THURSDAY, JANUARY 16, 1913.

A MATHEMATICIAN'S LECTURES ON AERONAUTICS.

The Dynamics of Mechanical Flight. Lectures delivered at the Imperial College of Science and Technology, March, 1910 and 1911. By Sir G. Greenhill. Pp. iii+121. (London: Constable and Co., Ltd., 1912.) Price 8*s*. 6*d*. net.

Up to the present time the study of problems relating to aeroplanes and airships has conspicuously failed to attract the attention of our leading mathematicians and mathematical physicists. This is the more surprising in view of the important part that has been played in the past, and is still being played, by methods of mathematical analysis in systematising and elucidating our knowledge of electric phenomena. A book by so trustworthy a mathematician as Sir G. Greenhill should prove of great value in clearing up the misunderstandings which have so frequently arisen as to the meaning and use (or misuse) of formulæ in connection with aeronautics.

This book claims to be the substance of the lectures given by Sir G. Greenhill at the Imperial College, and in view of the difficulties of writing a book of this character, the author has probably valid reasons for not wishing to extend its scope beyond the limits of these lectures. What he has done is to present in the first place a simple account of some of the more elementary problems which are discussed in detail in his report on the stream lines past a plane barrier, and in the second place a general summary of the formulæ that are involved in relations between lift, drift and horsepower, gyrostatic action, the screw propeller, and the pneumatical principles of the airship. As might naturally be expected by those who know Greenhill's writings, the introduction is mainly taken up with quotations from Greek, English, and other classics.

There are two methods of investigating the pressure on a plane moving through a fluid medium. One is the Newtonian method, which expresses the pressure in terms of the momentum communicated to the column of air on which the plane impinges. The other is based essentially on Bernouilli's pressure-equation, which determines the pressure from the stream line motion past the plane.

The Newtonian method still finds great favour with a large class of practical men, and many attempts have been made to apply it to aeroplanes. But beyond Newton's deduction of the so-called "sine-squared" law for a medium which, as Greenhill remarks on p. 14, is taken "to behave like a cloud of particle dust," little or no progress has been made in obtaining results that can be regarded as established on a trustworthy basis. On p. 41 Greenhill gives a figure showing a popular misrepresentation of the stream lines past a cambered plane, which finds favour with some of these neo-Newtonian would-be philosophers, but in which the absence of any broadening of the stream lines is inconsistent with the existence of any thrust or lift.

The theory of discontinuous motion as originated by Kirchhoff and Helmholtz, and developed by Lord Rayleigh, Schwarz and Christoffel, Michell, Love, and finally at very great detail in Greenhill's report, comprises all the problems that are soluble by existing analytical methods regarding fluid pressures on planes, as determined from Bernouilli's equation. It is true that they involve assumptions which at best form only a first approximation to the conditions prevailing in actual aeroplanes. But a closely analogous relation exists between the application of conjugate functions to electrical problems and the calculations required in practical electric engineering. No one will question the value of analytical applications of complex variables to electricity, and similarly these hydrodynamical investigations offer the best basis for a theoretical explanation and study of aeroplane pressures.

A considerable portion of the chapters on this subject is devoted to a discussion of the integrals involved in problems where the first integration can be effected without the use of elliptic functions. The condition for this is that there must only be two edges at which discontinuities are formed, or that the number of such edges must be reducible to two from considerations of symmetry. In such cases the "Omega" diagram representing the logarithm of the reciprocal of the velocity has only two right-angles, and the first integration only involves a quadratic expression under the radical sign. A table of different forms of this integral is given in the present book. Since the book appeared, some researches have been started at Bangor on the lift and drift of bent planes, with the view of estimating the effects of camber. One such application is suggested by Greenhill on p. 40, who, however, assumes that the stream lines divide at the bend; this we find is not the general rule, but a particular case. The object of the research is to obtain numerical tables of the lift and drift in particular systems, and so to acquire some information regarding their relative efficiency. The integrals are all capable of evaluation, and this research could probably not have been started but for Greenhill's previous work on the subject.

The chapter on gyrostatic action is of an elementary character, and those who have seen Greenhill experimenting with bicycle wheels at former mathematical congresses will not be surprised to find these experiments detailed here. The chapter on the screw propeller contains a summary of the principal theories and formulæ that have been proposed, but, as the author points out, all these are based on certain assumptions. The discontinuous motion past the blades of a propeller is far too complicated to admit of analytical investigation. The reference on p. 105 to the method of fixing two screws on the same shaft so as to neutralise the rotational angular momentum of the wake seems deserving of careful attention. This system may not have been of much advantage when applied to the early screw steamers, but with the increasing size and speed of modern flying machines, an arrangement of the kind may not improbably prove indispensable, especially in a rare medium like air. Without some such plan increased speed can only be obtained by increasing the revolutions of the screw or decreasing the pitch, and in the latter case the proportion of energy wasted in the rotation of the wake increases correspondingly, as does also the couple, tending to turn the aeroplane over sideways unless it is provided with twin-screws. The last chapter deals with the pneumatical principles of an airship, that is to say, mainly elementary hydrostatics.

For the student of exact science, this book will afford a good account of the principles and formulæ which determine the forces acting on a flying machine when it moves through the air. The study of the motions which an aeroplane undergoes under the action of these forces is another matter altogether. On the other hand, those who require to apply formulæ to actual machines will have a guarantee that the formulæ in this book are at least sound deductions from the assumptions on which they are based.

G. H. BRYAN.

MUNICIPAL TRADING AND CURRENCY.

(1) *Principles and Methods of Municipal Trading.* By Douglas Knoop. Pp. xvii+409. (London: Macmillan & Co., 1912.) Price 10*s.* 6*d.* net.

(2) *The Standard of Value.* By Sir David Barbour, K.C.S.I., K.C.M.G. Pp. xvi+242. (London: Macmillan & Co., 1912.) Price 6*s.* net.

(1) THE subject of municipal trading presents an initial difficulty of definition. The economic or "reproductive" undertakings of local authorities may be divided into trading enterprises carried on for profit, and those of which the charges do not fully cover the cost and which are therefore subsidised. Mr. Knoop confines himself to the former, but includes those businesses which are sometimes carried on for profit and sometimes are not. As a result, his work has gained in completeness and thoroughness.

The arrangement of the book is admirable, and each chief division of the subject, such as Extent, Management, and Selling or Labour Policies, is separately dealt with. Moreover, both the general treatment and the criticism are, with a few exceptions, ample and well-informed. One may mention especially the case of reserve funds and renewals, in which the author's strictures appear most just, and the judicious summing-up regarding the "writing-down" of the commercial to the housing value of cleared sites. The author's conclusions limit the municipal management of competitive enterprises to those which tend to become monopolies; otherwise, "with one or two small exceptions, it is strongly to be deprecated." This appears unduly pessimistic, but few will deny the very great value of the book as a history, description and criticism.

(2) Sir David Barbour, a former Financial Member of the Council of the Governor-General of India and one of the Royal Commission on Gold and Silver, aims at placing on record the results of his wide administrative and financial experience. His book deals primarily with the causes of appreciation or depreciation, whether in a gold standard or under a system of bimetallism. Regarding the latter, he holds that a definite verdict either way is not possible, but is doubtful whether the adoption of a gold standard would have taken place if all its consequences could have been foreseen.

There is a slight preliminary treatment of some general questions of economic theory which bear upon the subject, and a fuller one of the Quantity Theory and of the relations of money, credit and prices. Here the author is inclined to underestimate the modifications of the theory that are brought about by the influence of credit, at any rate in the case of wholesale transactions. Again, it is not the total output of fresh gold, but the part of it that is used for coinage, including reserves of bullion, that influences the level of prices. The second half of the book is both the more valuable and the more interesting part of it. The points are well made that to lower general prices, decreased cost of production must be accompanied by increased output; and that "the fall in the gold price of silver was due to the fall in the gold price of commodities produced in the gold standard countries and exported to the silver standard countries." The whole book is clear and readable, and, embodying as it does the theoretical conclusions of a man of wide practical experience, contains much that is of interest and value.

N. B. DEARLE.

BUILDING STONES.

(1) *Handbuch der bautechnischen Gesteinsprüfung.* Für Beamte der Materialprüfungsanstalten und Baubehörden, Steinbruchingenieure, Architekten und Bauingenieure, sowie für Studierende der technischen Hochschulen. By Prof. J. Hirschwald. Zweiter Band. Pp. xvi+388–923. (Berlin: Gebrüder Borntraeger, 1912.) Price 32 marks.

(2) *Building Stones and Clays: Their Origin, Characters and Examination.* By Edwin C. Eckel. Pp. xv+264. (New York: J. Wiley and Sons; London: Chapman & Hall, Ltd., 1912.) Price 12*s.* 6*d.* net.

(1) THE first volume of Hirschwald's comprehensive work was noticed in NATURE of June 6, 1912 (vol. 89, p. 344). This, the second and final volume, deals with the application of the methods previously described.

One of the outstanding features of Hirschwald's method is the frank acknowledgment that different types of stone demand that attention should be paid to their peculiarities of structure and mineral composition. Thus, he treats separately each of the following types:—Sandstones, grauwackes, limestones — dolomites — marbles, roofingslates, granites, gneiss with mica schists, syenites—diorites—diabases, porphyries, trachytes—rhyolites—andesites, basalts, schalsteins and tuffs. Under each of these heads he gives an account of the general petrographic characters, microstructure, chemical composition, peculiarities of weathering, special methods of testing applicable to the stone, the mode of obtaining a valuation of the stone's weather-resisting qualities from the results of testing, and remarks upon the points to be observed in the quarries.

Microscopic examination he rightly regards as of the first importance, and by its means the structure and mineral composition of the stone are analysed with great minuteness, and the results of the examination are expressed in terms of weather-resisting quality. This is done by assigning a symbol to each recognisable degree of each of the characteristics of stone structure, *e.g.*, in sandstones made of quartz grains bound by siliceous "cement" there are four grades: Kα, grains in optical orientation with their neighbours; Kβ, grains joined by outgrowths not so related; Kγ, microgranular quartz; Kδ, amorphous silica. Then come thirteen grades of "contact cement" other than simple silica. The pores in the stone are treated separately; there are twenty-two grades of "texture pores," empty or variously filled, and as many grades of "structure pore" types, and so on. Tables are given in which these symbols and the numerical results of physical tests are assigned values according to a scale of weather resistance which is itself the result of observations and tests made on tried stones actually employed in buildings of considerable age. The results of observation and test are added together to obtain the desired figure representing the quality (Q). This, for example, is the formula worked out for a certain sandstone—

$$\begin{array}{ccccc} \text{Kd pgk; ce} & \text{Kb} & \zeta_r\omega_1 & \text{S}\eta\text{V} & \text{Q} \\ 0{\cdot}52(2-0{\cdot}5) & +\,0{\cdot}5\times1{\cdot}5 & -\,0{\cdot}5 & +\,0{\cdot}45 & =1{\cdot}45=(\text{I to II}) \end{array}$$

indicating that the quality-class of the stone is between first and second grade.

The book provides fully worked-out tables and schemes for the valuation of microscopic observations and experimental results, so that by employing them it would be a comparatively easy matter to obtain the formula for any new stone.

At the recent congress of the International Association for Testing Materials it was decided to recommend that Hirschwald's method should be tried and reported upon by testing institutions, and to assist in this process a set of type microslides and small samples of building stone with annotations by Prof. Hirschwald will be procurable from Krantz, of Bonn.

(2) It is interesting to examine Mr. Eckel's new work on building stones and clays side by side with Hirschwald's book. The former is a well-produced volume treating the subject on broad lines and mainly from an American point of view. The first two chapters are upon elementary geology; then follow eight chapters describing the geological, chemical and physical properties of the principal stone groups; one on the field examination and valuation of stone properties, and one on the laboratory testing of stone. Part ii., the short section on clays, is inadequate and rather out of place nowadays in a book on building stones.

The book contains much plain common sense, together with what can be regarded only as padding; thus, on p. 42 the author makes it clear that commercial analyses of granite are of little or no use, yet he immediately introduces twelve pages of analyses. There are more than thirty-eight pages of compiled analyses in the book and a number of tables of physical test results quoted from various sources. The latter are of small value because, as the author himself well knows, the tests are not made under comparable conditions. Though much of the tabulated matter might have been omitted without loss, the writer's outlook, as a practical engineer, on the testing problem is well worth consideration.

The restricted American scope of the work is illustrated by the scant notice taken of the trachytes, tuffs and other volcanic rocks which play an important part in Europe. Copious lists of American references are given, as well as statistics of production quoted from official publications.

In another edition, "White Man's Field, Red Man's Field and Yellow Man's Field," misquoted on p. 159 from Beare's table, should be transformed from their present "Wild West" state into the more readily recognisable "White Mansfield Stone," etc.

PHYSICS FOR CHILDREN AND STUDENTS.

(1) *The Boy's Playbook of Science.* By John Henry Pepper. Revised, rewritten, re-illustrated with many additions by Dr. John Mastin. Pp. x+680. (London: George Routledge & Sons, Ltd.; New York: E. P. Dutton & Co.) Price 5*s*.

(2) *Examples in Applied Electricity.* By C. G. Lamb. Pp. iv+61. (Cambridge: The University Press, 1912.) Price 2*s*. 6*d*. net.

(3) *Manuale di Fisica ad Uso delle Scuole Secondarie e Superiori.* Volume Primo. Meccanica. By Prof. Bernardo Dessau. Pp. xii+500. (Milano: Società Editrice Libraria, 1912.) Price 12 lire.

(1) TO say that this book is a remarkable one would in a sense be true, but might at the same time be misleading. If the term be used it must be qualified by saying that the remarkable features are mainly undesirable. No doubt the object of the book is commendable, for no one denies that it is an excellent thing to interest youth in the wonders of natural phenomena, and, further, that the treatment should be as comprehensive as possible. At the same time, it is surely better to explain a few things well than to give loose and inadequate explanations of many.

In this respect the book in question is not at all successful. A very large number of phenomena are dealt with in a manner which is often too cursory to be clear, and is sometimes, indeed, actually erroneous. Thus in treating the subject of gravitation the author, after regretting the fact that there are not many good lecture-table experiments illustrating this effect, goes on to say that "attention may be directed to the fact of a piece of potassium thrown on the surface of water in a plate generally rushing to the sides, and, as if attracted, attaching itself with great force to the substance of the pottery or porcelain." Although not an absolute statement of fact, this is at least a suggestion that the movement is the result of gravitational attraction between the potassium and the sides of the vessel. The N rays of Prof. Blondlot are spoken of as though their existence had never been disputed, and heat is spoken of as a force.

