy the requirements of psychology.

Both these papers are too materialistic, and take no notice of modern psychological research, which has demonstrated the paramount importance of *experience* in determining modes of reaction. This is especially remarkable in a publication issued in a series of "Psychological Monographs" by the "*Psychological Review* Company," of Princeton, N.J.

GEOLOGY AT THE BRITISH ASSOCIATION.

THE address of the President, Prof. Grenville A. J. Cole, was a brilliant and stimulating commencement to the proceedings of this section. Following it came an interesting address by Dr. George Hickling on the geology of Manchester and district, in which he pointed out the excellent position of Manchester, both geographically and geologically, situated at the junction of the red beds and the coal measures, with a great variety of opportunities for field-work in the neighbouring Pennine Chain. Prof. E. J. Garwood followed with a paper on the discovery of Solenopora and Sphærocodium in the Silurian rocks of Britain. Up to the delivery of his presidential address at Birmingham these organisms had not been found in Silurian rocks, but careful search has now proved that Solenopora occurs both in the Wenlock and Woolhope limestones. In areas on the borders of Herefordshire and Radnorshire had been found crystalline limestones, upwards of 80 ft. thick, containing remarkable developments of these and similar algal growths, amongst which were the remains of Girvanella and Sphærocodium, the latter genus being now recorded for the first time from rocks in Britain.

Prof. W. Boyd Dawkins contributed two papers. The first was on the classification of the Tertiary strata by means of the Eutherian mammals, based on their evolution. The most important break in the succession of life-forms occurs at the close of the Oligocene period, since when there is a marked continuity showing that the present face of the earth is merely the last in a long succession in the Tertiary period. His second paper dealt with the geological evidence in Britain as to the antiquity of man. He agreed with Prof. Boule in regarding the evidence of the rostro-carinate eoliths found in East Anglia as of doubtful value. The Ipswich skeleton was obtained from a shallow pit of decalcified boulder clay (not boulder clay *in situ*) into Glacial sands, and was, he believed, a case of interment which might be of any age from neolithic to modern times. In the case of the Piltdown skull, he fully accepted Dr. Smith Woodward's opinion that the find belongs to the early Pleistocene period. The evidence indicated that man appeared in Britain and the Continent at the period when he might be expected to appear from the study of Tertiary mammalia—at the beginning of the Pleistocene age, when the existing Eutherian mammalian species were abundant. He may be looked for in the Pliocene, but in the older strata he can only be represented by an ancestry of intermediate forms.

On September 9 a joint discussion was held with Section E on the classification of land forms, which will be reported in the records of that Section. Afterwards Canon Bonney gave some notes on new sections in Charnwood Forest. Considerable quarrying had thrown light on sections previously described, which had caused him to modify his previous views. He was now convinced that the dominant Bardon breccia was really a very exceptional case of fluxion breccia. Prof. W. W. Watts followed with notes on the granite surfaces of Mount Sorrel. It had been suggested that some of the ground and polished surfaces known in this area and in certain other Midland localities might be due to wind action in Pleistocene times. A recently discovered section at Mount Sorrel showed glacial striæ crossing wind grooves at a high angle, proving that the Triassic wind grooves had survived actual glaciation.

Dr. A. H. Cox and Mr. A. K. Wells contributed an account of investigations on the Ordovician sequence in Cader Idris. Re-examination of the area had shown that the older views of the igneous rocks of this area, as all of Arenig age, must be modified. Four distinct volcanic centres in the Ordovician series had now been discovered. Prof. W. G. Fearnsides presented a preliminary account of investigations to prove the underground contours of the Barnsley seam of coal. The sites were plotted on a half-inch map, the depths to the coal were corrected for height above sea-level, and contour lines had been drawn among the spot-levels so obtained. From an analysis of the underground contours of the Barnsley bed, it is found that its strike lines generally range from N.E.–S.W. or N.W.–S.E., it being difficult to find either a N.–S. or E.–W. strike constant over more than a few miles of country. The greatest structural division of the coalfield basin is by the equivalent of a N.E.–S.W. anticline, of which the southern limb is along the line of the Don faults from Sheffield to Doncaster. North of this line there is some evidence of a syncline with its axis central near Frickley. The inclination of the Barnsley bed is steepest near the outcrop, the measures flattening out when the central line of the syncline is approached. The map indicates the interdependence of underground structure and topographical relief.

On September 10 both morning and afternoon meetings of the Section were required to complete the programme. The morning session commenced by a description by Prof. J. W. Sollas of reconstructions of fossils by serial sections, illustrated by several remarkable models of restorations of a graptolite, a primitive fish, the skull of a reptile from the Karoo, and the skull of *Ichthyosaurus communis*, from Lyme Regis. The last-named was 520 mm. in length, and had been studied in 520 sections taken at equal intervals apart, and revealed in remarkable detail the internal structure of the head. Prof. R. C. Wallace, of Manitoba, described the brine springs of that area, which issue from the Middle and Upper Devonian limestones, and circulate in the Dakota limestone at the base of the Cretaceous, depositing salt at certain dolomitic horizons. The salt flats where the springs reached the surface were devoid of vegetation and studded with ice-carried boulders, granite, gneiss, etc., which have suffered intense chemical disintegration. Ferromagnesian minerals have been most intensely affected. The causes of this special disintegration, as compared with that of sea-water, were discussed. The boulders were partially submerged and films of liquid were maintained on the surface, in contact with atmospheric oxygen. Owing to partial adsorption by colloids an acid residual solution was produced, which is a powerful corrosive agent.

Dr. Albert Wilmore dealt with the Carboniferous limestone zones of N.E. Lancashire, describing the sequence found in the neighbourhood of Clitheroe and the Knoll district. Mr. H. Day referred to observations on a collection of fossils from Treak Cliff and Peakshill, Castleton, and discussed the value of the brachiopods and corals as zonal determinations, when compared with those of the Bristol area. He concluded that any system of zonal indices could be of local value only, and not of general application. Dr. Arthur Vaughan, who was recovering from a serious illness, dealt with the shift of the western shore-line in England and Wales during the Avonian period. He concluded that a land mass stretching from Wales to Wicklow formed a barrier during the Avonian period between a "N.W. channel," reaching to the Isle of Man and the Lake district, and a "S.W. channel," which was an extended Bristol Channel. This barrier formed the land-crest between these two channels during the whole of Viséan time, and had a dominant trend from Anglesey to Dudley. The whole neck of land which contained the barrier and separated the "channels" shifted steadily southwards as Viséan time proceeded, owing to the advance of the sea on its northern side and its retreat on the south. The remarkable similarity of the Viséan sequence north and south of this barrier indicated free sea communication round its western margin, along which the sea remained persistently coastal during the period.