Another curious feature is the order in which the various subjects are taken. For some unaccountable reason a chapter an aerial flight—in which several pages are wasted upon an absurd and unnecessarily long list of persons who have at various dates been killed in attempting to fly—is sandwiched in the section on chemistry between the liquefaction of gases and the halogens.

It should be said that the contents of the book are limited to the consideration of the science of inanimate objects, and undoubtedly convey much useful information. Nevertheless, the weaknesses which have been referred to above render it impossible to bestow upon the book any hearty recommendation.

(2) The author of this little volume has compiled, mainly from test papers set to the students in the Cambridge Engineering Laboratory and from the papers in the Mechanical Science Tripos, a considerable number of numerical questions in electrical engineering. They are arranged in the form of papers of some eight questions each, and the answers are given at the end of the book. The questions are varied in character and, although they do not include the subjects of polyphase currents and wireless telegraphy, should prove very useful in engineering schools.

(3) This first volume of Prof. Dessau's Manual of Physics includes rather more than what is usually denoted by the title of "Mechanics" in England. Besides the ordinary mechanics of solids and fluids we find treated in an elementary manner—as, indeed, is the whole book—such phenomena as gravitation, elasticity, diffusion of gases, and the interference of waves. The book is exceedingly well printed and the diagrams are uniformly good.

OUR BOOKSHELF.

Science from an Easy Chair. Second Series. By Sir Ray Lankester, K.C.B., F.R.S. Pp. xiii+412. (London: Adlard and Son, 1912.) Price 6*s*. 6*d*. net.

SIR RAY LANKESTER'S weekly contributions to *The Daily Telegraph* represent the high-water mark of popular papers on scientific subjects. The general public has in recent years been infected with a feverish desire for sensation; and as science can offer little to gratify that appetite, thoughtful articles upon its achievements are now relatively much fewer in the periodical Press than they were a generation or two ago. Possibly men of science are partly to blame for this state of affairs. They must be specialists in order to make progress in their own particular fields of inquiry; and they are often not only themselves unfamiliar with the commonest vocabularies of other departments of natural knowledge, but also regard the endeavour to create a comprehensive interest in nature as a thing of little importance.

There are, unfortunately, very few, if any, men of science in these days of minute specialisation who are capable of writing such illuminating papers on scientific methods and results as those in this volume and the collection which preceded it. The papers are perfect models of scientific exposition: simple, yet not childish; informative, but not tedious; bright without being flippant; sparkling with human interest and original always. Thirty-one main topics form the subjects of the chapters of the present volume, and upon all of them the author writes with freshness and breadth of knowledge that command admiration. For the student of science whose work is running in a narrow groove the papers provide a pleasant antidote; and to readers engaged in other activities they will be a revelation.

One minor point is worth mention. Sir Ray Lankester, writing on the work of glaciers, refers to glaciated rocks that have "the form of rounded humps, compared to a sheep's back, and hence called '*roches moutonnées*.'" We thought that several years ago Prof. Grenville Cole had shown this interpretation to be incorrect, for the reason that de Saussure, who first used the term, meant to suggest a resemblance of the rocks, not to a flock of sheep, but to the wigs styled in his day *moutonnées*.

An Analysis of the Church of St. Mary, Cholsey, in the County of Berkshire. By Prof. F. J. Cole. Pp. viii+62+23 plates. (Oxford: B. H. Blackwell; London: Henry Frowde, 1911.) Price 5*s*. net.

THE professor of zoology in the University College of Reading teaches, in this book, a valuable lesson to church architects and archæologists, "that only an investigation by methods of precision can bring the study of the parish churches within the cognisance of serious research." Ecclesiastical architecture is now quite a dead art. It has lost the living touch with nature. Of its true natural basis even Dr. Cole has nothing definite to say. Still, he has discovered the nearest thing to it, and is well qualified to teach his lesson. The case may be put in stronger terms, but let Dr. Cole speak:

"But, unfortunately, the morphological method is hardly, if ever, carried to its legitimate extreme. The amateur, finding it easy to classify his detail according to the Norman, Early English, Decorated, and Perpendicular convention, cultivates the deadly shade of that architectural Upas. 'Yet that way perdition lies.' On the other hand, the professional architect gives us a set of drawings, of the greatest value let it at once be said, but unaccompanied by any attempt to wrest the secrets from the building he has been measuring." (Pref. iv.)

It is the author's insistence on exact measurement that will lead the student "to the bed-rock of ascertained fact." It is measurement, more than fashions or "styles," that differentiates periods in architecture. But while the author has succeeded in making out successive periods by measure, it seems not to have occurred to him to consider why certain measures were adopted, and why they should differ with the lapse of time. To some extent, the value of orientation is recognised, but it is to be hoped that the author's next "attempt to wrest the secrets" from St. Mary's, Cholsey, or any old church, will be to show that the individual measures represent celestial spaces or distances, and that the orientation is the key to the structural symmetry. JOHN GRIFFITH.

Experimental Physiology. By Prof. E. A. Schäfer, F.R.S. Pp. viii+111. (London: Longmans, Green and Co., 1912.) Price 4*s*. 6*d*. net.

EXPERIMENTAL physiology is a convenient, but not very logical, name for that part of physiology which is not chemical. The present little book is a handy guide to the student in the practical class. It is the outcome of many years' experience in the teaching of such classes, and will form a trustworthy laboratory companion. The descriptions of the experiments are clear and concise, and a special word of praise is to be accorded to the excellent diagrams which accompany the text. The great bulk of the work which the student can himself perform is necessarily limited to the pithed frog. Experiments on living animals under anæsthesia can only take the form of demonstrations. Experiments on man himself are not restricted by law, and the present-day tendency of the physiological teacher is to increase the number of exercises which the students can perform upon themselves or upon each other, and to diminish the importance of the humble but still necessary frog. W. D. H.

The Centenary of a Nineteenth-Century Geologist—Edward William Binney, F.R.S. By James Binney. Pp. 58. (Taunton: Barnicott and Pearce, 1912.) Price 2*s*. 6*d*. net.

EDWARD BINNEY was born on December 7, 1819, and died in December, 1881. He was three times president of the Literary and Philosophical Society of Manchester, was president of the Manchester Geological Society, and in 1856 was elected a fellow of the Royal Society. With Young and Meldrum he commenced the manufacture of mineral oils from Boghead coal obtained from Bathgate, near Linlithgow, in 1850; and in fourteen years—when the patent had run out—a net profit of 60,000*l*. was made.

Mr. J. Binney's little book is a tribute to a successful man of business and a keen student of nature. Prominence is given to details of litigation of little interest to scientific readers; and filial regard will perhaps account for the remarks as to the want of acknowledgment by Williamson of what he owed to Binney in the study of fossil plants. Whether local printers or the author are responsible for the neglect of elementary rules of punctuation throughout the book is not for us to decide.

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 Double Refraction produced by the Distortions of Elastic Bodies according to Volterra's Theory.

THE interesting experiments of Prof. E. G. Coker on the application of optical methods to technical problems of stress distribution have been described in an article in NATURE of December 5, 1912. This article suggests that this would be an opportune moment to publish, outside of Italy, the results of researches which Sig. Trabacchi and I undertook some years ago for a similar purpose (*Rend. Lincei*, vol. xviii., 1909). There is this essential difference from Prof. Coker's experiments, that our object at that time was the experimental verification of precise calculations deduced from Volterra's theory of elastic "distortions" (*Ann. de l'École Normale de Paris*, 1907).

The peculiarity of these distortions consists in the entire freedom of the distorted bodies from the influence of external forces. Let it suffice to recall the two simplest cases, namely those in which a small slice, with faces either radial or parallel, is removed from a cylindrical ring of elastic matter, and the cut surfaces then glued together. There exist accordingly internal tensions, but no external forces; this makes the theoretical calculation quite rigorous, and the experimental conditions very similar to the hypotheses in the theory. I found it easy, starting from Volterra's general formulæ, which permit the calculation, point by point, of the tensions in the interior of the cylinder, to prophesy the figures of double refraction which should be observed in polarised light traversing the ring in the direction of its axis, and—more precisely—the equations of the absolutely black lines, corresponding to various orientations of the ring with respect to the principal sections of the polariser analyser.

In the case of a radial cut I was able to predict the formation of a circle and a cross, the arms of the cross being parallel to the sections of the polarisers, irrespective of the orientation of the ring in its plane. So far as can be calculated, the radius of the circle depends only on the exterior and interior radii of the ring, and not on the angular amplitude of the cut. The circle is the locus of points where the distortion is reduced to a uniform dilatation or compression, that is, where the isotropy of the body is unaltered.

It was a less simple matter to foresee the aspect of the phenomenon in the case of a cut with parallel faces equidistant from the axis. In Fig. 1 the x axis coincides with the faces glued together after the removal of the slice. With the nicols parallel and perpendicular to this axis, the theory demands the formation of a black straight line in the direction of the x axis, and of a curve of the fourth order, tangent to the exterior circle at the extremities of the diameter perpendicular to the x axis. In Fig. 2 are reproduced the lines theoretically calculated when the nicols are inclined 45° to the direction of the cut; in this case one should observe a black line perpendicular to the x axis, and two curves similar to the two branches of a hyperbola; there should be, furthermore, four isolated black points at P, Q, R, S. The curves predicted are not neutral curves, that is to say, curves without double refraction, but isogonal curves, *i.e.* curves wherein the double refraction has a constant direction, that of the nicols. As a matter of fact, there exists in this case no neutral line, but merely six neutral points.

These calculations were, at my suggestion, verified in this institute by Sig. Trabacchi. He made use of rings of freshly prepared gelatine, and by their im-

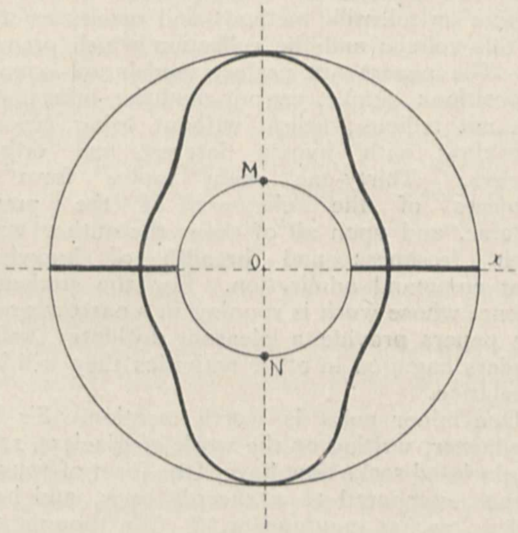

FIG. 1.

mersion in water avoided all possibility of accidental double refraction which might result from adhesion to the supporting glass plate. The ring, in a horizontal plane, was lowered carefully in a glass dish of water. The dish was illuminated from below by polarised light coming from a black mirror; a simple optical device was used, which allowed the entire

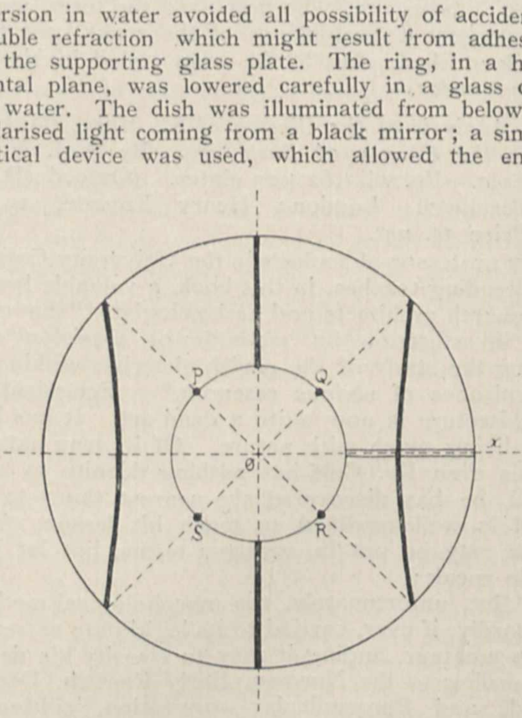

FIG. 2.

image of the ring to be projected through a nicol of dimensions much smaller than those of the ring.

Figs. 3, 4, and 5 reproduce the photographs obtained. The first corresponds to the radial cut, the others to the cut with parallel faces, with the light polarised respectively parallel to, and at 45° from, the direction of the cut. The correspondence with the theoretical calculations is more than satisfactory; especially in view of the difficulty of making, in a material soft and easily distorted, the cuts called for by the theory.

It would certainly be preferable to make use of celluloid, as Prof. Coker now does. I did indeed attempt it at the time of these experiments, but experienced some little difficulty in glueing the celluloid after cutting it, inasmuch as, in accordance with Volterra's theory, pressure is exerted on some regions of the faces in contact, tension on others.

The optical method, which permits the investigation of the internal distribution of tensions, has thus given us the means of verifying the theory of elasticity in a salient point, namely Volterra's theory of distortions, just as it has given Prof. Coker the means of supplying, by the use of experimental models, certain deficiencies of the theory—a theory which cannot always submit to rigorous calculation the complex conditions of internal strains to which the materials of practical construction are subject.

O. M. CORBINO.

Rome, Physical Institute of the Royal University.

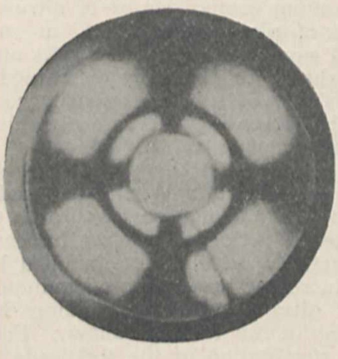

FIG. 3.

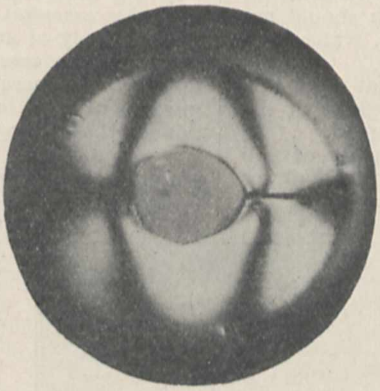

FIG. 4.