Dr. Albert Jowett contributed a preliminary note on the glaciation of the western slopes of the southern Pennines. No striated surfaces of solid rock had been found at high levels, and for detailed information of the ice-movement we had to depend on striations at Salford and Fallowfield, on the distribution of drift at high levels, and on the systems of drainage along the edge of the ice. These indicated a general movement from N.W.–S.E. The first barrier of hills met with on approaching the Pennines from the South Lancashire and Cheshire plain was almost everywhere overridden with ice, which left definite deposits of drift with foreign rocks up to 1360 ft., and scattered erratics up to 1400 ft. This drift had been traced across the main Pennine divide near Chapel-le-Frith (1100 ft.). Great lakes were held up by the ice-barrier some time after it commenced to retreat from the western slope of the Pennines. During early stages of the retreat the drainage from the lakes in and north of the Etherow valley escaped northwards, and ultimately discharged through the Walsden gap into the Calder. When the ice-barrier east of Manchester fell below 600 ft., this drainage followed the course of that south of the Etherow valley and escaped southwards.

The afternoon meeting commenced with a discussion on radio-active problems in geology. Sir E. Rutherford opened the discussion by putting the problem from the point of view of the older geologists, with their comparatively low estimate of the age of the earth, though higher than physicists of those days were inclined to concede. The discovery of radium had greatly modified the position, and the age of the earth, based on evidence of radio-activity, was very much higher than the estimates accepted by geologists. The problem was how to reconcile geological facts with these new physical determinations. Sir Ernest Rutherford was inclined to believe that the larger estimates were nearer correct than the smaller.

Prof. J. Joly faced the problem from the viewpoint of the geologist on the assumption that geologists were agreed on the matter. He made several suggestions which might have the effect of reducing the large numbers derived from the study of radio-active materials.

Prof. Soddy hoped that geologists would not be in any immediate hurry to decide between the geological and radio-active estimates of the age of the earth. Owing to the element of uncertainty about the initial stages of the disintegration and the long periods involved, there was a great *terra incognita,* and the new theory of isotopes made it necessary to take into account many possibilities not thought of a couple of years ago. In addition there was always the possibility that thorium might be a branch of the uranium family, in which case some of the arguments that had been used entirely fell to the ground. While he saw no successful method at present of altering the *general* order of the radio-active estimate, he did not regard it as more than tentative, and there might well be unknown factors of sufficient importance to bring the two methods into closer agreement in the future. Dr. J. H. Teall, Prof. Sollas, and Dr. J. W. Evans continued the discussion.

Prof. C. A. Edwards described the results of experiments producing twinning in metallic crystals. His remarks were illustrated by an interesting series of lantern slides. Dr. J. W. Evans followed with a description of the different methods by which the interference figures of a small mineral in a rock slice could be kept distinct from those of the adjoining minerals. He discussed various methods of using a diaphragm with the Becke combination of lenses, and condemned the common practice of placing the diaphragm for this purpose immediately below the Bertrand lens.

Dr. G. Hickling contributed a paper on the microstructure of coal, illustrated by a series of beautiful lantern slides, showing remarkable success in dealing with very difficult material. He concluded that coal was essentially a "replacement" deposit consisting of an original peat-like mass of vegetable *débris,* in which the substance of the component tissues has been largely or wholly replaced by the liquid decomposition products of other vegetation. The concluding paper was by Mr. Thomas Crook, describing the economic mineral products of Damaraland, S.W. Africa, and emphasising their value. Several research committees were reappointed; and new committees were appointed to investigate rocks of Old Red Sandstone age at Rhynie, Aberdeenshire, and of Lower Carboniferous age at Gullane, Haddingtonshire. The sectional work concluded with a field excursion to Edale and Castleton. The surprise of the week was the magnificent weather, which made a successful meeting also a delightful memory.

W. L. C.

CORRESPONDING SOCIETIES AT THE BRITISH ASSOCIATION.

THE first meeting of the Conference of Delegates was held on September 8, and it was announced that the General Committee of the British Association had altered the titles of officers of the Conference from Chairman and Vice-Chairman to President and Vice-President, thereby giving them the same status as those of the Sections. Sir Thomas Holland delivered his opening address, entitled "The Classification of Scientific Societies," which was printed in NATURE of September 16.

The first subject for discussion was "Local Museums," suggested by the Selborne Society, and introduced by Dr. W. E. Hoyle. He laid it down that the first and fundamental function of a museum was to preserve. Museum officials are nowadays given so much advice about the desirability of making our exhibits æsthetically attractive, of compiling explanatory labels which shall at the same time instruct the specialist and interest the casual visitor, and of catering for school children, that they are, he said, in danger, perhaps, of forgetting that their paramount duty is to see that "neither moth nor rust doth corrupt" and that "thieves do not break through nor steal."

He gave a definition of a local museum, the first duty of which, he maintained, was to preserve the things of interest pertaining to the locality. Then he touched upon the important and delicate question of the relations which ought to exist between the local museum and the national museum. Difficulties arose when it was required to determine in particular cases what objects were of national importance and should be preserved in a national museum.

After the first function of a local museum had been adequately discharged, Dr. Hoyle thought that if means and opportunities allowed, collections should be provided which gave the visitor a preliminary sketch of some department of knowledge. He alluded to "index" collections, though he thought the term "introductory" collections would be more appropriate. Dr. Hoyle had something to say with regard to the coming into touch of the museum with the educational system of the locality, and he saw nothing out of place in a local museum developing a special subject quite disconnected with the locality if it had the power to do so without interfering with its proper work.

In the discussion which followed, Dr. Bather touched upon principles which should guide local curators in their selection of what should be considered of national and local interest. Type specimens should be placed in museums where they would be well looked after. Moreover, researchers, though they would naturally seek for local objects, such as fossils, in a local museum, ought not to have to look for, say, New Zealand fossils, through all the museums of the British Isles.

Dr. Marie C. Stopes thought that there might be a balance of good in decentralising collections, even of type specimens, for the visiting of local museums brings a stimulus to the local people, and widens and humanises the interests of specialists.

It seemed evident from other remarks that if local museums are to be properly educational, in the general sense of the word, there should be special institutions or special sections of existing museums with their own organisation, so as not to burden curators unduly.

Prof. Geddes directed attention to the survey of Greater London now being carried out by the Architects' War Committee, which deserved the co-operation of museums and natural history societies.

The second meeting was held on Friday, September 10. As a result of the importance of the presidential address, and the interest which had been taken in its suggestions, the vice-president, Mr. William Whitaker, moved a resolution in the following terms:—"That this conference invites the attention of the Corresponding Societies' Committee to the president's opening address, in which suggestions are made for reforming the existing, varied, and unorganised practice of publishing original papers." An outline was given of ways in which this might be done, and the resolution was carried.

The second subject for discussion was "Colour Standards," suggested by the British Mycological Society, and introduced by Mr. J. Ramsbottom. He described and illustrated a number of the schemes which had been formulated with the object of obtaining some uniformity of colour description in the many branches of natural science. Recent attempts at colour standards have each something against their general adoption, and, except for horticulturists, mycologists, and possibly ornithologists, they are much too full. It would seem best to have a well-arranged list of two hundred well-named colours for ordinary use, which colour scheme could be amplified in those branches of science where needed.

In this case, also, a good discussion was aroused, and as it was pointed out that the work of preparing such a series of colour standards for scientific and commercial uses, though of interest to many of the committees of the Association, was not the province of any one of them, a resolution was passed referring the matter to the Corresponding Societies' Committee.

In many ways the Conference of Delegates at Manchester was the most successful that had been held in this country for a considerable time.

WILFRED MARK WEBB.

SECTION B.

CHEMISTRY.

OPENING ADDRESS[1] BY PROF. WILLIAM A. BONE, D.Sc., F.R.S., PRESIDENT OF THE SECTION.

THIS year is, as many of you are doubtless aware, the centenary of Davy's invention of the miner's safety lamp which formed the starting point of his brilliant researches upon flame, in which he disclosed, and brought within the range of experimental inquiry, most of the intricate and baffling problems connected with the fascinating subject of gaseous combustion. Also the ground on which we meet to-day is known to the whole scientific world as the place where, during more than a quarter of a century of continuous investigation, a succession of Manchester chemists, led and inspired by Prof. H. B. Dixon, have devoted themselves to the elucidation of the many problems which Davy's work foreshadowed. Therefore, both in point of time and place, the occasion is singularly appropriate for a review of recent advances in this important field of scientific inquiry.

At the Sheffield meeting of the Association in 1910, I had the honour of presenting to a joint conference of Sections A and B (Physics and Chemistry) a report summarising the then "State of Science in Gaseous Combustion,"[2] which gave rise to a keen and stimulating discussion, and was not only printed *in extenso* in the annual reports for that year, but was also widely circulated through the medium of the scientific and technical Press. There is no need, therefore, for me to refer in any detail to the results of researches already dealt with in that report. I can more usefully devote part of the time at my disposal to supplementing it with a review of more recent researches, which have considerably extended our knowledge in many directions.

Gaseous Combustion: Ignition Phenomena.

The first section of my 1910 report was concerned with ignition temperatures and the initial phases of gaseous explosions; and it is in connection with ignition phenomena that subsequent progress has been most marked.

For the ignition of a given explosive mixture, it is necessary that the temperature of its constituents should be raised, at least locally, to a degree at which a mass of gas self-heats itself by combination until it bursts into flame, or, in other words, to a degree at which the chemical action becomes autogenous or self-propelling, so that it quickly spreads throughout the whole mass. This particular degree, or in some cases range, of temperature is commonly spoken of as the ignition-point of the mixture; but in using the expression, certain qualifications should be carefully borne in mind. In the first place, as H. B. Dixon and H. F. Coward showed in 1909,[3] whereas when certain combustible gases—such, for example, as hydrogen and carbon monoxide, the mechanism of the combustion of which is probably of a fairly simple character—and air or oxygen are separately heated in a suitable enclosure before being allowed to mix, the temperature at which ignition occurs lies within a

1 Abridged by the author.
2 See *Journal of Gas Lighting*, vol. cxi., p. 648.
3 *Ibid.*, vol. cvii., p. 323.

very narrow range, which is, within the limits of experimental error, the same for both air and oxygen (*i.e.* in the case of hydrogen it is 580° to 590°, and for carbon monoxide 640° to 658°). On the other hand, in cases where the mechanism of combustion is known to be very complex (*i.e.* hydrocarbons), the ignition range is either fairly wide or else is materially lower in oxygen than in air (or both). Thus—

	In air	In oxygen
Methane ...	... 650°–750° ...	556°–700°

The explanation of such behaviour is probably to be sought in the known complexity of the combustion, and the marked tendency for appreciable and fairly rapid interaction between the inflammable gas and oxygen before the actual ignition-point is reached. If, by any means, such preliminary interaction could either be entirely suppressed, or if, on the other hand, it be very rapid in character, the observed "ignition range" would be narrowed, as is actually the case with ethylene (542° to 547° in air, and 500° to 519° in oxygen).

There are two other means by which an explosive mixture may be ignited. One is by adiabatic compression, and the other, and most commonly employed of all, is by the passage of an electric spark. The adiabatic compression of an explosive mixture was originally suggested by Nernst as a means of determining its ignition-point, provided (1) that ignition is not produced locally, while the main temperature of the gas is still far below the true ignition temperature; (2) that the piston of the apparatus does not move appreciably after the gas has been raised to its ignition-point. At the time of my 1910 report, Falk, in America, had applied the method in the case of hydrogen and oxygen mixtures, with results which, in the light of more recent work, would appear to have been misleading or erroneously interpreted. Thus, for instance, he found that of all the mixtures of hydrogen and oxygen, the equimolecular H_2+O_2 mixture has the lowest ignition temperature (514°), from which he concluded that the gases react initially to produce hydrogen peroxide rather than steam. Such a conclusion, which I believe to be erroneous, naturally directed attention to the experimental method involved.

The subject was promptly taken up here, in Manchester, by H. B. Dixon and his co-workers,[4] with the result that much new light has been thrown on the phenomena accompanying ignition. The ratio of the ignition temperature to the initial temperature of the mixture before compression, both expressed in degrees absolute (T_2/T_1), may be calculated from the compression ratio (V_1/V_2) by means of the well-known formula for adiabatic compression :

$$\frac{T_2}{T_1}=\left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

where γ=the ratio of the specific heats at constant pressure and volume, respectively, of the mixture compressed, and which for a mixture of diatomic gases, such as hydrogen and oxygen, is usually taken as 1·40.

Dixon's recent photographic analysis of the appearance of flame when mixtures of carbon bisulphide and oxygen (CS_2+3O_2) are adiabetically compressed, have proved that the flame, starting from a point or layer, always takes an appreciable time to spread through the mixture, and that unless special precautions are taken to arrest the piston at the moment of its attainment of the ignition condition, it may be driven in much further than the minimum distance for ignition.

[4] H. B. Dixon, L. Bradshaw, and C. Campbell, Trans. Chem. Soc., 1914, pp. 105, 2027 ; H. B. Dixon and J. M. Crofts, *ibid.*, p. 2036.

The real ignition-point, as above defined, is not necessarily synchronous with the actual appearance of the flame. There may be, and usually is, an appreciable "pre-flame" period. Only in the fastest burning mixtures is this period negligible; hence the necessity of artificially stopping the movement of the piston at the beginning of the period—a precaution which Falk seems to have neglected.

According to Dixon and Croft's recent determination by this method of the ignition-points of mixtures containing electrolytic gas, whereas successive additions of hydrogen or nitrogen progressively raise the ignition temperature of the undiluted gas by regular increments, as would be supposed, successive additions of oxygen, on the other hand, lower it, as a glance at the following table will show :—

Ignition Points of Mixtures Containing Electrolytic Gas by Adiabatic Compression.

(H. B. Dixon and J. M. Crofts, 1914.)