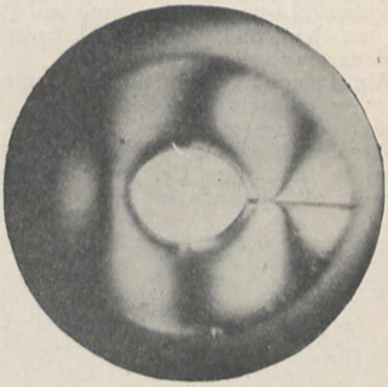

FIG. 5.

The Bacterial Theory of Soil Fertility.

IN vol. v., part i. (October, 1912) of *The Journal of Agricultural Science*, Messrs. Russell and Petherbridge state that "partial sterilisation appears to be the proper method of dealing with 'sick soils'" (p. 91). I venture to think that the theory of *partial sterilisation*—which is indeed very attractive—will not stand examination. According to this theory the fertility of a soil depends largely on its bacterial population, the enemies of which are destroyed by partial sterilisation, which the bacterial spores survive.

Now if this theory is correct, it should follow that complete sterilisation must diminish the fertility of a soil, since all bacterial spores will have been destroyed. This, however, is not the case, as Dr. Russell is apparently aware, for Drs. Darbishire and Russell in the same journal (vol. ii., part iii., December, 1907, p. 319) state: "a few experiments have been made with soils heated to 120° C. The same kind of results are obtained as at the lower temperatures, but they are somewhat intensified."

In other words, complete sterilisation gave an increased crop over partial sterilisation. The comparative effects of complete and partial sterilisation on a soil were shown by the present writer (*Cairo Sci. Jour.*, vol. iv., No. 43, April, 1910), maize in soil untreated, soil heated to 95° C., and soil heated to 170° C. yielding green weights in the proportion of 145·5, 151·7, 1055·6 (see Fig. 1).

Without having experimented on the effects of complete sterilisation of a sick soil, Messrs. Russell and Petherbridge state (*loc. cit.*, p. 90), "our experiments thus lead to the conclusion that at least two factors are concerned in soil sickness: a falling off in bacterial activity and an accumulation of plant parasites and disease organisms."

As a matter of fact, all that is proved is, as in Drs. Russell and Darbishire's paper quoted, that partial sterilisation produces both increased crop and increased bacterial activity. The illogical conclusion is then drawn from this that increased crop is due to increased bacterial activity. This erroneous deduction would not have been arrived at had a few parallel experiments been conducted with completely sterilised soils.

Again, the authors find that plants grow as well in extracts from the "sick" soil as in extracts from partially sterilised soil. They conclude that the "sickness" is therefore not due to a soluble toxic substance. But does this prove it? The phenomenon of absorption (or adsorption) of soluble salts by soils appears to have been overlooked. Further, these results are in direct contradiction to the very elaborate experiments carried out by the U.S.A. Department of Agriculture.

With regard to the growth of seedlings in water extracts of soils, very little detail of the method of the experiments is given. For instance, it is not stated at what stage the seedling was planted in the water extract. That certain precautions may have been overlooked would appear possible from the statement (used as an argument against the toxic theory) that "cucumber seeds are very sensitive to unfavourable conditions, but they germinate fully as well in 'sick' soil as in partially sterilised soil."

Now Pickering (*Journ. Agric. Sci.*, vol. ii., part iv., and vol. iii., parts i. and iii.) pointed out that germination is delayed in heated soils—a fact long known to farmers—and supposed that this was due to the production by heat of a toxic substance. The present writer (*loc. cit.*) proved that this delay is due entirely to a physical cause, viz. the increased osmotic pressure in the water contents (and water extract) of a heated soil; this causes imbibition by the seeds to be checked, in some cases to such an extent that they rot before they have absorbed sufficient water to cause germination.

Now if the seeds in Russell and Petherbridge's experiments were germinated in the soil extracts, after five days' growth (plate iii., Fig. 3*a*), we should scarcely expect the seedling in the extract from the heated soil to have made up for time lost in germination. Even if the seeds were all germinated under the same conditions, *e.g.* in water, and seedlings in similar stages of growth were then transferred to the soil extracts—as was the case in the writer's experiment above quoted—we still have in the case of some varieties of plants this delayed germination period extended to a considerable length in water cultures; in other words, the extract from a heated soil retards growth during a period of several days after the germination has actually taken place. This appears to be connected in some way with the formation of root hairs, the growth of which is often entirely inhibited in water cultures.

The safest way of testing the effect of various soil extracts on plant growth is to sow seeds in different portions of one and the same soil (which should not be too rich), and then, after germination, water with the various soil extracts.

Until some assurance is forthcoming that the necessary precautions have been taken, the results of the water cultures mentioned cannot be accepted.

Finally, it will be difficult for any theory of soil fertility that, like Dr. Russell's, claims that all, or almost all, depends on bacterial activity to explain away the injurious effect of any one plant on all its neighbours (see present writer in *Journ. Agric. Sci.*, vol iv., part iii.).

F. FLETCHER.

Kyambu, British East Africa, November 27, 1912.

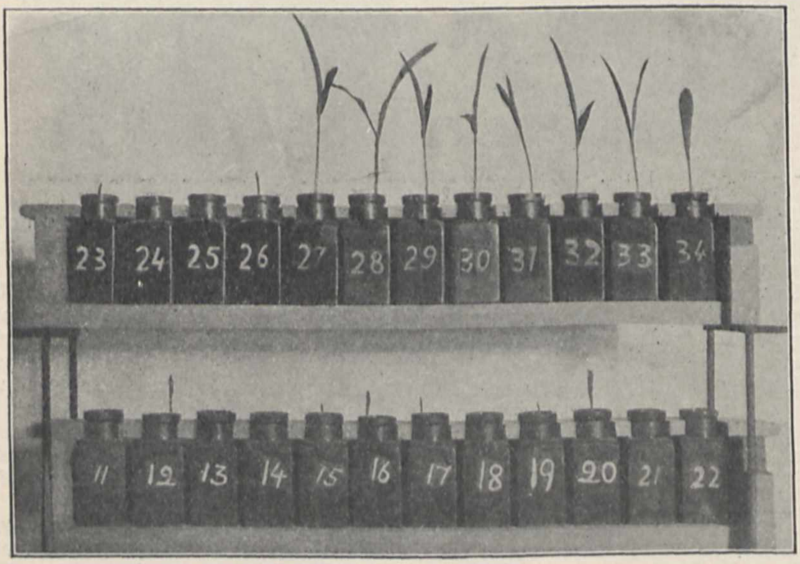

FIG. 1.—Maize plants after growing for seven days in soil previously treated as follows:—11–18 not heated; 19–26 heated to 95° C.; 27–34 heated to 170° C.

MR. FLETCHER is under a misapprehension in attributing to me a "theory" that "all, or almost all," of soil fertility depends on bacterial activity. I should certainly agree with Mr. Fletcher that any such hypothesis, if it were advanced, would be much too narrow to account for the facts.

Soil fertility is not due to the operation of any one factor, but of several. At least five conditions have to be fulfilled by the soil if the plant is to make satisfactory growth. There must be (1) adequate food supply; (2) proper water supply; (3) suitable temperature; (4) enough air for the roots; (5) absence of injurious substances or factors. Every one of these conditions is essential; any one that is unfulfilled sets a limit to the growth of the plant, and therefore to the fertility of the soil.

I have discussed the interaction of these various factors at some length in my book on "Soil Conditions and Plant Growth," and need now only refer to the place of bacterial action in the scheme.

Among the various nutrients required by the plant are the nitrogen compounds. Nitrates are the compounds usually obtained from the soil, but ammonium salts also serve; there is evidence, however, that highly complex compounds like the proteins, peptones, &c., are of little value to the plant even when they are soluble. Now the nitrogen compounds of the soil are mainly complex and insoluble, but they decompose slowly to form ammonia, which then oxidises to nitrates.

It has been repeatedly demonstrated that *when all the other essential conditions are satisfied,* an increase in the supply of ammonium compounds or of nitrates increases the amount of plant growth, *i.e.* of soil fertility. An increased supply of ammonium salts and nitrates may be brought about either by direct addition of these compounds or of substances easily converted into them, or by increasing the rate at which ammonia production takes place in the soil.

The production of ammonia in the soil is largely due to bacteria. When the conditions are made more favourable to bacterial action a marked increase in activity sets in, accompanied by an increased production of ammonia and nitrate. A corresponding increase in soil fertility follows. Partial sterilisation of the soil leads to marked increases in bacterial numbers for reasons that Dr. Hutchinson and I have discussed elsewhere. The accompanying increase in the amount of ammonia produced is so closely connected with that of the bacterial numbers that no reasonable doubt can be entertained as to its bacterial origin.

So much for the general relationship of bacterial activity to soil fertility. We can now turn to some of the details raised by Mr. Fletcher. He goes on to say that if bacterial activity has anything to do with soil fertility a completely sterilised soil ought to be less fertile than a partially sterilised soil. Unfortunately no one has ever succeeded in carrying out this experiment. When a soil is heated to 170° C., as in Mr. Fletcher's experiments, or even to 120° C., as in some of ours, it alters so completely that it can no longer be compared in any sense with the unheated soil. A considerable amount of decomposition takes place, and much ammonium and other simple soluble nitrogen compounds are formed. There is no reason to suppose that it matters to the plant whether the ammonium and other compounds are formed by bacterial action or by any other process; the essential point is that they should be formed; whatever their origin, they serve as plant nutrients. The increased gain in plant growth on such highly heated soils can be largely attributed to this cause.

The water-culture experiments, like the other experiments made at Rothamsted, were carried out with all the care and precautions that we could command. The obvious pitfalls mentioned by Mr. Fletcher were avoided. The fact that our results differ from those obtained by the United States Bureau of Soils implies no contradiction at all; they worked with "sour" soils, and we worked with the entirely different "sick" soils. We could find no evidence whatsoever of the presence of any toxin in our sick soils, or in our normal soils, but we do find abundant evidence of the activity of organisms detrimental to the ammonia-producing bacteria. We are therefore justified in regarding these detrimental organisms as one of the factors limiting soil fertility. We have shown that partial sterilisation destroys these organisms, and that it causes an increase in numbers of ammonia-producing bacteria, in the amount of ammonia produced, and in the fertility of the soil; these factors are all so closely connected with one another that no reasonable doubt can be entertained of the existence of a causal relationship between them. E. J. RUSSELL.

Rothamsted Experimental Station, Harpenden.

Precocity of Spring Flowers.

I HAD occasion to remark in a letter to NATURE (No. 1477, vol. lvii., February 17, 1898) on the unusually early flowering of many winter and spring flowers in the December of 1897 and the January of 1898; so many of these records have been surpassed already during the recent remarkably mild period that I am venturing to put a few of them before your readers. For the last twenty years I have kept a record of the first flowers of about eighty species of wild and garden spring flowers in this county, and the season named above is the only example which at all approaches the present one in the precocity of flowering.

The winter aconite began on December 8, and has been flowering profusely since the middle of the month, when about a hundred blossoms were gathered in one day; other early dates are December 20, 1911, December 23, 1897; the first week in January is the mean, the latest January 27, 1887. Green hellebore, January 10; usually end of February; latest, March 26, 1902. Fetid hellebore, December 1; usually early February; latest, February 21, 1904. Lesser celandine, December 1; usually early February; latest, March 12, 1900; other early records, January 20, 1898 and 1901. Wild white sweet violet in the hedges, January 5, many to be seen now, whereas mid-February to early March is its usual season. *Pyrus japonica* on many walls has been as much covered with flowers throughout December as it is usually in April and May.

Strawberry-leafed cinquefoil, December 24; usually begins in February. Gooseberry, January 5; a bush in the garden with many opened flowers. Hedge parsley abundant in the hedges in January; usually begins in mid-April. *Lonicera fragrantissima*, from December 18 onwards; usually begins early in January; earliest, December 10, 1900.

Adoxa moschatellina (Moschatel), in bud January 11; usually flowers in April. *Petasites fragrans* (winter heliotrope), mid-November, occasionally as early, but more usually December and January. Yellow coltsfoot, January 7; usually early March; earliest previously, January 21, 1898, February 20, 1897; latest, March 26, 1909. Primroses abundant in December and early January. *Omphalodes verna* abundant December; usually early March; latest, April 1, 1902. Spurge laurel, December 20; usually early in February; January 12, 1912, January 29, 1898, March 18, 1897. Dog's mercury, ♂ flowers, November 28; earliest previously, December 21, 1900; latest, March 12, 1900. Hazel, both ♂ and ♀, January 5; earliest ♂, December 24, 1911, ♀, January 16, 1906.

Chimonanthus fragrans (winter sweet), very abundant from November 14; earliest before, December 9, 1907. Yellow crocus, January 5; earliest, January 22, 1901, January 24, 1898. *Galanthus Elwesii*, November 14. Common snowdrop, December 28; earliest, January 8, 1912. Foliage has been out for some time on honeysuckle and elder, and even the "brushwood sheaf round the elm-tree bole is in tiny leaf," which, according to Browning, should not occur until April! Flower-buds are swelling on English elm and grey willow.

ELEONORA ARMITAGE.

Dadnor, Herefordshire, January 13.

MANY references are being made to the numbers of plants in flower now to be found in various parts of the country. May I give a list of those I gathered on January 6 in our garden in South Devon, ranging from 230 to 500 ft. above sea-level?

Gorse (double French and single), ivy, jasmine (yellow), honeysuckle, crocus (yellow), polyanthus, primrose, berberis, *Daphne mezereum*, ribes (pink and white), daisy, veronica (purple and pink), laurustinus, azalea (white), rhododendron (red), clianthus ("parrot's bill") mignonette, heath (white and Mediterranean), violet (Russian, white, and Neapolitan), rose (pink, yellow, and "Dorothy Perkins"), genista (yellow), passion-flower, forget-me-not, snowdrop, lavender, cyclamen, tobacco-plant (white), ivy geranium (pink), wallflower, borage, *Helliborus* (*foetidus*, *orientalis*, and *niger*), arabis, *Garrya elliptica*, arbutus, solanum, pansy, *Aubrietia purpurea*, and *Pieris* (*Andromeda*) *floribunda*. T. MARY LOCKYER.

Salcombe Regis, Sidmouth.