Electrolytic Gas, $2H_2+O_2=526°$

$+x\ H_2$		$+x\ N_2$		$+x\ O_2$
x=1 ... 554°	...	x=1 ... 537°	...	x= 1 ... 511°
x=2 ... 561°	...	x=2 ... 549°	...	x= 7 ... 478°
x=4 ... 602°	...	x=4 ... 571°	...	x=15 ... 472°
x=8 ... 676°	...	x=8 ... 615°		
(526+18 x)°	...	(526+11 x)°		

The observed raising effects of successive dilutions with hydrogen and nitrogen call for no comment, save that the relatively greater effect of hydrogen as compared with nitrogen may be attributed to its greater thermal conductivity; but the lowering effect of oxygen is indeed puzzling, and its meaning can only be conjectured. Dixon and Crofts have suggested that it may be due either to the formation of some active polymeride of oxygen under the experimental conditions, which seems to me doubtful, or that the concentration of oxygen in some way or other brings about increased ionisation of the combustible gas. This at once raises the larger question of whether or not ignition is a purely thermal problem, as until recently has generally been supposed

Prof. W. M. Thornton, of Newcastle-upon-Tyne, recently published some very suggestive work on the "Electrical Ignition of Gaseous mixtures,"[5] which, apart from its theoretical interest, has an important bearing on the safety of coal mines where electrical currents are used for signalling and other purposes.

The common belief that any visible spark will ignite a given explosive mixture of gas and air is, of course, quite erroneous; for just as Coward and his coworkers have shown that for a given explosive mixture and sparking arrangement there is a certain limiting pressure of the gaseous mixture below which ignition will not take place, so from Thornton's work it would appear that a definite minimum of circuit energy is required before a given mixture at given pressure can be ignited by a spark. And, moreover, he has stated that the circuit energy required for the spark ignition of a given mixture (say) of methane and air is something like fifty-six times greater with alternating than with continuous current at the same voltage. From this he has argued that the igniting effect cannot be simply thermal, but must be in part at least ionic. This conclusion he further supports with the statement that the igniting power of a unidirectional current is proportional to the current in the case of many gaseous mixtures over an important part of their working range of inflammability.

While there is much that is suggestive in Thornton's work, there is also a good deal which seems

[5] Proc. Roy. Soc., A, vol. xc., 1914, p. 272 ; vol. xci., 1914, p. 17.

very difficult to interpret from a chemical viewpoint. I here refer more particularly to his later supposition of "stepped ignition," which is based upon certain observed abrupt increases in the minimum igniting current required with condenser discharge sparks as the proportion of combustible gas in the air mixture examined progressively increases. In other words, it is claimed that continuous alteration of the proportions of gas and air in an explosive mixture is, or may be, accompanied by discontinuous alterations in the spark energy required for ignition. I must confess that, after careful examination of the published curves, I am quite at a loss to give them any chemical interpretation, and to being somewhat sceptical about the supposed "stepped ignition." A repetition and extension of Prof. Thornton's experiments would be most valuable as a means to a better understanding of the conditions of spark ignition.

Influence of Electrons upon Combustion.

During the discussion upon my 1910 report, Sir J. J. Thomson reminded us chemists that combustion is concerned, not only with atoms and molecules, but also with electrons moving with very high velocities. They might be a fact of prime importance in such intensive forms of gaseous combustion as are realised in contact with hot or incandescent surfaces, as also in the explosion wave. It is well known, of course, that incandescent surfaces emit enormous streams of electrons travelling with high velocities, and the actions of such surfaces may be due to the formation of layers of electrified gas in which chemical changes proceed with extraordinarily high velocities. Again, the rapidity of combustion in the explosion wave might, he thought, conceivably be due to the molecules in the act of combining sending out electrons with exceedingly high velocities, which precede the explosion wave and prepare the way for it by ionising the gas.

With regard to this interpretation of the action of surfaces, Mr. Harold Hartley carried out a promising series of experiments in my laboratory at Leeds University upon the combination of hydrogen and oxygen in contact with a gold surface, which lend some support to the idea. But they require further extension before it can be considered as finally proved. It is my intention in the near future to resume the systematic investigation of the matter as rapidly as circumstances permit; but the experimental difficulties are formidable, and the mere chemist working by himself may easily be misled. We badly need the active co-operation of physicists in elucidating the supposed *rôle* of electrons in combustion.

Prof. H. B. Dixon and his pupils have, at Sir J. J. Thomson's suggestion, recently tested the idea as applied to the explosion wave, with, however, negative results.[6] It is known, of course, that the motion of the ions can be stopped at once by means of a transverse magnetic field, in which they curl up, and are caused to revolve in small circles; and the question which Prof. Dixon decided to put to the test of experiment was whether the damping of the electronic velocities in a powerful magnetic field would have any appreciable effect either upon the initial phase of an explosion or upon the high velocity of detonation. But though he employed a very intense magnetic field produced by some powerful magnets specially constructed by Sir Ernest Rutherford for the deflection of electrons of high velocity, no appreciable effect was observed upon the character or velocity of the flame with any gas mixture at any stage of the explosion. And inasmuch as the high constant velocity of the explosion wave can be entirely accounted for on the theory of a compression wave liberating the chemical energy as it passes through the gases, there seem as yet to be no experimental grounds for attributing it to the ionising action of electrons.

The Initial Period of "Uniform Movement" or "Inflammation" of Flame through Inflammable Mixtures, and Limits of Inflammability.

Mallard and Le Chatelier, in their classical researches upon the combustion of explosive mixtures, discovered that the propagation of flame, when such a mixture is ignited in a horizontal tube, differs according as whether the ignition occurs near the open or closed end of the tube. In the first case, the flame proceeded for some distance down the tube at a practically uniform and fairly slow velocity, corresponding to the true rate of propagation "by conduction." This period of uniform movement is succeeded by an irregular oscillatory period, in which the flame swings backwards and forwards with increasing amplitudes, finally either dying out altogether or else giving rise to detonation. With certain oxygen mixtures, the initial period of uniform slow velocity was shorter, and appeared to be abruptly succeeded by detonation without the intervention of any oscillatory period. When, however, such mixtures were ignited near the closed end of a horizontal tube, the forward movement of the flame was continuously accelerated from the beginning, under the influence of reflected compression waves, until detonation was set up. Such, in general, was the sequence of the phenomena that were observed by these distinguished French investigators.

They proceeded to determine experimentally the velocities of the uniform slow movement of the flame in the case of a number of air and combustible gas mixtures, and plotting their results (in cms. per sec.) as ordinates against percentages of inflammable gas as abscissæ, they obtained "curves" which were in each case formed of two inclined straight lines converging upwards to a point which represented the composition and flame velocity of the most explosive mixture. And they concluded that the points at which the downward production of the two lines met the zero velocity line would define the upper and lower limits of inflammability for the particular series of gas-air mixtures. Thus the curve they obtain for methane-air mixtures showed a maximum velocity of 61 cms. per second for a mixture containing about 12·2 per cent. of methane, with lower and upper limits corresponding to 5·6 and 16·7 per cent. of methane respectively.

An exact knowledge of the velocities of flame propagation during this initial period of uniform slow movement, as well as of the limits of inflammability for mixtures of various combustible gases and air, is very important from a practical point of view. Makers of apparatus for burning explosive mixtures of gas and air want to know the speed of flame propagation through such mixtures, not only at ordinary temperatures and pressures, but also when the mixtures are heated and used at higher pressures. Also, it would be important to know whether or not, in the case of a complex mixture of various combustible gases and air, when complete composition can be determined by analysis (as, for example, coal gas and air), the velocity of flame propagation can be calculated from the known velocities for its single components. Unfortunately, although more than thirty years have elapsed since Mallard and Le Chatelier's work was published, the necessary data are still wanting to answer such questions; and anyone who will systematically tackle the problem and carefully work

6 Proc. Roy. Soc., 1914, Section A, vol. xc., p. 506.

it out in detail will be doing a real service to the gas-using industry.

An accurate knowledge of the behaviour of methane-air mixtures under known variations of conditions is of prime importance from the point of view of the safety of coal mines, and it is rightly occupying the attention of my friend and former collaborator, Dr. R. V. Wheeler, at the Home Office Experimental Station at Eskmeals. From papers which he has already published, as well as from some unpublished results which he has very kindly permitted me to refer to in this address, it is now possible to correct certain errors in Mallard and Le Chatelier's results, and to arrive at a clear view of the phenomena as a whole.

In the first place, it would appear that the initial "uniform movement" of flame in a gaseous explosion, or, in other words, propagation of the flame from layer to layer by conduction only (as defined by Le Chatelier) is a limited phenomenon, and is only obtained in tubes of somewhat small diameter—wide enough, however, to prevent appreciable cooling of the flame, but narrow enough to suppress the influence of convection currents. Moreover, ignition must be either at or within one or two centimetres of the end of the tube; otherwise—particularly with the more rapidly moving flames—vibrations may be set up right from the beginning.

While all methane-air mixtures develop an initial uniform slow flame-movement period when ignited at, or near, the open end of a horizontal tube, both its linear duration as well as the flame velocity are not, according to private information which Dr. Wheeler has sent me, independent of the dimensions of the tube. The speed of flame increases with the diameter of the tube; and the linear duration of the uniform period increases with both the diameter and length of the tube up to a certain maximum, after which increased length probably makes no appreciable difference. Also, for the same tube, it varies with the proportion of methane in the explosive mixture—being greater as the speed of the flame diminishes, until with the two "limiting" explosive mixtures it appears to last almost indefinitely.

Dr. Wheeler's recent re-determination of the velocities of the flame movement during this initial uniform period for mixtures of methane and air in varying proportions within the limits of inflammability, has revealed serious errors in Mallard and Le Chatelier's original results for horizontal tubes of the same diameter as those which Dr. Wheeler has employed. Moreover, Mallard and Le Chatelier's method of determining the composition of the upper and lower limits of inflammability by extrapolation from their curves has been proved to be unwarranted. Dr. Wheeler considers the length of the tubes used by Mallard and Le Chatelier (1 metre only) was insufficient to ensure that the speed measurements of the initial uniform flame-movement period were unaffected by the subsequent "vibratory period." Also, the methane used by them, prepared as it was from sodium acetate, would obviously be impure. According to Wheeler, the limits of inflammability for horizontal propagation of flame in methane-air mixtures, at atmospheric temperature and pressure, correspond to 5·4 and 14·3 per cent. methane contents, respectively.

Messrs. Burgess and Wheeler have recently determined the limits of inflammability of methane when mixed, at atmospheric temperature and pressure, with "atmospheres" of oxygen and nitrogen containing less oxygen than ordinary air. From their results (see below) it would appear that, as the oxygen content of the atmosphere is reduced, the limits of inflammability are narrowed until they coincide when the oxygen content falls below 13·3 per cent., which means that an atmosphere containing 13·3 or less per cent. of oxygen is truly extinctive for a methane flame at ordinary pressures.

Atmosphere		Methane, per cent.	
Oxygen	Nitrogen	Lower limit	Higher limit
20·90	79·10	5·60	14·82
17·00	83·00	5·80	10·55
15·82	84·18	5·83	8·96
14·86	85·14	6·15	8·36
13·90	86·10	6·35	7·26
13·45	86·55	6·50	6·70

Behaviour of Weak Mixtures of Gases and Air.

My review of this part of the subject would be incomplete without a reference to some interesting observations which have been made by Dr. H. F. Coward and co-workers at the Manchester School of Technology, upon the behaviour of weak mixtures of various inflammable gases and air, at, or just below, the lower limit of inflammability in each case.[7] Their principal experiments were carried out in a rectangular box of 30 cm. square section and 1·8 metres length, with two opposite sides of wood, and the other two of plate glass. The box was placed in an upright position, the bottom being water-sealed and the top closed, with a suitable igniting device placed near the bottom. They have shown that caps or vortex rings of flame may be projected for some distance upwards from the source of ignition—sometimes apparently for an indefinite distance—without igniting the whole of the combustible mixture. In such mixtures there may be an indefinite upward slow propagation of flame, together with incompleteness of combustion, much of the combustible mixture remaining unburnt, and the question very naturally arises as to how the term "inflammability" should be scientifically defined. Dr. Coward has argued, with some force, that a gaseous mixture should not be termed "inflammable" at a given temperature and pressure, unless it will propagate flame indefinitely—the unburnt portion being maintained at that temperature and pressure. Inflammability thus defined would be a function of the temperature, pressure, and composition of a particular mixture only, and would be independent of the shape and size of the containing vessel; and, provided that it is kept in mind that for each particular mixture at a given temperature and pressure a certain minimum igniting energy and intensity is requisite, I am inclined to agree with the definiton. Also, there is a possibility that in a mixture just at, or very near, one or other of the limits of inflammability, flame may be propagated upwards, but not downwards.

From his experiments, Dr. Coward has assigned the following as the lower limits of inflammability of hydrogen, methane, and carbon monoxide respectively, in air at atmospheric temperature and pressure:—

	Per cent.
Hydrogen	4·1
Methane	5·3[8]
Carbon monoxide	12·6

Recent Investigation upon the Combustion of Hydrocarbons and the Relative Affinities of Methane, Hydrogen, and Carbon Monoxide respectively for Oxygen in Flames.

(This part of the address, which was read as a separate paper, reviewed the principal results of an investigation by Prof. Bone and collaborators on

[7] Trans. Chem. Soc., 1914, vol. cv., p. 1859.

[8] Too much stress need not be laid upon the difference between this number and the 5·6 per cent. given by Dr. Wheeler (*loc. cit.*), because Dr. Coward himself admits that the flames of mixtures containing from 5·3 to 5·6 per cent. of methane are very sensitive to shock; while a 5·6 per cent. mixture will always propagate flame indefinitely, even when there is a moderate disturbance. The conditions must be exceedingly tranquil to prevent extinction in the other cases.

"Gaseous Combustion at High Pressures," recently published *in extenso* in Phil. Trans. Roy. Soc., A, vol. ccxv. (1915), pp. 275 to 318.)