THE effect of the mildness of the winter is shown in the number of wild plants now in flower, some of them evidently survivors from the autumn, others early spring flowers, and yet others entirely out of season. During a walk on January 3 and 4 from Brighton through Ditchling and Haywards Heath to Balcombe, we observed no fewer than thirty wild flowers in blossom, many of them being abundant.

The list is as follows:—Daisy, gorse, dandelion, cinquefoil, primrose, feverfew, avens, red deadnettle, hawkweed, groundsel, chickweed, shepherd's purse, yarrow, lesser celandine, garlic mustard, dwarf spurge, spear thistle, barren strawberry, ivy-leafed speedwell, corn marigold, dog's mercury, dove's-foot crane's-bill, field speedwell, herb robert, white deadnettle, cress, lesser periwinkle (a garden escape), and the following, all young plants: wild-beaked parsley, buttercup, and rose campion.

EDITH HOW MARTYN.

Light Perception and Colour Perception.

THE Departmental Committee on Sight Tests has recommended a method of classifying colour-blindness by measuring the luminosity of the colour sensations by means of the flicker method of photometry. The degree of abnormality is estimated by the ratio of red to green compared with the normal. This classification is absolutely erroneous. Light perception and colour perception are quite distinct—that is to say, there may be considerable defect of colour perception without defect of light perception. The first two cases of colour-blindness (dichromics who confused red and green) examined by me on the method suggested by the Committee had a ratio identical with the normal, whilst a man who had not the least defect of colour perception had an abnormal ratio. Prof. A. W. Porter and I examined one of the above-mentioned colour-blind men by another method, and we could not detect the least defect in the perception of luminosity in any part of the spectrum. We ascertained the point of extinction and the point of reappearance of light from all parts of the spectrum. F. W. EDRIDGE-GREEN.

London, December 25, 1912.

The late Mr. Leigh Smith and Novaya Zemlya.

MAY I be allowed to point out to you that there is an omission in the short notice your publication quoted from *The Times* on the death of Mr. Leigh Smith?

Your countryman was found and rescued on the west coast of Novaya Zemlya, near the mouth of Matotschkin Sharr, by Captain J. Dalen, Dutch R.N., who was in command of the Dutch exploration vessel, *Willem Barents*. Sir Allan Young, in the *Hope,* was near, but Leigh Smith and his men did not know it when they were found and directed to the English ship by the Dutchmen. This occurred on August 3, 1882.

Next year, when the *Willem Barents* again left for exploration work in northern waters, Sir Clements Markham and Mr. Leigh Smith came over to Amsterdam and presented two fine silver cups to the president of the Dutch Committee for Polar Research Work in kind remembrance of his being seen and brought to safety by Captain Dalen and his crew.

This act of courtesy by Mr. Leigh Smith was much appreciated by our countrymen.

W. H. R. v. MANEN.

Rotterdam, January 10.

COUNTRIES AND CUSTOMS.[1]

(1) THE jealousy of the State Government renders Nepal perhaps the least-known country in the Empire among those with which we maintain friendly relations. To a student of art like the writer it is peculiarly interesting, because it forms a link between India and Tibet. Mr. Brown was allowed some liberty in visiting the sacred sites in the valley; but if he secured any new information on geography or politics he has not disclosed it. On the subject of Newar art he gives us some valuable facts and impressions. The Gorkhas, now the ruling caste, have contributed little to the art treasures of the country, and the art of the Newars represents a Tibetan substratum largely influenced from India. But it is the India of the Middle Ages, not that of the present day, when the people have come under foreign control, Mohammedan or British. The book is provided with many fine photographs, and a few sketches in colour to illustrate Newar architecture and work in metal, stone and wood. The author traces with skill the varied influences which have contributed to establish the Nepalese art school, and he gives some interesting facts, partly in corroboration, partly in extension, of those admirable essays on local religion and custom for which we are indebted to the late Dr. H. A. Oldfield. The pleasant, unaffected style in which these notes are recorded makes them more valuable than those which usually accompany books the claim of which to support lies in the illustrations alone.

(2) Our knowledge of Papua is rapidly increasing. Mr. R. Williamson's book on the Mafulu Mountain People, the work of an explorer and expert in ethnology and law, has been soon followed by the present work, which is of quite a different class. Mr. Murray admits his lack of scientific knowledge in ethnology, geology, botany, and indeed in any other branch of science; but he enjoys the advantage of long experience of the country, and Sir W. MacGregor assures us that "he has had opportunities of seeing into the heart of things in New Guinea in a way that no previous writer could ever lay claim to." This opinion is justified by the study of his book. He begins with a careful geographical account of the British province, followed by a history of the island from the age of the first explorers, an exhaustive account of the native tribes, of the methods under which the Australian officers administer justice, and of the progress in developing the resources of the country. The book is provided with a fairly adequate map and a good series of photographs.

In an interesting introduction, Sir W. MacGregor describes the task which lay before the new officials, the establishment of a land system, criminal and civil legislation. He concludes that "the two finest and best institutions I left in New Guinea were the constabulary and village police, and the missions." The book is almost purely ethnographical. The Papuo-Melanesians, he thinks, were the result of more than one immigration; but he declines to dogmatise on the origin and affinities of the Papuans. Students of cannibalism will find full details of the custom in a repulsive form. Most interesting, and full of instruction to other administrators whose lot lies among savage peoples, is the account of the methods by which the natives are being gradually civilised, and how a system of law, adopting all that is useful among the indigenous institutions, has been introduced. The book may be safely recommended as an instructive account of some of the wildest races in the Empire.

(3) The fine volume which describes this attempt to explore North China is, to some extent, the record of a failure. In the expedition organised and financed by Mr. R. S. Clark, of New York, it was proposed to start from T'ai-yuan Fu, in Shansi, and after traversing Shên-Kan, *i.e.*, the provinces of Shansi and Kansu, to skirt the Tibetan border to Ching-tu Fu, in Schuch'uan; then to descend the Min River to Sui-fu or Hsu-chou Fu, and return to Shanghai *viâ* the Yang-tzu. Its primary objects were—a careful plane-table survey of the whole route followed, astronomical observations for latitude and longitude at all important towns, to observe the meteorological conditions, to collect specimens, and to use photography in various ways. The work of the survey was placed in charge of a Punjabi surveyor, Hazrat Ali; Captain Douglas, V.C., D.S.O., of the Royal Army Medical Staff, was allowed by the

[1] (1) "Picturesque Nepal." By Percy Brown. Pp. xvi+205. (London: A and C. Black, 1912.) Price 7*s*. 6*d*. net.
(2) "Papua or British New Guinea." By J. H. P. Murray. With an Introduction by Sir William MacGregor, G.C.M.G., C.B. Pp. 388+plates+map. (London: T. Fisher Unwin, 1912.) Price 15*s*. net.
(3) "Through Shên-Kan. The Account of the Clark Expedition in North China, 1908–9." By Robert Sterling Clark and Arthur de C. Sowerby. Edited by Major C. H. Chepmell. Pp. viii+247+64 plates+2 maps. (London: T. Fisher Unwin, 1912.) Price 25*s*. net.

War Office to take charge of medical affairs, and Dr. A. de C. Sowerby was zoologist, our countrymen being thus largely represented on the scientific staff. The expedition crossed the Yellow River, went into winter quarters at Yen-an Fu, and thence the route lay roughly westward. But at Lan-chou, Hazrat Ali, while engaged in surveying, was murdered in circumstances which were never fully ascertained, and the popular excitement thus aroused necessitated the return of the party. It is much to be regretted that, in spite of every kind of pressure on the Chinese Foreign Office, no reparation has been made for this atrocious murder of a British subject.

Colossal Buddha, at Ta-fu-ssŭ, Shensi. From "Through Shên-Kan."

In addition to the account of the journey which was thus tragically interrupted, a careful itinerary and a good map are provided. Mr. Clark and Dr. Sowerby contribute reports on the results. Most of the collections, except the insects which Captain Douglas has presented to the British Museum, have gone to the United States National Museum. Some interesting mammals, including a new three-toed jerboa (*Dipus sowerbyi*) and a polecat (*Vormela negans*), were found; but the record in other departments is rather disappointing. On the whole, considering the disaster which brought the expedition to a close, much useful work was done, and the splendid series of photographs makes the work of permanent value to science.

A NEW INTERNATIONAL PHYSICAL INSTITUTE.

IN the year 1911 an account was given in this journal (vol. lxxxviii, p. 82) of a conference of scientific men in Brussels to discuss the general theories of radiation. This meeting, which was of unusual interest and importance, was due to the initiative of Mr. Ernest Solvay, of Brussels. At the conclusion of the meeting, Mr. Solvay offered to donate a sum of money to assist scientific research in the domain of physics and chemistry. After consultation with Prof. Lorentz, of Leyden, the president of the meeting, Mr. Solvay agreed to found an International Physical Institute for a limited period of thirty years, to have its headquarters at Brussels. The resources of the institute were provided by the generous donation of a capital sum of one million francs. Part of the proceeds is to be devoted to the foundation of scholarships for the promotion of scientific research in Belgium, part to defray the expenses of international meetings to discuss scientific problems of interest, and the residue to be awarded in the form of grants to scientific investigators to assist them in their researches.

For the first year, which terminates on May 1, 1913, a sum of about 17,500 francs is available for the latter purpose. It is the intention of the committee each year to give grants for special lines of work. As the first international meeting was engaged in the discussion of the theories of radiation, it is proposed this year to assist preferentially researches on the general phenomena of radiation, comprising Röntgen rays and the rays from radioactive bodies, general molecular theory, and theories of units of energy. The grants will be awarded without distinction of nationality by the administrative committee of the institute on the recommendation of the international scientific committee.

The administrative committee is composed of Profs. P. Heger, E. Tassel, and J. E. Verschaffelt, of Brussels; the scientific committee is composed of H. A. Lorentz (Haarlem), Mme. Curie (Paris), M. Brillouin (Paris), R. B. Goldschmidt (Brussels), H. Kamerlingh-Onnes (Leyden), W. Nernst (Berlin), E. Rutherford (Manchester), E. Warburg (Berlin), and M. Knudsen, secretary (Copenhagen).

The requests for subsidies should be addressed before February 1, 1913, to Prof. H. A. Lorentz, Zijlweg 76, Haarlem, Holland. They should be accompanied by definite information on the problem to be attacked, the methods to be employed, and the sum required. Definite regulations have been drawn up for the administration of the institute and for the periodical change of the members of the international scientific committee, which are intended to be representative of the active scientific workers in physics and chemistry in Europe.

Mr. Ernest Solvay has in the past been a very generous supporter of science, and has been responsible for the endowment of several scientific institutes in Brussels. The new Solvay International Institute, which is due entirely to the generosity of Mr. Solvay, is unique in character, and promises to be of great value to science. It will offer an admirable opportunity for scientific men of all nations to meet together and to exchange views on questions connected with physics and chemistry, and to obtain a consensus of opinion as to the best direction in which grants should be given to extend or deepen our knowledge of special subjects. As the funds available for distribution are limited, the decision of the committee to restrict the grants for each year to investigations in a special department of science seems a wise one, and should be more fruitful in results than if the money were distributed in small sums over a wide field of scientific inquiry. The subjects for which grants are available will, no doubt, be changed from time to time in accordance with the decision of the international committee.

E. RUTHERFORD.

THE BIRMINGHAM MEETING OF THE BRITISH ASSOCIATION.

THE arrangements for the forthcoming meeting of the British Association in Birmingham are being actively proceeded with, and the following provisional statement shows how matters stand.

Among the new features of the British Association meeting at Birmingham in September next there will be a complete series of "Citizens' Lectures." These are intended to give working men and women the opportunity of taking part in the association's meeting. They will be held each evening (except the first evening and Sunday evening) and will constitute a perfectly distinct branch of work from the regular activities of the association.

In view of the central and accessible position of Birmingham, a large attendance of members is anticipated, and a local fund of 6000*l.* is being raised in order that the arrangements may be worthy of the city. A sum of 4000*l.* has already been promised as the result of a private canvass, and a public appeal for the remainder has just been issued.

The meeting will commence on Wednesday, September 10, after an interval of twenty-seven years since the last visit to Birmingham. The usual opening business meetings will then be held, and will be followed by the inaugural address of the president (Sir William White, K.C.B.) in the evening. On Thursday, September 11, the sectional meetings will commence, and the programme includes an evening reception by the Lord Mayor (Lieutenant-Colonel E. Martineau) at the Council House. On the Friday, in addition to the usual programme of sectional and committee work, there will probably be a reception at the new University Buildings, Bournbrook, and special arrangements will be made to show members over the various scientific departments. In the evening one of two discourses will be given.

The excursions on the Saturday will include Stratford, Coventry, Kenilworth, Warwick, and Shrewsbury; whilst special expeditions will be arranged for archæologists, botanists, geologists, and geographers. On the Sunday there will be special services at the Cathedral and other places of worship. The following day there will be an entertainment given by the local committee. On Tuesday, September 16, the draft programme includes a conference of delegates, a garden party in the afternoon, and the delivery of the second discourse in the evening. The usual closing business meetings will be held on Wednesday, September 17.

LORD HALDANE ON EDUCATIONAL ORGANISATION.

THE announcement made by the Lord Chancellor on Friday last, in replying to the toast of his health as the guest of the Manchester Reform Club, will be welcomed by all who have the interests of English education at heart. Speaking after consultation with the Prime Minister, the Chancellor of the Exchequer, and the President of the Board of Education, Lord Haldane said the next great social problem with which the Government intends to deal is education and its organisation. As readers of NATURE will know, the British Science Guild and other important bodies working for the provision of a properly coordinated and complete system of education have long urged the need for action on the part of the State if this nation is, in the coming keen competition for the markets of the world, not to be outclassed by nations which have organised their educational forces.

It may be hoped that this great question will be approached in the spirit of Lord Haldane's remarks, and that our legislators will unite in building up a complete national system of education suited to modern needs.