Fuel Economy and the Proper Utilisation of Coal.

Leaving now the scientific aspects of flame and combustion, I wish to say a few words as a technologist upon the great national importance of a more adequate scientific control of fuel consumption and the utilisation of coal generally, with special reference to the situation created by this terrible and ruinous European conflict. And my remarks will be addressed in part to my chemical friends and colleagues, who are primarily interested in scientific research and its industrial applications, and in part also to the commercial and manufacturing community which is chiefly interested in the financial results of such scientific activity.

Notwithstanding the fact that we are raising annually in the United Kingdom—according to the official estimate for 1913—287 million tons of coal, of which 189 million tons (or, say, 4 tons per head of the population) were consumed at home, more or less wastefully, it is indeed surprising how little has been done, or is being done, by the scientific community to impress upon the Government and the public generally the importance of establishing some systematic control or investigation of fuel consumptions in all large industrial areas. Deputations have waited upon the Government about the question of reviving our languishing coal-tar colour industry; so that in future we may be independent of Germany for the supply of the 2,000,000*l*. of dye-stuffs required by our textile industries; and already a State-aided organisation, with an advisory scientific committee, has sprung into existence to achieve this desirable result. But no organised body of men of science, so far as I know, has ever thought it important, or worth while, to take an active interest in the vastly greater subject of fuel economy and the proper utilisation of coal, upon which the dyeing industry depends for its raw material.

It is unnecessary for me to remind you that the contending armies in this Armageddon of the nations depend upon certain distillation products of coal for their supplies of high explosives; and there is little doubt in my mind but that Germany's violation of the neutrality of Belgium, and her subsequent seizure of that country and of a large tract of northern France, had more than a purely political or strategic significance. She, doubtless, wanted also to seize for herself (and at the same time to deprive her enemies of) coalfields lying just beyond her own borders, which are capable of furnishing abundant supplies of coal admirably adapted for yielding the raw materials for the manufacture of high explosives. A country in which all metallurgical coke has for years past been manufactured under chemical supervision in bye-product coking-ovens, with recovery of ammonia, tar, and benzol, and in which the wasteful beehive coking-ovens have long ago ceased to exist, was scarcely likely to overlook the military importance of the Belgian coalfield with its many bye-product coking-plants. And, moreover, but for German commercial acumen and enterprise, during many years past, our own bye-product industry would not have attained even to its present respectable dimensions. Certainly it owes very little to the interest or attention of British chemists, most of whom are, unfortunately, but little aware of its circumstances and conditions, and seem to care even less for its particular problems. And yet, in proportion to the capital outlaid upon it, it is one of the most profitable of all our chemical industries, coal-tar colours not excepted.

Fuel economy, and the proper utilisation of coal, whether in connection with manufacturing operations or domestic heating, will become one of the most important national questions during the trying years that will follow hard upon this war, because of all directions in which national economy can be most healthfully and advantageously exercised, this is perhaps the most obvious and prolific. For it is tolerably certain that, with an efficient and systematic public supervision of fuel consumption, we ought to be able, even with existing appliances, to save many millions of pounds of our annual coal bill, and with improved appliances still more millions—a saving which would in the long run redeem a considerable amount of the war loan which has been much more easily raised than it will be repaid.

Now, I fear that not only are chemists for the most part lamentably ignorant of the nature of coal, and of modern fuel technology, but they have been for many years past so indifferent about such questions that they have been content to leave them almost entirely to engineers, who, as a body, are notoriously deficient in chemical sense and experience. The engineer has, indeed, not usurped the place of the chemist, but has had to do his best to fill the position long since abdicated by the chemist.

This, indeed, seems strange when we remember that the foundations of modern chemistry were deeply laid by investigators who were, above all things, "fire-worshippers." But, judging from most chemical text-books, nearly all that the modern student of chemistry is taught in our academies about combustion was known to Lavoisier; and I question whether in the majority of our university laboratories any investigation on coal or combustion is ever undertaken. And yet the subject is full of most fascinating and fundamental theoretical problems—for the most part unsolved—and the nation consumes every week as much coal as could be exchanged for the whole quantity of aniline dyes used by its textile industries in a year.

Moreover, such advances as have been made during recent years—and they are by no means inconsiderable—have nearly all been in the direction of the wider applications of gaseous fuels. Yet in how many of our university laboratories is even gas analysis taught, or how many of our schools of chemistry provide systematic courses in the chemistry and manipulation of gases, without which no professional training of industrial chemists, however much "research work" it may include, ought to be considered satisfactory? It is my opinion that this important branch of our chemical craft and science has not, for many years past, been accorded its proper place and share of attention in the ordinary curriculum of the majority of our academic institutions.

Of the 189 million tons of coal consumed in the United Kingdom in the year 1913, about 40 million tons, or, say, approximately one-fifth of the whole, were carbonised either in gas works, primarily for the manufacture of towns' gas, or in coke-ovens for the manufacture of metallurgical coke—in practically equal proportions. Two-thirds of the latter was carbonised in bye-product recovery plants; the remainder in the old wasteful beehive ovens. So that, roughly speaking, we have—

Total coal carbonised=40 million tons		
In gas-works	In bye-product coke ovens	In beehive coke ovens
20 ...	13·5 ...	6·5

At present there are 8297 bye-product coke-ovens built in this country, of which 6678 are fitted with benzol recovery arrangements, capable of producing something like 10 million tons of coke per annum.

The yields of the various bye-products obtainable on such coke-oven installations naturally vary with the locality and character of the coal seam; but they probably average somewhat as follows—expressed as percentages on dry coal carbonised:—

District	Ammonium sulphate	Tar.	Benzol and toluol as finished products
Durham ...	0·9 to 1·45	2·5 to 4·5	0·6 to 1·0
Yorkshire ...	1·3 to 1·5	3·5 to 5·0	0·9 to 1·1
Derbyshire ...	1·3 to 1·6	3·5 to 5·0	0·9 to 1·1
Scotland ...	1·4 to 1·6	3·5 to 5·0	0·9 to 1·1
South Wales ...	0·9 to 1·1	2·0 to 3·5	0·6 to 0·75

Or, to put the matter a little differently, each ton of dry coal carbonised yields from 20 to 35 lb. of ammonium sulphate, from 56 to 112 lb. of tar, and from 2 to $3\frac{1}{2}$ gallons of crude benzol, etc.—according to the locality. About 65 to 70 per cent. of the crude benzol is obtained as finished products—benzene, toluene, solvent and heavy naphthas.

How rapid has been the development of the bye-product coking industry in this country during recent years may be judged from the following official returns of the quantities of ammonium sulphate annually made by such plants, as compared with the corresponding quantities produced in gas-works.

Year	Tons of ammonium sulphate produced in: Bye-product coke-oven plants	Gas-works
1903 ...	... 17,435 ...	149,489
1908 ...	... 64,227 ...	165,218
1913 ...	... 133,816 ...	182,180

In the natural course of events, the final disappearance of the wasteful beehive coking-ovens from this country is now only a matter of a few years; but I venture to suggest that public interest would justify the Government fixing, by law, a reasonable time-limit beyond which no beehive coke-oven would be allowed to remain in operation, except by express sanction of the State, and then only on special circumstances being proved.

There is also much need of a better and more systematic chemical control, in the public interest, of bye-product coking plants. At present, in far too many cases, the chemists employed in coke-oven laboratories are men who have practically no chemical training other than that obtained in evening classes. And, with few exceptions, the chemist, however competent he may be, is entirely subordinated to the directing engineer, and regarded as a mere routine analyst. I can say, from personal knowledge, that plants which are managed and controlled by experienced chemists of broad training, combined with force of character, yield much better results than those which are controlled by men without such qualifications.

And even in this crisis when so much depends on plants working, not only at their maximum output capacities, but also, chemically speaking, under conditions calculated to ensure the highest yields of benzol and toluol, with a proper selection of coal, I doubt whether the measures which have been taken to advise and supervise the coke-oven industry are really adequate from the point of view of chemical control. I do know, for instance, that the experience and resources of the majority of our university departments of applied chemistry which specialise on fuel technology and cognate matters have not been as fully utilised as they might have been in this connection. I cannot for one moment imagine a similar state of things being permitted in Germany, where we may be sure that nothing is being left undone in the way of fully utilising all the available expert chemical and engineering knowledge which can be brought to bear on this important aspect of war munitions; and I venture to say that, whatever may be the case in this country, in Germany at least the staff and resources of no publicly maintained department of fuel technology will not be fully employed on war problems.

The coal-gas industry, which deals with some twenty million tons of coal per annum, has, especially within recent years, shown a growing appreciation of the aid of chemical science, in regard not only to the actual manufacture, but also to the domestic and industrial uses of coal gas. The endowment by the industry, in 1910, of a special chair at the Leeds University, in memory of the late Sir George Livesey (of which I had the honour and pleasure of being the first occupant), was a sure sign of the faith of its leaders in the value of scientific research into its special problems; and, from personal knowledge and intercourse with gas engineers, I can assure my chemical colleagues that any serious interest taken by scientific chemists in these problems, or in training men to tackle them, will be welcomed by the industry, no matter from what quarter such help or interest may come. For although the carbonisation of coal in gasworks is efficiently carried out, no one in the industry supposes that finality has been reached, or that existing methods and conditions cannot be improved under better chemical control.

And, moreover, the gas industry has just recently given a striking example of the public benefit which may accrue from the whole-hearted co-operation of the chemist and engineer in the new nickel-catalytic process for the removal of carbon bisulphide from coal gas, which has been worked out, and brought to a successful issue, by the combined skill and efforts of Mr. Charles Carpenter, Mr. W. Doig Gibb, and Mr. E. V. Evans, of the South Metropolitan Gas Company. They have shown that the sulphur content (as CS_2) of London coal gas can be reduced on a large scale, in regular day-to-day working, from nearly 40 to about 8 grains per 100 cubic ft., without in any way deteriorating the quality of the gas, at a cost (including interest and depreciation) of 0·299*d*. per 1000 cubic ft. Such a striking success was, as Mr. Carpenter acknowledges, only achieved "because of the unrestricted and unreserved collaboration of the chemist and the engineer." Incidentally, the gas industry is to be congratulated on this tacit abandonment of the old contention that coal gas was either none the worse for the presence in it of a certain amount of sulphur compound, or (alternatively), if worse, that a minute amount of sulphur dioxide in the atmosphere of a living room is so rapidly absorbed by the ceiling that its harmful effects are nullified.

As the outcome largely of the work of the Joint Committee appointed in 1907 by the Institution of Gas Engineers and the University of Leeds (of which I was a member) to investigate gas-fire problems, the manufacturers of these appliances have paid much more attention than formerly to the scientific aspects of construction, so far as to ensure the best combination of radiant and ventilating effects, and nearly all the larger firms have now their scientific staffs busily employed in making further advances. Prominent among the pioneers in scientific gas-fire construction has been Mr. H. James Yates, who will to-morrow enlighten you as to some of the most recent improvements. I can, however, from personal knowledge testify to the enterprise shown by most of the leading manufacturers, and that their combined efforts have resulted in a very efficient and perfectly hygienic domestic gas-fire. A committee appointed by the Institution of Gas Engineers, upon which scientific men are largely represented, is now considering the adoption of a standard method of testing the radiant efficiencies of gas-fires. Thus no one can say that the gas industry is not making every effort to put its affairs upon a thoroughly scientific basis.

Passing on to the metallurgical and allied industries (who, of course, are large consumers of fuel), there is much here to be done in improving the construction and operation of furnaces in order to check the waste of fuel. But of these details there is no time to treat; and one instance of the possibilities of very large economies as the result of scientific control must suffice.

It is perhaps common knowledge that the most economical arrangement of plant for the manufacture of iron and steel is one in which bye-product coke-ovens, blast-furnaces, steel furnaces, and rolling mills are brought together on one site and under one organising direction, so that the surplus gases from the coke-ovens and blast-furnaces may be utilised to the fullest extent. My relative, Mr. T. C. Hutchinson, of the Skinningrove Iron Company, who has devoted many years of anxious thought and practical study to this important problem, ventured some few years ago to predict that—with the most approved type and arrangement of plant, working under strict scientific control by competent chemists—it would soon be possible to make finished steel rails or girders from Cleveland ironstone with no further consumption of coal than is charged into the bye-product coke-ovens for the production of the coke required for the blast-furnace, and all subsequent experience at Skinningrove has fully demonstrated that his prophecy can be fulfilled in everyday practice. Of course, it means a constant watchful control by a well-paid and competent scientific staff under efficient leadership, and in Mr. E. Bury—an old Owens College student, trained in an atmosphere of "gas and combustion"—we have found the very man for the work.

It is perhaps unnecessary, even had time permitted, for me to multiply instances of possible economies in other important directions—such, for instance, as power production and the heating of domestic apartments. There is probably no direction in which equally good results would not accrue with proper scientific application and control as those already cited as having been reached in the direction of carbonisation, or in the iron and steel industry. To-morrow we are to discuss the important subject of smoke prevention, in which many Manchester public men are showing an active interest, so that there will be some further opportunity of referring to the matter.

But may I, in conclusion, appeal in all seriousness to chemists and scientific men generally to take up this important matter effectively as a public duty at this crisis in the country's affairs? I would suggest that the Government be memorialised with a view to the establishment of a central organisation for the supervision of fuel consumption and the utilisation of coal somewhat on the lines of the existing alkali works inspection, which has been so beneficial to chemical industry. And in connection with such an organisation there might be undertaken a much needed systematic chemical survey of British coalfields, as well as experimental trial of new inventions for fuel economies. There would certainly be no lack of important work for such a properly organised department of the State, and there can be no doubt at all that the results of its activities would be, not only a very large direct saving in our colossal annual coal bill, but also a purer atmosphere and healthier conditions generally in all our large industrial areas.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—In his valedictory address to the Senate, the retiring Vice-Chancellor, Dr. M. R. James, the provost of King's College, stated that the University has shrunk to less than one-third of its former numbers; no fewer than 10,000 Cambridge men have entered the military and naval services. The Rev. T. C. Fitzpatrick, president of Queens' College, was elected Vice-Chancellor for the ensuing year. The Quick professorship of biology is vacant, as the period of three years for which Dr. G. H. F. Nuttall was appointed has now ended.