In the course of his address Lord Haldane said:—

In what I am going to say I am not speaking casually, or with any light sense of responsibility, but, after consulting with the Prime Minister and the Chancellor of the Exchequer and Mr. Pease, we have decided that this question is the next and the most urgent of the great social problems we have to take up. Of course, it is education. The state of education in this country—elementary, secondary, and higher—is chaotic, and my colleagues and I feel that the time has come when a step forward must be taken and on no small scale. As a second message, Mr. Lloyd George sends word that his heart is in this question just as it is in insurance, and that he is ready to throw himself into it with the whole-heartedness with which he threw himself into the insurance question. After consultation that is what we think. As a nation England has never been sufficiently interested in education to stir up its leaders about it. That arises partly from the fact that the leaders themselves have not thrown themselves into the education question sufficiently to stir up the nation. Now is the time for the leaders to make an effort, and that is what the Prime Minister and the Chancellor of the Exchequer think. How is it to be done? Education, if it is to be interesting, must be an appeal to the spirit. It must be an endeavour to raise the level intellectually and morally of the coming generation, upon whose superiority the country will depend in the days to come to meet growing competition. It is worth while making a sacrifice to bring about that result. I do not want you to be under any illusion. It is a tremendous question which we have before us. It is a costly question, too, but I will point out that the expenditure is productive expenditure.

In looking at the balance-sheet in the matter we must not look only at the debit items. If the nation is educated as it should be, the charge for old-age pensions will be smaller than it is now, because there will be fewer people left with less than 13*l*. a year. Income tax will yield more, because more people will be over the income tax limit. The taxes will yield more because the production of the country will be greater. Education means increased power of production. Then the bill on what I may call the negative side of the account will be smaller. Smaller payments will be necessary on account of crime and drunkenness. All social shortcomings will be less among better educated people. We must keep up the capacity of this country to lead in the production of the world. The cost of education on a great scale, even though it involves a great sacrifice, is a sacrifice well made.

We intend to try to make education an interesting subject. I wish that we had Matthew Arnold again among us, writing as he wrote thirty-five years ago. One thing is quite certain—what is about to be done for the coming generation must not be done at the expense of the ratepayer. In Scotland there is a university to one and a half millions of the population; in England a university to three and a half millions. Some remedy for that must surely be found.

A national system of education must be not merely elementary, secondary, or university, but it must be one entire whole, and it must start from this—the child must be made fit to receive the education. A great step forward in that direction has already been made. Then we must remember that though we are making provision by which children may have chances of becoming university students, the bulk of them will not get beyond the elementary school, and full provision must be made for them to do the best that they can within their limits. We must do something substantial in the way of making the teacher's profession more popular.

I am not speaking in the air on this question. We have been busy with the experts for some time, and I should not have ventured to speak as I have done if we did not see pretty clearly the path along which we are going. When we come to work out these things comprehensively it is marvellous how difficulties disappear. I see no reason to despair of our accomplishing rapidly such a reform in our educational system as should put us at least on a level with any other nation in the world.

NOTES.

THE scientific world has lost one of its veterans by the death of Louis Paul Cailletet in Paris on January 5. Born in 1832, at Chatillon-sur-Seine, he studied at the School of Mines and the Faculty of Sciences at Paris. His first work was in metallurgy, and he made many scientific investigations into the principles of cementation and puddling. Later work on the theory of smelting led him to investigate the properties of gases under pressure. As a result of an admirable series of researches he was able to announce in 1877 that he had liquefied oxygen by cooling produced by sudden release from considerable pressure. The same result was obtained by Pictet at Geneva in the same year by a different method, and quite independently. Later investigations enabled all the so-called permanent gases to be liquefied with the exception of hydrogen, which was left for Wroblewsky, who had been his pupil, and much of the later work of Amagat, Dewar, Kamerlingh Onnes, Linde, and Claude was the direct result of his methods and discoveries. In conjunction with Mathias, investigations on vapour pressures and critical volumes led to the discovery of the law of the rectilinear diameter, which has had such fruitful results. Always devoted to scientific work, he became much interested in aviation, acting for many years as the president of the Aëro Club of France. The Academy of Sciences elected him a corresponding member in 1877, and gave him the Jecker prize and elected him an academician in 1884. In 1910, on the occasion of his academic jubilee, he was proclaimed the father of modern cryogenics.

ZOOLOGISTS and naturalists interested in the big game of East Africa, and sportsmen wanting to know something of the country, of the methods of transport and of the paraphernalia for a hunting trip, will not regret spending a couple of hours at the Holborn Empire, where some of the results of Mr. P. J. Rainey's recent photographic studies of wild animals are being shown by the Jungle Film Company of

America. The exhibition consists of a series of moving pictures, the sequence of which, to relieve the eyes of the audience, is periodically interrupted by a show of ordinary slides, the whole depicting various incidents and adventures that happened during the trip. The best and most interesting pictures were taken behind an artificial screen at a water-hole, which was visited by elephants, giraffes, zebras, oryxes, baboons, and other species, the scene being enlivened by a fight between two rhinoceroses and by the sensational death of one of them, which charged the photographer in a disconcerting manner. The main object of the expedition was, however, to trap and photograph, not to kill. One of the scenes depicting the struggles of a trapped hyæna is perhaps needlessly prolonged, not to say painful, and the attempt of the expositor to rob the creature of the well-deserved sympathy of the audience by abusing him as a scavenger and body-snatcher will appeal only to the childish-minded, and it will, of course, be well known to English sportsmen that the idea of hunting lions with dogs, which is claimed as a novel feature of the trip, was regularly practised more than half a century ago by that intrepid sportsman Gordon Cumming.

JOHN NAPIER of Merchiston made the first public announcement of his invention of logarithms in 1614, and an English translation of his work was issued two years later, that is, one year before his death. Announcement having been made of a proposal to celebrate the tercentenary of Napier's discovery next year, it may be of interest to state the position of the matter. The Royal Society of Edinburgh has invited the cooperation of other scientific and educational bodies in arranging for this celebration, and the great majority of these institutions and corporations have nominated representatives upon the general committee, which will be convened at an early date to consider the whole question. Among the bodies which were invited by the Royal Society of Edinburgh to cooperate were the Edinburgh Town Council, the universities and technical colleges of Scotland, the Faculty of Actuaries, the Merchant Company, the Heriot Trust, the Edinburgh Committee for the Training of Teachers, the Chamber of Commerce, Merchiston Castle School, and the like. The only societies outside Scotland which were asked to send representatives to the general committee were the Royal Society of London and the Royal Astronomical Society, these being respectively included because of their national importance as the highest representatives of science in our country and of that particular science of astronomy which was the first to benefit by Napier's great invention. We understand that nothing has yet been decided as to the character of the celebration; a congress of calculators and an exhibition of all kinds of aids to calculation in the form of tables or instruments have been mentioned; but no scheme can be definitely adopted until the general committee has met.

WE are informed that Vittorio Emanuele III., King of Italy, has consented to the use of the prefix "Royal" by the Italian Geographical Society.

SIR RICKMAN GODLEE, president of the Royal College of Surgeons, will deliver the Hunterian oration in the theatre of the college on Friday, February 14, at four o'clock.

THE death is announced, at eighty years of age, of Dr. W. H. Dickinson, past-president of the Royal Medical and Chirurgical Society and of the Pathological Society, and at different times Croonian, Lumleian, and Harveian lecturer, as well as censor, of the Royal College of Physicians.

THE Geological Society of London will this year award its medals and funds as follows:—Wollaston medal, Rev. Osmond Fisher; Murchison medal, Mr. G. Barrow; Lyell fund, Mr. S. S. Buckman; Bigsby medal, Sir Thomas Henry Holland, K.C.I.E., F.R.S.; Wollaston fund, Mr. W. W. King; Murchison fund, Mr. E. E. L. Dixon; Lyell fund, Mr. Llewellyn Treacher; Barlow-Jameson fund, Mr. J. B. Scrivenor and Mr. Bernard Smith.

PROF. GUIDO CORA informs us that the fall of a house in Rome on January 8 was clearly registered at the Collegio Romano Observatory by an Agamennone seismograph at 4.26 a.m. The first earth movement came from the north-east, corresponding to the position of the Via del Tritone, where the fall occurred, by which fifteen people were killed, and afterwards the ground continued to vibrate for twenty minutes.

LIEUT. FILCHNER, the leader of the German Antarctic expedition, returned from the south to Buenos Aires on January 7. He has apparently crossed an ice-belt of great width (1200 nautical miles), and discovered, last February, a new land in 76° 35′ S., 30° W., extending to 78° or 79° S., to which the name of King Luitpold has been given. Its boundaries and extent are by no means clearly defined in reports to hand. Lieut. Filchner declares himself satisfied with the results, but the expedition has returned earlier than was expected, and he expresses the hope that work will be carried on. There is later to hand a report of dissension between the members of the nautical and scientific staffs of the expedition, which, it is to be hoped, may not have prejudiced the work.

GERMAN geographers and their colleagues elsewhere are concerned over rumours of disaster to the German expedition in Spitsbergen. The ship has been abandoned in the north at Treurenberg Bay, and though it may be salved in the summer, it is by no means certain that the crew and staff, or some of their members, are not lost or in extremity, for the leader, Lieut. Schröder-Stranz, was away on a sledging journey from which he had not returned. Captain Ritschel, with infinite difficulty and much suffering, has made his way to Advent Bay, and a relief expedition has been organised. The original party was not apparently prepared to winter in the field.

CAPTAIN EINAR MIKKELSEN's account of his expedition to north-east Greenland, presented at the meeting of the Royal Geographical Society on January 13, sounded like a chapter of accidents successfully overcome. At the very first, in the summer of 1909, he was delayed with trouble over his dogs, and those he obtained appear to have done him but poor service. Much additional labour devolved upon himself and his companion, Iversen, who made the journey to Danmarks Fjord, and they had to struggle as well against privation, and, from time to time, sickness. They were in large measure dependent on caches of provisions, the contents of which might or might not prove sufficient for their needs, and on obtaining game, the appearance of which was problematical. Captain Mikkelsen outlined his discoveries relating to the important work of the Mylius Erichsen expedition, as it was his main object to recover the records of the lost leader and his companions, Brönlund and Hoeg-Hagen. He was successful, and referred to the serious import to his own plans of the report left by Erichsen of the non-existence of the Peary channel. This channel Mikkelsen had intended to follow to the north-west coast. By his experiences of boat-work among the ice, and of journeying over the sea and inland ice, and coastwise, Mikkelsen has added comprehensively to our knowledge of the conditions of travelling in Greenland.

M. A. PRAZMOWSKI contributes a second study on the nitrifying organisms of the group Azotobacter in the *Bull. Internat. de l'Acad. des Sciences de Cracovie* (No. 7B, July, 1912). Azotobacter is a true Schizomycete, though it has affinities both with the protozoa and with the unicellular algæ. Its pre-eminent function is to fix nitrogen, and it is probable that it can obtain nitrogen either from nitrogenous compounds or from the free nitrogen of the atmosphere.

MALARIA is prevalent in the Andaman Islands, Bay of Bengal, and a valuable report on the subject has been furnished by Major Christophers (Scientific Memoirs of the Government of India, No. 56, 1912). The chief carrier in the settlements is the anopheline mosquito *Nyssomyzomyia ludlowi*, a species which breeds in and about salt swamps, and was not found at a greater distance from salt or brackish water than half a mile. It was proved to carry the malignant tertian parasite, and it is quite probable that it carries all forms of the malaria parasite.

DR. WIELOWIEJSKI has directed our attention to an article by Prof. Hofer in the *Osterreich. Fischerei Zeitung* (No. 21, 1912) on the biological purification of sewage effluents, &c., by means of fish. Tanks have to be provided, in extent at the rate of one hectare (2·5 acres nearly) per 2000–3000 persons. They work well even in winter, when covered with ice, and are quite equal in efficiency to irrigation in sewage farms, and financially the return is better than from sewage farms, as 500 kilograms of fish (carp) are reared per hectare (in what time is not stated).

IN spite of the enormous and rapidly increasing output of zoological literature at the present time, it is surprising what a large number of well-known types, constantly studied by students in the laboratory, remain inadequately described. A good general account of the morphology of such forms is always valuable, even if it be restricted to some particular system of organs, and we welcome the appearance in the *Zeitschrift für wissenschaftliche Zoologie* of two monographs of this kind. The description by Rudolf Hillig of the nervous sytem of *Sepia officinalis* (*op. cit.*, vol. ci., part 4) is a detailed and admirably illustrated piece of work, which cannot fail to be widely useful, though we fear that but few students will be able to find time to follow it out in all its intricacies. The same remarks apply with equal force to the more comprehensive account by Erich Reupsch of the anatomy and histology of the common Heteropod, *Pterotrachea coronata* (*op. cit.*, vol. cii., part 2).

Two notable monographs on the invertebrate fauna of Japan have recently been published in the Journal of the College of Science, Imperial University of Tokyo. The first (vol. xxx., art. 2) is on "The Errantiate Polychæta of Japan," by A. Izuka, and contains a systematic account of the group illustrated by twenty-four plates. The term "errantiate," instead of "errant," strikes us as being somewhat peculiar, and we do not remember to have seen it before. The second (vol. xxix., art. 2) is a posthumous work on the actinopodous Holothurioidea, by the late Prof. K. Mitsukuri, whose death was such a grievous loss to zoological science. This work has been edited by Prof. I. Ijima and Mr. H. Ohshima, and is illustrated by admirable text-figures of the calcareous skeletal elements and plates of external form. The coloured illustrations, drawn from life, are very beautiful, and for quaintness of form and colour it would be difficult to find any invertebrate to surpass *Enypniastes eximia*.

OBSERVATIONS made on Long Island at the beginning of June, 1911, have enabled Dr. L. Hussahof, in *The American Naturalist* for December, 1912, to obtain new information with regard to the breeding habits of the sea-lamprey (*Petromyzon marinus*). It has been considered that fertilisation in these lampreys is internal—a supposition which may be explained by the fact that the eggs can develop parthenogetically, but in ordinary cases normal fertilisation takes place. Both this formation and spawning occur in a kind of nest made in the bed of a stream by carrying away stones in the circular sucking mouth until a basin-shaped depression is formed, on the bottom of which sand accumulates. Like eels, lampreys never return to the sea after spawning. Death appears to be mainly due "to the cycle of metabolic processes initiated on the maturing of the gonadial products"; but this may be aided by reduced vitality due to the labour of removing stones from the nest, and also by the development of "fungus" in the self-inflicted wounds made during the breeding season.

THE determination of the magnitude of the experimental error in agricultural field trials has recently attracted considerable attention in this country, and has now been investigated in the United States by Prof. Lyttleton Lyon, of Cornell. The results are published in the Proceedings of the American Society of Agronomy, and afford interesting confirmation of those obtained at Rothamsted and at Cambridge.

MESSRS. LAUDER AND FAGAN have issued in bulletin form (Report 26, Edinburgh and East of Scotland Agricultural College) a summary of their investigations on the effect of heavy root feeding on the milk of cows. They show that the feeding of a ration containing a large quantity of water does not reduce the percentage of fat or increase the percentage of water in the milk. A more concentrated ration certainly yields a larger quantity of milk, but the turnip ration, on the other hand, gave richer milk and at a lower cost.

AN account has been published from the Entomological Laboratories of the Agricultural Research Institute, Pusa, of the Tetriginæ (Acridiinæ), by Dr. J. L. Hancock. The members of this subfamily are so variable in structure and coloration that difficulty is experienced in drawing specific distinctions between some of the closely allied forms. The author has carried out a systematic arrangement of the species, and has succeeded in dividing the members of this genus into two groups by the characters of the frontal costa and the position of the superior paired ocelli.

THE existence of circular currents in the Sea of Japan, we learn from *The Japan Chronicle*, Kobe, of December 19, 1912, has been established by Dr. Wada, the meteorologist of the Korean Government-General. Great weight is attached to the discovery by Japanese authorities, who regard it as having an important bearing on the distribution of marine life and even on human migrations in East Asia. Dr. Wada carefully studied the movements of nearly 400 mines, laid in Vladivostok Bay by the Russians and Japanese during the war, which drifted on to the coasts of Japan, and further observed the drift of 120 bottles thrown into the Sea of Japan from a steamer belonging to the Government. From the data obtained, Dr. Wada concludes that the Liman current, running down from the Siberian coast, flows southward past Kang-won and Ham-gyong Provinces, Korea; from Cape Duroch the stream sweeps round to the coast of Echizen, Japan, whence it goes northward along the coast of Japan together with the Tsushima current. One stream goes out into the Pacific through the Tsugaru Strait, and another stream continues northward to Tartar Strait, where it rejoins the Liman current, thus forming a complete circle.

SHORTLY after the great Valparaiso earthquake of August 16, 1906, attention was directed to certain luminous phenomena that were observed before, at the time of, and after the earthquake. The observations have recently been analysed by Count de Montessus de Ballore, the director of the Chilean Seismological Office (*Bollettino* of the Italian Seismological Society, vol. xvi., pp. 77–102). The total number of records collected is 136. Of these 44 are decisively, and 16 implicitly, negative; in 38 cases some lights of an indefinite character were noticed; in the remaining 38 records the observation of luminous phenomena is more or less explicit. Many of the negative records are communicated by persons accustomed to scientific investigations, and in some cases contradict alleged observations of lights at the same places. It does not follow that the lights, when observed, were connected with the earthquake, for, in the centre and south of Chile, a storm raged during the night of the earthquake, and it was from this part of the disturbed area, and not from the epicentral district, that most of the observations came. Count de Montessus therefore concludes that, for the Valparaiso earthquake at any rate, the connection of the luminous phenomena with the earthquake is not proven.

IN *Science* of December 6 Prof. J. E. Church, jun., in charge of Mount Rose Observatory, on the summit of a peak of the Sierra Nevada Mountains (altitude 3292 metres), gives an interesting account of its plans and progress. The meteorological station is at present the highest in the United States, and was established privately a few years ago for the purpose of ascertaining the minimum temperatures at that point; it was subsequently attached to the University of Nevada. Although the staff only occupies the observatory during part of the year, the station is well provided with specially constructed self-recording instruments, and bids fair to become of considerable importance in the study of mountain meteorology. Among the main problems which occupy attention may be mentioned (1) the prediction of frosts at lower levels and the relationship of the former to the passing of storms over the summit. A temperature survey has been in progress for two seasons for the purpose of delimiting areas suitable for fruit-growing, and several auxiliary stations have been established at various levels. (2) The influence of mountains and forests on the conservation of snow. A special bulletin on this subject is now being prepared. Prof. Church points out that "forests may be too dense as well as too thin for the maximum conservation of snow." The ideal forest seems to be one filled with suitable glades, which may be produced by judicious pruning or by proper planting.

UNDER the title, "A Class of Periodic Orbits of Superior Planets," Prof. F. R. Moulton, in a paper reprinted from the Transactions of the American Mathematical Society, xiii., 1, discusses the problem of three bodies of a distant particle moving subject to the attraction of two finite bodies which revolve about the common centre of gravity, with special reference to the case of nearly circular orbits.

IN a note contributed to the *Atti dei Lincei*, xxi., (2), 7, Dr. Giovanni Giorgi considers the solution of problems in elasticity where after-effect (the *Nachwirkung* of Boltzmann) is taken into account. The object is to show that when any problem in statical elasticity has been solved, the corresponding solution in the present instance can be deduced by substituting an expression involving a differential operator for the constant modulus of elasticity.

VARIOUS definitions of a curve have been given by Jordan, Schönflies, Young, Veblen, and others. In the Memoirs of the College of Science and Engineering, of Kyoto, Japan, Mr. Takeo Wada examines these and proposes a new definition of a simple curve, based, like those of Veblen and Young, on the theory of sets of points. It is shown that this definition of a curve is equivalent to that of Jordan, and it appears independent of the dimensions of the space in which the curve exists.

PART 2 of vol. viii. of the Bulletin of the Bureau of Standards contains a complete description of the work done by Messrs. E. B. Rosa, N. E. Dorsey, and J. M. Miller in determining the value of the international ampere, which deposits 1·11800 milligrams of silver in one second, in terms of the absolute ampere, which is one-tenth of a c.g.s. unit of current on the electromagnetic system. The method used is that of the Rayleigh current balance of the single moving-coil type. The balance itself was a 30-cm. beam Rueprecht, from one pan of which the moving coil was suspended between two coaxial fixed coils. The coils were water-cooled so as to minimise convection currents in the air. The ratio of the radii of fixed and moving coils, 50 and 25 cm. respectively, was found by using them as concentric galvanometer coils. The quantity directly measured by the authors was the electromotive force in international volts at the ends of a standard ohm carrying one absolute ampere, but by comparing their result with that of Messrs. Rosa, Vinal, and McDaniel, giving the international volts at the ends of the resistance when an international ampere passed through it, they find that the absolute ampere deposits 1·11804 milligrams as against the international ampere, 1·11800 milligrams, of silver in one second.

THE past year has been notable as regards the smaller electrical apparatus in that great development has taken place in domestic electrical appliances. Both manufacturers and central station engineers have at last awakened to the fact that in order to compete with the gas companies in cooking and other appliances an organised campaign is necessary to bring before the public at large the advantages of the smaller electrical domestic apparatus as produced at the present time. Consequently the engineers of municipal undertakings and supply companies have been working hard to bring the hitherto comparatively unknown domestic electrical appliances before their consumers, and the manufacturers also by improved and simplified heating units have largely contributed to the success of this campaign. The present year should see a reasonably cheap and economical electric oven put on the market to compete with the everyday gas cooker, which at present, on account of its low initial cost, still holds the field against the electric oven among the general public. Several English manufacturers have also during the past year put down extensive plant for the production of small electric motors and fans, the greater part of which up to quite recently were imported from Germany and Italy.

REPRODUCTIONS from photographs of H.M. submarine-boat *E4* appear in both *Engineering* and *The Engineer* for January 10. This boat is of the latest type, constructed by Messrs. Vickers, Ltd., at Barrow-in-Furness, and is of large size and great speed. The surface speed of about sixteen knots is obtained from heavy oil-engines of more than 1500 brake-horse-power. It is understood that the vessel is nearly 180 ft. in length and 23 ft. in beam; the submerged displacement is about 800 tons. A wireless telegraphy mast is fitted, and there is a large rudder at deck level, which improves the steering of the vessel when submerged. It is also stated that the vessel accommodates disappearing guns. When travelling at the surface, *E4* draws about 12 ft. of water. Very little authoritative information has been given regarding vessels of the *E* class, for obvious reasons.

THE fortieth year of publication is reached by the 1913 issue of "Willing's Press Guide." The volume provides an admirable index to the Press of the United Kingdom, and useful lists of the principal Colonial and foreign periodical publications. The journals and proceedings of the various scientific and other learned societies are duly indexed.

THE address on "The Place of Mathematics in Engineering Practice," delivered by Sir William White before the International Congress of Mathematicians at Cambridge last August, and referred to in our report of the proceedings of the congress (September 5, vol. xc., p. 4), has been published in full in our comprehensive contemporary *Scientia* (vol. xii., N. xxvi.-6), the London agents of which are Messrs. Williams and Norgate.

OUR ASTRONOMICAL COLUMN.

THE SUN'S MAGNETIC FIELD.—The question of the sun possessing a magnetic field, similar to the terrestrial magnetic field, is discussed, especially with regard to the phenomena of the sun's upper atmosphere, by M. Deslandres, in No. 27 of the *Comptes rendus* (December 30, 1912). He first discusses the matter theoretically, and, supposing the magnetic field to be produced by the rotation of the sun's electric charge, shows that a solar ion expelled vertically from the sun should be so deviated by the field as to describe a helix having its axis parallel to the field; if many luminous ions are expelled in the form of a prominence the helical motion at the base of the prominence, as seen from the earth, will depend upon the position of the prominence in the solar magnetic field. From a number of observations, M. Deslandres shows that the recorded phenomena are in accordance with the demands of the theory, and he accepts as certain the existence of a general magnetic field about the sun, similar to that of the earth, and in general much more feeble.

THE INTEGRATED SPECTRUM OF THE MILKY WAY.—The Harvard analysis of the spatial distribution of the spectra of more than 32,000 stars indicates that the Sirian type predominates in the Milky Way, and therefore the integrated spectrum of the galaxy should be of the A type. To test this conclusion Dr. Fath has actually secured spectra of certain large areas of the Milky Way, and finds that his results are not exactly confirmatory. With the special spectrograph he used for his work on the zodiacal light, he exposed a plate for a total of 30h. 20m. on the rich region of the Milky Way that is partially bounded by the stars γ, δ, and λ Sagittarii; a second plate was exposed for a total of 65h., and gave better results.

The general character of the spectrum so secured is solar in that it shows the F, G, H, and K lines, and three broad absorption bands more refrangible than K; a bright line is suspected at $416\mu\mu$, but may be merely a subjective phenomenon due to contrast. Plates of other regions were taken, and agree in indicating that the integrated spectrum of the Milky Way is of the solar type.

Dr. Fath suggests that his result differs from that obtained at Harvard because he dealt with altogether fainter stars, and that beyond a certain undetermined magnitude stars of the solar type predominate. A perfectly independent photographic investigation also indicates that, in the mean, the fainter stars of the Milky Way are the redder. These results, if they prove to be perfectly general, are most important from the cosmological point of view. (*Astrophysical Journal*, vol. xxxvi., No. 5, p. 362.)

Comets due to Return this Year.—Mr. Hollis, continuing a function performed by the late Mr. W. T. Lynn for many years, discusses briefly in *The Observatory* (No. 457) the periodic comets due to return this year. Holmes's comet, period 6·86 years, is due to pass perihelion early in the year, but the conditions are not very favourable; it was observed in 1899 and 1906. Finlay's comet, period about 6·5 years, was discovered at the Cape in 1886, and was observed in 1893 and 1906; at the latter return it passed perihelion on September 8. Both these comets are of the Jupiter family, to which also belongs the object (1906IV) discovered by Dr. Kopff in 1906, and calculated to have a period of 6·67 years. Two other comets may appear, but are not expected with any great confidence. The first, discovered by Mr. E. Swift in 1894, was considered to be possibly identical with de Vico's lost comet, but has not been seen since, although a thorough investigation gave a period of 6·4 years. Finally, Westphal's comet of 1852, calculated to have a period of about sixty years, may appear, and five search-ephemerides for it have been published by Herr Hnatek in the *Astronomische Nachrichten*, No. 4619.

Parallax Investigations.—In parts iii. and iv., vol. ii., of the Transactions of the Astronomical Observatory of Yale University, Dr. F. L. Chase and Mr. M. F. Smith publish the results of their heliometer observations of the parallaxes of forty-one southern stars, most of which have large proper motions. The methods employed and the individual results are discussed at length, and then the final results are collected into one table showing the magnitude, spectrum class, position, proper motion, and parallax of each object. Seven stars show a total proper motion exceeding 1″, and eight have parallaxes exceeding 0·1″; only two stars are common to both categories. The volume concludes with a valuable catalogue of the collected parallax results obtained at the Yale Observatory for nearly 250 stars.

EXPLOSIONS IN MINES.[1]

At the end of the report before us the Committee gives the following short summary of its principal contents:—

"A method is described by which the relative inflammability of different dusts can be ascertained by measuring the temperature of a platinum coil which just ignites a uniform cloud of dust and air projected across the coil fixed in a glass tube. It is shown that the relative inflammability does not depend upon the 'total volatile matter,' but on the relative ease with which inflammable gases are evolved.

"The order of inflammability so obtained corresponds in a remarkable degree with the percentage of inflammable matter extracted from the same coals by pyridine.

"We are of opinion that these two methods form a valuable means of discriminating between different coals in regard to the sensitiveness of their dusts to ignition. It must, however, be borne in mind that these tests have been made with dusts artificially ground and sieved to an equal degree of fineness, and since coals differ considerably in their power of resistance to pulverisation, the friability of a coal must be taken into account."

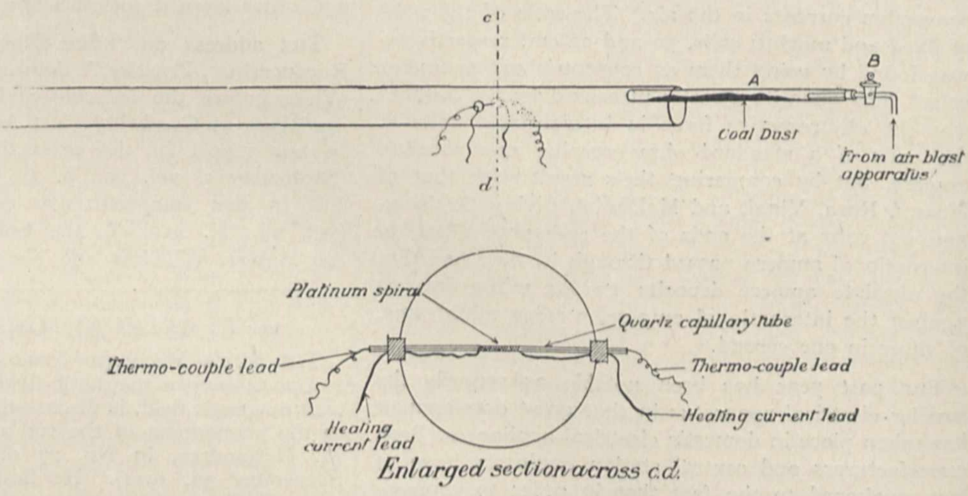

Fig. 1.—Apparatus for determining the relative ignition-temperatures of coal-dust clouds.