ALTHOUGH much of the best glass used in England is of English manufacture, large quantities of glass, principally of the cheaper types, have been for some years imported. Cheaper labour, cheaper transport, and the scarcity of technically trained managers and chemists, together with the prevalence of "rule-of-thumb" methods, have been the determining factors. The manufacture of fine glass requires a peculiar combination of engineering, physical, and chemical knowledge and training, and the chemical knowledge is not usually obtainable in university or technical college courses, because of the specialised nature of the subjects and the difficulties which arise in translating laboratory experiments into practice on a manufacturing scale. To meet these difficulties, the University of Sheffield has established a department of glass manufacture and technology, and has instituted special technological courses. A syllabus of special lectures and laboratory work has been issued with details of a projected full-time three years' course. The announcement indicates the variety of scientific and technical work which is essential to a good training in glass manufacture, and includes, *e.g.*, the chemistry of the materials, the glasses and pots, the fuel used, the furnaces, the temperatures at which they work, variations in the methods of melting, chemical actions in the process of melting, methods of working the glass, such as rolling, pressing, and blowing, grinding and cutting, and the machinery and appliances incidental to all these operations. The success of these courses will necessarily depend on the co-ordination of the lectures and the laboratory practice with larger scale experimental work; but the University of Sheffield, with its experience of similar problems in the metallurgical department, should be well qualified to deal with these difficult problems. Their successful solution should be of material assistance to a very important and growing branch of British industry which it is particularly essential to encourage as much as possible at the present time.

THE third war programme in connection with the Chadwick Public Lectures dealing with the last quarter of the present year has now been published. Prof. D. Noel Paton is giving a course of three lectures on "Food in War Time" at the Hampstead Central Library, Finchley Road, London, N.W. The first lecture was given on Monday last, and the others will be given on the two succeeding Mondays, at 8.15 p.m. Dr. R. O. Moon, physician to the Serbian Isolation Hospital at Skoplje (Uskub), will lecture on "Typhus in Serbia," at the Royal Society of Medicine, 1 Wimpole Street, Cavendish Square, London, W., at 5.15 p.m. on October 20 and 29, and on November 3. On November 10, at 8.15 p.m., Mr. A. Saxon Snell will lecture on "Emergency Military Hospital Construction" at the Royal Institute of British Architects, Conduit Street, London, W. On November 17, at 8.15 p.m. Mr. W. E. Riley will lecture on "Some Conclusions on Housing our Workers," at the Royal Sanitary Institute, 90 Buckingham Palace Road, London, S.W. The admission to all lectures is free.

THE calendar for the current session of Armstrong College, Newcastle-upon-Tyne, one of the constituent colleges of the University of Durham, is now available. Since August, 1914, the buildings of the college have been in the occupation of the War Office, and the various departments of the college are housed temporarily in different buildings throughout the city. The arrangements for the session follow the general lines of previous years. Complete courses of study leading up to degrees in pure and applied science have been provided. Students who wish to graduate in applied science may take up one of the following branches: general mechanical, marine, civil, or electrical engineering, naval architecture, mining, and metallurgy. Such a degree is accepted by the Institution of Civil Engineers in lieu of their examination for associate membership, and by other corporations. Courses are also provided in preparation for degrees in commerce. A gratifying characteristic of the work done in the college is the active co-operation of employers of labour in the district, who have made it easy for students to obtain experience of workshop conditions during or after their college course.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 27.—M. Ed. Perrier in the chair.—Paul **Appell**: A second form of Θ functions of the fourth degree.—Henry Le **Chatelier** and Jules **Lemoine**: The heterogeneity of steels. An account of the application of an etching reagent proposed by Stead (methyl alcoholic solution of cupric and magnesium chlorides containing hydrochloric acid), with details of the proportions found to give the best results. Nine reproductions of microphotographs accompany the paper.—J. **Haag**: A system of differential formulæ concerning the elements of a projectile submitted to a quadratic resistance of air.—Charles **Rabut**: The calculation of the strength of a beam reinforced with metal bands.—P. **Vaillant**: The laws of flow of liquids in drops. The weight of a drop from a given orifice depends on the number of drops per second. It is proved that the weight of a drop is a parabolic function of the frequency of fall, and experimental data are given in support of this.—P. W. Stuart **Menteath**: The Permian of the western Pyrenees.—Jules **Welsch**: The Pliocene lignites of Bidart, Lower Pyrenees. South of Biarritz there are deposits of lignite the age of which is near to the Middle Pliocene.—R. **Chudeau**: Rain and vapour pressure in western and equatorial Africa.—J. **Bergonié**: A new method of physical treatment of the after results of wounds: pneumatic pulsatory massage. A detailed description of the mode of application of mechanical massage to the treatment of masses of cicatricial tissue. Particulars of the results obtained will be published later.—P. **Portier**: The resistance of certain races of *B. subtilis* arising from insects to chemical reagents. The organisms, isolated from the larva of *Tenebrio molitor* and the chrysalis of *Myeloïs cribrella,* prove to survive very drastic treatment, including 50 hours with 5 per cent. phenol, 25 hours with 20 per cent. formaldehyde, 95 per cent. alcohol more than fourteen months, boiling chloroform, and other reagents. This resistance to chemical reagents is greater than any hitherto observed, and has a direct bearing on the problem of sterilisation of instruments and bandages.—J. **Wolff** and Mlle. Nadia **Rouchelmann**: The properties of a chromogen universally distributed in plants.—A. de la Baume **Pluvinel**: The use of Hughes's induction balance for the detection of projectiles in the wounded.

BOOKS RECEIVED.

Department of Agriculture and Technical Instruction for Ireland. Suggestions for the Teaching of the First Year's Syllabus in Experimental Science for Day Secondary Schools. By E. P. Barrett. Pp. 19. (Dublin: Browne and Nolan, Ltd.)

Armstrong College, Newcastle-upon-Tyne. Calendar, Session 1915–16. Pp. 523. (Newcastle-upon-Tyne: Armstrong College.) 1*s.*

Five Figure Mathematical Tables. Compiled by E. Chappell. Pp. xvi+320. (London: W. and R. Chambers, Ltd.) 5*s.* net.

DIARY OF SOCIETIES.

THURSDAY, OCTOBER 7.

EUGENICS EDUCATION SOCIETY, at 5.15.—Eugenics and the Doctrine of the Super-man: Prof. J. A. Lindsay.

FRIDAY, OCTOBER 15.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—The Theory of Grinding, with reference to the Selection of Speeds in Plain and Internal Work: J. J. Guest.

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