In the body of the report the subjects are discussed under three heads:—On the relative inflammability of coal dusts; the effect of the admixture of an incombustible dust with coal dust; and experiments on the relative inflammability of different coal dusts at Liévin. Three appendices deal, respectively, with the following subjects:—(1) The volatile constituents of coal; (2) the extraction of coal by pyridine; (3) analyses of coals and their relative ignition-temperatures.

From the results of the analyses contained in No. 1 appendix the Committee concludes that "all coals contain at least two different types of compounds of different degrees of ease of decomposition"; that coal "must be regarded as a conglomerate of which the degradation products of celluloses form the base and the changed resins and gums of the plants the cement"; that the latter are most readily decomposed by heat, yielding as gases mainly the paraffin hydrocarbons; that these are probably the substances which

[1] Second Report to the Secretary of State for the Home Department of the Explosions in Mines Committee. Cd. 6431. (London: Wyman & Sons, Ltd., 1912.) Price 7½*d*. The illustrations which accompany the present article are from this report, and are reproduced with permission of the Controller of H.M. Stationery Office.

have been shown by Bedson to be extractable in considerable quantity from coal by the action of pyridine; and that the inflammability of any particular kind of coal dust depends more upon the proportion of paraffin-yielding substances contained in it than upon that of its volatile matter considered as a whole.

The apparatus employed by the Committee for ascertaining the temperature of ignition of different kinds of coal dust resembles that previously employed for the same purpose by Bedson and Widdas, and by Taffanel, in so far that, in each, a small cloud of fine dry dust (1 or 2 grams) is projected by a puff of air into a tube, or closed space, in which it is raised to the temperature of ignition by coming more or less closely into contact with an electrically-heated surface or spiral of platinum wire. Bedson and Widdas had no means of measuring the temperature of ignition directly, but hoped to determine it by calculation from the varying number of amperes required to effect ignition with different kinds of dust. In this they were disappointed in consequence of the alteration which the coil of platinum wire underwent owing to the adhesion of particles of dust to it. Taffanel and the Committee, on the other hand, both measure the temperature by means of a thermo-couple. It will be sufficient, for present purposes, to describe the appliances used by the Committee.

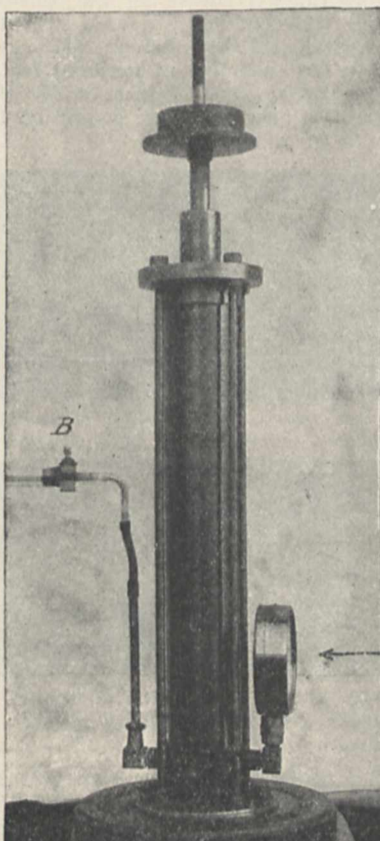

FIG. 2.—Apparatus for giving a constant puff of air.—A brass cylinder 65 cm. long and of 11 cm. internal diameter is fitted with a weighted piston. For the experiments, the weight employed is such as to give a pressure of 2 lbs. per sq. in.

The puff of air is produced by opening a stopcock *B*, Figs. 1 and 2, in a tube one end of which communicates with the interior of a vertical brass cylinder at its bottom end. The cylinder, which is 65 cm. long by 11 cm. in diameter, is provided with a weighted piston, which gives a pressure of 2 lb. per sq. in. to the air in its interior. The other end of the tube with the stopcock is connected to a larger tube A (Fig. 1), 2·5 cm. in diameter by 45 cm. long, in which a charge of about 2 grams of sieved and dried dust is laid along the bottom. The latter tube is supported near the upper side of a third horizontal glass tube, 8 cm. in diameter by 140 cm. long, open at both ends, as shown. A thin-walled quartz tube of capillary bore, with a platinum coil of 32 gauge wire, 17 mm. long by 1·5 mm. in diameter, closely wound upon its outside, and with a platinum and platinum-rhodium thermo-couple passing through it, extends horizontally across a diameter of the larger tube at a point 40 cm. from one end. The thermocouple is connected to a mille-voltmeter calibrated to read to temperatures on the Centigrade scale. The cross-section in Fig. 1 shows the disposition of the various connections and the position of the platinum spiral. By the adjustment of an external resistance the coil can be heated to any desired temperature up to 1400° C.

If ignition takes place freely when the dust-cloud is puffed into the combustion tube, the temperature of the coil is lowered 10 or 20 degrees, and another trial made, and so on, until the dust-cloud does not ignite. The mean of the two last observations is then taken as the ignition-temperature.

The following observations regarding the dust of a coal (224 N) containing 2·11 per cent. moisture, 35·70 per cent. volatile matter, 59·99 per cent. fixed carbon, and 2·20 per cent. ash, which was passed through a 240 mesh sieve, and dried for an hour at 107° C., may be given as an illustration of the method of finding the temperature required:—

Temperature of platinum coil.	Result.
1040° C.	Ignition. Flame propagated rapidly to end of tube.
1020° C.	Ignition. Slow propagation of flame.
1000° C.	No ignition.
1010° C.	No ignition. A few sparks round coil.

Ignition-temperature, 1015° C.

Fig. 3 shows two photographs of the flames produced in this apparatus.

A table on p. 9 gives the relative ignition-temperatures of a number of different dusts the total volatile matter of which, calculated on ash-free dry coal, varies from 41·77 per cent., with an ignition-temperature of 1065° C., to 26·02 per cent., with an ignition-temperature of 1095° C. The intermediate results are so incongruous amongst themselves that the Committee can discover no relationship between the percentages of volatile matter and the ignition-temperatures.

On the other hand, a similar table on p. 10, which gives the percentage extracted by pyridine, shows also that while the dust of one coal with a total proportion of volatile matter amounting to 32·14 per cent., and a percentage of 37·9 extracted by pyridine, ignites at a temperature of 1005° C., that of another, containing 36·3 per cent. of volatile matter, and a percentage of only 22·1 extracted by pyridine, requires a temperature of 1090° C. to produce ignition.

While fully alive to the fact that the relationship between ignition-temperature and percentage extracted by pyridine cannot be expected to hold rigidly, the Committee is of opinion that the results obtained up to the present are encouraging, and intends to continue the investigation on the same lines.

In the experiments on mixtures with a coal dust the ignition-temperature of which was 1005° C. when pure (passed through a 240 mesh sieve and heated to 107° C. for an hour), it was found that with 80 per cent. coal dust and 20 per cent. shale dust the ignition-temperature was 1095° C.; with 80 per cent. coal dust and 20 per cent. calcium carbonate, 1095° C.; and with 96 per cent. coal dust and 4 per cent. sodium bicarbonate, 1095° C., and similarly with smaller percentages of the inert substances.

M. Taffanel's apparatus, experiments, and conclusions are described in the "Cinquième série d'Essais sur les Inflammations de Poussières," published in August, 1911, but space fails us to do more than mention them in this place.

Appendix I. is an abridgment of two papers—by Dr. Wheeler and M. J. Burgess—contained in vol. xcvii. and vol. xcix. of the Transactions of the Chemical Society, which deal with the destructive distillation of coal and the products evolved from it at different temperatures. Appendix II. is a description of the method of extracting those matters contained in coal that are soluble in pyridine, by means of a Soxlet fat-extraction apparatus, of which an illustration is given. Appendix III. is a table of analyses (ultimate and proximate) of forty-six different samples of coal. It also contains the percentage (on ash-free dry coal) extracted by pyridine, and the relative ignition-temperature of each.

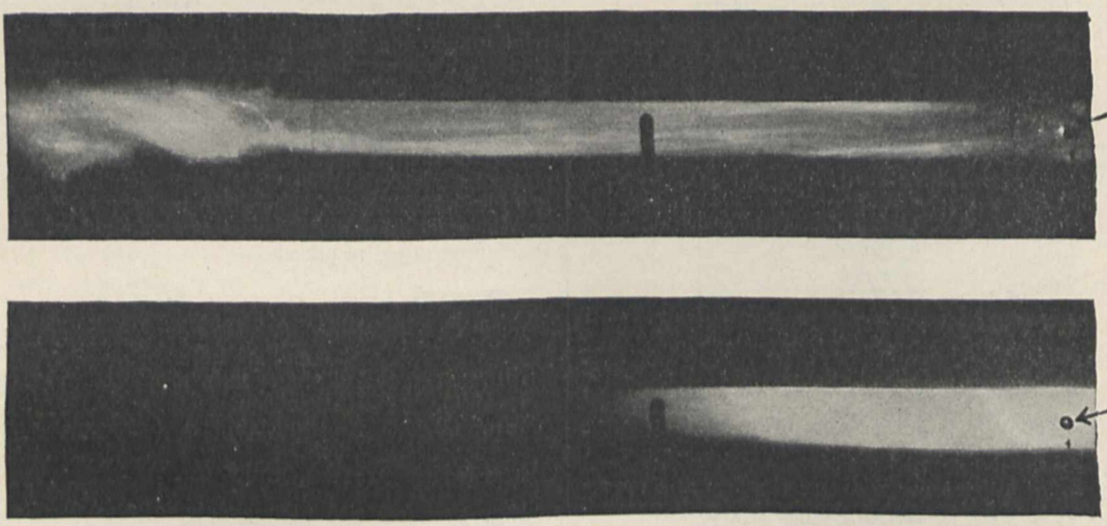

FIG. 3.—Typical photographs of the flames produced on the ignition of coal-dust clouds. The igniting-coil is at A.

The members of the Committee are to be congratulated on the ingenuity displayed in the construction of the apparatus for ascertaining the ignition-temperature of more or less combustible dusts. The results of their experiments, as well as those of M. Taffanel in the same direction, are, in themselves, exceedingly interesting, and may, in some as yet occult manner, tend towards the prevention of colliery explosions. They would undoubtedly be of service if an attempt were made, at any time, to classify mines according to the more or less inflammable nature of the coal dust produced in them. But as the attempt to do this in Germany led to disastrous results in the case of at least one mine[2] in which the coal dust was supposed to be innocuous, the experiment is obviously a highly dangerous one.

W. GALLOWAY.

[2] Carolinenglück, February 17, 1898: 116 killed.

THE BONAPARTE FUND OF THE PARIS ACADEMY OF SCIENCES.

THE committee of the Paris Academy of Sciences appointed to deal with the distribution of the Bonaparte Fund for the year 1912 has made the following recommendations, which have been accepted by the academy:—3000 francs each to MM. Louis Gentil, Pallary, J. Pitard, and Bouguil, members of the scientific expedition to Morocco. This expedition will undertake geological, zoological, botanical, and agronomical researches with a view to the future development of the country. 3000 francs to Prof. de Martonne and his fellow-workers, Jean Brunhes and Émile Chaix, for assisting the publication of a collection of morphological documents, entitled "Atlas Photographique des Formes du Relief Terrestre." 3000 francs to Louis Dunoyer for the construction of apparatus for the complete study of absorption and fluorescence spectra of the alkali metals. 3000 francs to M. Hamet, for collection of material for his work on the Crassulaceæ. 2500 francs to M. Bosler for the purchase of a prism of large dispersion for studying planetary spectra. 2500 francs to M. Baldit, for the purchase of self-recording instruments for studying the electrical phenomena of the atmosphere. 2500 francs to Paul Pascal for apparatus required for the study of absorption in the ultra-violet by substances the magnetic properties of which have been previously studied. 2500 francs to M. Schlegel, for assistance in his work on some Crustacea. 2000 francs to M. Sauvageau, for assistance in his studies on the distribution of the Cystoseira. 2000 francs to M. Welsch, to assist him in the continuation of his geological work. 2000 francs to M. Bierry, to defray the expenses of his proposed work on the metabolism of the carbohydrates. 2000 francs to Dr. Mawas, to allow him to continue his experiments on the mechanism of the accommodation of the eye. 2000 francs to M. Gruvel, to assist him in his exploration of the bay of Lévrier from the zoological, oceanographical, and geographical points of view.

Awards from this fund are not given as prizes for completed work, but are given to workers of proved competence for assistance in carrying out definite researches.

THE WEATHER OF 1912.

THE almost complete absence of summer weather and the frequent rains at almost all seasons have rendered 1912 memorable. The bad weather was more noticeable by contrast with the magnificent weather of 1911. The summer contrast for the two years was dealt with in NATURE for September 19, 1912, pp. 71–73.

LONDON RESULTS.

1912	Temperature Means						Rainfall			Sunshine	
	Max.	Min.	Max. and Min.	Diff. from average	Days above average	Frosty nights	No. of rainy days	Total fall	Diff. from average	Daily mean	Diff. from average
	°	°	°	°				In.	In.	Hours	Hours
January	44·9	36·0	40·4	+2·0	19	8	18	3·03	+1·15	0·89	−0·51
February	48·6	38·6	43·6	+3·8	23	7	21	1·73	+0·25	1·33	−0·78
March	53·3	40·5	46·9	+4·4	26	1	19	2·58	+1·06	2·97	−0·39
April	59·8	39·4	49·6	+1·5	17	2	2	0·04	−1·53	7·47	+2·44
May	67·5	46·5	57·0	+3·2	24	—	12	1·29	−0·63	6·15	−0·26
June	69·5	49·3	59·4	−0·9	11	—	18	2·35	+0·31	7·29	+0·81
July	74·9	54·4	64·6	+0·9	15	—	11	1·24	−1·16	5·34	−1·91
August	66·7	50·1	58·4	−4·5	1	—	26	4·27	+1·93	3·69	−3·09
Sept.	60·8	46·5	53·7	−4·5	4	—	5	2·11	−0·04	3·96	−1·26
October	57·1	39·3	48·2	−2·2	9	2	14	1·88	−0·90	3·96	+0·88
Nov.	48·3	39·3	43·8	+0·4	17	6	16	1·55	−0·67	0·89	−0·83
Dec.	50·5	40·7	45·6	+5·8	26	2	21	2·82	+0·99	0·86	+0·07
Year	58·5	43·4	50·9	+0·8	192	28	183	24·89	+0·76	3·73	−0·40

The Greenwich observations given in the foregoing table are taken from the reports of the Meteorological Office. The mean temperature for the year is 50·9°, which is 0·8° in excess of the average. From June to October inclusive July was the only warm month. In both August and September the deficiency was 4·5°, and in the two months combined there were only five warm days. December, with the mean of 45·6°, was 5·8° in excess of the average. There have only been two Decembers since 1841 with a higher mean; these were 46·2° in 1852, and 45·8° in 1868. The excess of temperature in March was 4·4°, and the month in some districts was the mildest during forty years. There were only twenty-eight days with frost during the year.

The wettest months of the year were August, January, December, and March. There were only five days without rain in August, and only ten dry days in December. The driest month was April, with a total rainfall of 0·04 in., and at some places in the south-east of England the month was rainless.

The year's sunshine was 1364 hours, and the sunniest month was April, with a duration of 225 hours, which is 85 hours in excess of the average, and it was double the duration registered in August, which, with its 114 hours, was the least sunny month of any from April to October inclusive.

The summary for the year given by the Meteorological Office from the results for the fifty-two weeks ended December 28 shows that the greatest excess of rain in any district was 9·57 in. in the south-west of England, whilst in all the English districts, except the north-west, the excess was more than 5 in. The west of Scotland was the only district with a deficiency of rain, and there it was less than an inch short of the average. The duration of bright sunshine was deficient over the entire kingdom; the greatest deficiency amounted to 0·9h. per day for the year in the north-east of England, and 0·8h. per day in the east of Scotland, the south-west of England, the south of Ireland, and the Channel Islands.

CHAS. HARDING.

SCIENCE TEACHING IN PUBLIC SCHOOLS.[1]

IN the period of more than sixty years during which I have watched the progress of education in this country, no feature seems to me to stand out more prominently in that progress than the entrance and establishment of science in a recognised place in the tuition of our public schools. At the beginning of the period the teaching of even the rudiments of a knowledge of nature formed no part of the ordinary curriculum of study. Here and there, indeed, there might be found an enlightened headmaster or other teacher who, impressed with the profound interest and the great educational value of the natural sciences, contrived to find time amid his other duties to discourse to his pupils on that subject, and sought to rouse in them an appreciation of the infinite beauty, the endless variety, the ordered harmony, and the strange mystery of the world in which they lived. He might try to gain their attention by performing a few simple experiments illustrative of some of the fundamental principles of physics or chemistry, or by disclosing to their young eyes some of the marvels which they might discover for themselves among the plants and animals of the countryside. Such broad-minded instructors, however, were rare, and were far ahead of their time.

There were then no special science teachers, no school laboratories, no proper school museums. The range of instruction in the public schools still lay within literary lines, pretty much as it had existed for centuries; excellent, indeed, so far as it went, but somewhat out of date, and no longer in keeping with the modern advance of knowledge and culture all over the world. Boys left school, for the most part, profoundly ignorant of nature, save in so far as they had been able to pick up information by the way, from their own observation, reading, or reflection. At the universities they fared little better. Chairs for the cultivation of various branches of science had indeed been founded there. But the duties of the professors were usually considered to consist chiefly or solely in the delivery of lectures, which were sometimes dull enough, and, where not required in reading for degrees, would attract but scanty audiences. An enthusiastic or eloquent professor might gather around him a goodly company of listeners as, in geology, Buckland used to do at Oxford and Sedgwick at Cambridge. But the laboratory work and experi-

[1] From the presidential address delivered to the Association of Public School Science-masters on January 8 by Sir Archibald Geikie, K.C.B., Pres.R.S.

mental demonstrations, now admitted to be so essential, had scarcely begun to be instituted in the universities. Lord Kelvin's famous physical laboratory, one of the earliest institutions of the kind in this country, was started by him only about the year 1850, and that of his friend Tait at Edinburgh some years later.

But the discoveries of modern science last century and the far-reaching effects of their practical applications in everyday life were arousing rapidly increasing attention in the community. Natural knowledge was seen to be both of supreme interest in itself and of paramount importance on account of the many ways in which it could minister to the welfare of man. It was impossible that education could long remain unaffected by this widespread appreciation. Alike on the schools and on the universities the force of public opinion began to make itself felt. Ere long a momentous step was taken by a Royal Commission which was appointed to inquire into the public schools, and which, in its report, "strongly recommended the introduction and fostering of natural science in these schools." The Public Schools Act, which embodied the recommendations of the Commission, was passed in 1868, and may be regarded as marking the definite starting point of this great reform.

Of course, the adoption of science teaching in the public schools has not everywhere made the same progress throughout the country. As was to be expected, it has been unequal, depending as it did on the disposition of the authorities at each school, as well as on the accommodation and funds available. In one or two schools the position of science is perhaps nearly as good as is at present required, and the rest are gradually improving. Everywhere the spirit of compromise and amity has prevailed, and there seems to be on all sides a general desire to meet the requirements of the science side, so far as the circumstances of each school will permit.

If from the schools we turn to the universities, we see that the advance of the provision for the sciences has there been still more rapid. Not only have the older seats of learning widened their range of studies and largely increased the facilities for scientific research, but newer universities have sprung up in different centres of population, with the dominant purpose of developing scientific training and promoting the prosecution of original investigation. As a further and significant proof that the community at large has awakened to the importance of making natural science one of the branches of education, we must also take account of the multiplication of secondary schools having a scientific element, and the rise of technical schools and colleges.

This retrospect of the past half-century and the outlook which it discloses for the future cannot, I think, be contemplated without considerable satisfaction by the reasonable advocates of science who are not swayed by an inborn spirit of iconoclasm. The advance which has been made may not have been as rapid as these reformers desire, or as we all hoped for. But it has been real, it is still in progress, and we may believe that it will now advance more equally and rapidly over the whole country.

But while I am of opinion that we have cause to rejoice over what has already been accomplished, I do not wish to draw too roseate a picture of the present state of the science teaching in this country, or of the position and prospects of the science-masters. I well know that these teachers are in many cases confronted with serious difficulties which hamper them in their work. They are, so to say, newcomers into the educational system of the country, and the subjects which they teach have consequently neither the prestige nor the position held by the long-established literary studies. Such a state of matters is obviously one that can only be changed by the lapse of time, and let us hope that this lapse will not be prolonged. In the meanwhile, the science-masters, straining every nerve to make their teaching effective, will, by their success in kindling a love of science among their pupils and demonstrating the educational value of their teaching, take the most effectual way to establish the position of science and to further their own claims for consideration.

The necessity of providing several science-masters, where circumstances permit, raises the difficulty of finding places for them in the already crowded time-table of the school. This is undoubtedly a very serious problem. Each of the various subjects taught contends for what is thought adequate time. And in this competition undoubtedly the older subjects in the curriculum, being already in possession, and having strenuous defenders, are at a considerable advantage over those which have been recently introduced. But the difficulty is one which, in the hands of a sympathetic headmaster and with a spirit of goodwill among the members of his staff, ought not to be insuperable. Even without the curtailment or abandonment of any of the studies already in the field, it should be possible by tactful rearrangement to secure at least the time demanded for the minimum amount of science teaching which is indispensable. In my opinion this minimum should ensure that every boy at a public school shall be given the opportunity of obtaining a broad general idea of the scope and bearings of natural science and of having his apprehension stirred with regard to the manifold interest and charm of nature. This end cannot be properly attained by lectures alone, though these, from an inspiriting teacher and well illustrated with experiments or demonstrations, are invaluable. They require, however, to be supplemented with practical work by the pupils, wherein they can themselves handle apparatus, and thus gain a far more vivid and lasting knowledge of physical and chemical laws and processes than can be acquired in any other way. They must also learn the fundamental elements of biology and geology, studying not only with the teacher in the class-room, but with specimens of plants and animals in the laboratory or museum, and where possible in the field.

The true educator, no matter in what branch of discipline he may be engaged, is not a man whose chief aim is to cram into the minds and memories of his pupils as ample a store of knowledge as these will hold, and whose success is to be judged by the results of competitive examinations. If this is true on the literary, it is not less so on the scientific side. And on the latter the temptation to teach in that unfruitful way is probably greater than on the former. I have known more than one teacher of science possessing a wide acquaintance with his subject, yet quite incapable of making use of it as a stimulating educational instrument. Full of details, he would pour them forth in wearisome iteration, without the guiding thread of logical sequence that would have linked them intelligibly and interestingly together. Men who have within them no store of living fire are hopelessly incompetent to elicit any spark of it in their listeners. I hope such men are rarer now than they were in my younger days. If they have not passed with the dodo and the gare-fowl into the domain of extinct creatures, they should be zealously kept out of our public schools.

In all the educational world I can think of no task more delightful to undertake than that of the science-master. At the same time there are few which demand so wide a range of qualifications. To reach the highest success in his calling the science-master must, of course, be thoroughly versed in his subject, alike theoretically and practically. He should, if possible, be a man who has himself done some original research, or at least is intimately familiar with methods of experimentation and investigation, and able to guide his pupils along the lines of independent research. I am strongly of opinion that his efficiency will be much augmented if he has had a good literary as well as a scientific training. When he enters on his teaching career he will soon find the great advantage of a cultivated style, both in discoursing and in writing. Unfortunately some able men of science who have neglected the literary side of their education cannot arrange their thoughts in proper sequence or express them with clearness and terseness. I would urge the science-master to keep his hold on literature, ancient as well as modern. Many a time when weary with his labours, and discouraged, perhaps, by the difficulties wherewith they are beset, he will find in that delightful field ample consolation and refreshment.

But, above all, the science-master must be thoroughly in love with his subject and possess the power of infusing some of his affection for it into his pupils. His evident and genial enthusiasm should be infectious and become an inspiration that appeals to his boys in everything he does, whether as he lectures and demonstrates to them in the class-room or as he shows them how to work in the laboratory. There are probably few other callings in the educational domain where the personal touch, the stimulating influence that springs from earnest devotion to a subject, has so many opportunities of manifesting itself and tells more promptly and powerfully on the pupils. The teacher who is gifted with such an inspiring power may do more in the way of developing a love of science with the meagre outfit of a parish school than a man without this influence can do with all the resources of a modern laboratory.

RADIATIONS OLD AND NEW.[1]

WHEN, therefore, X-rays are projected into any material we must think of them as a stream of separate entities, each one of which has complete independence of its neighbours and pursues a life of its own. It changes to a β ray and back again; as a β ray it is liable to loss of energy and much deflection, so that those rays which do not pass through the body but are held therein end as electrons moving about in the body with the velocities of thermal agitation; that is to say, with those velocities which free electrons in the body must possess on account of the share which they take in carrying the heat of the body.

Now we may ask ourselves what will be the result if transformations continue to take place at these lower energies; for the moment let us assume that they do. Let us consider some substance like a block of metal. Within it we know that there are innumerable electrons travelling to and fro with various speeds. In their motion is stored up energy; the communication of heat to the body makes them dance more quickly. When the quicker motion is begun in one part of the body, diffusion hands on the motion to the rest; that is to say, heat has been conducted through the body. If we try to pass an electric current through the body, it is the movement of the electrons that constitutes the current. This is the accepted theory at the present time. It is even possible—but this is not accepted by all—that the energy of the moving electrons in the body constitutes the main store of heat therein. The electrons do not all move at the same speed, of course; but there is a certain well-known distribution of their energies about a mean value. At any time a certain percentage of the electrons are moving with speeds lying within definite limits, although the individuals possessing such speeds are continually changing. If we now take into account the transformations of which I have been speaking, we find that there must be X-ray quanta—this name will do for them as well as any others—in such numbers as to be in equilibrium with the electrons of every variety of speed. In the case of the X-rays and electrons which we have been handling in our experiment, we find that the greater the energy the larger the number of X-ray quanta required to be in equilibrium with the corresponding electrons, for quanta of large energy are transformed into electrons much more rarely than quanta of small energy, whereas electrons of large energy are transformed as often, and perhaps more often, than those of small energy. Thus the distribution of energy amongst the quanta is not the same as the distribution amongst the electrons; in the former there is a much larger number—relatively—of the quanta of larger energy.

The electrons which we are considering have very little power of penetration or of breaking away from the substances in which they are. At high temperatures, when they move more quickly, there is a considerable emission, an effect which has been much studied recently. But at ordinary temperatures the emission of electrons is small. Recently R. W. Wood has suggested that there must be an "aura" of electrons surrounding a conductor and extending a minute distance away, since only in this way can we account for the fact that electricity passes freely from one conductor to another when they are separated by a space of the order of a wave-length of light. But if the electrons have such difficulty in breaking away from a substance, this is not true of the X-ray quanta. If they behave like those we have been investigating of recent years, they have far greater powers of penetration than the electrons, and every body must be emitting them in streams. Moreover, if bodies be placed near each other, there will be an interchange which will hand energy from one to the other until there is an equilibrium. If a hot body is placed near a cold one, the former contains some electrons and corresponding quanta of great energy, and as these stream over to the cold body, they go through transformations which permit of loss of energy, since for a time they put the energy into electron carriers which can exchange, and do exchange, energies with others—through the mediation of the atoms, it may be. X-ray quanta have not that power of themselves. Thus in time the two bodies are brought to the same temperature.

In this way we have a conception of radiation which on the surface differs from that which is ordinarily held. But does it do so really? May it be that we have merely found a different method of regarding the processes of radiation? If so, that would be a very good thing, for it is one of the best aids to inquiry to have more than one hypothesis which will link together a number of experimental facts. Nor need we be afraid if the hypotheses differ considerably. On the contrary, that means that we have the greater number of interesting things to discover between the two points of view and their final point of convergence.

Now we know that when light falls upon material substances there is an emission of electrons of slow speed; in other words, light radiation resembles

[1] Evening discourse delivered on September 6, 1912, before the British Association at Dundee by Prof. W. H. Bragg F.R.S. Continued from p. 532.

X-radiation in one important particular. Investigators have gone further. They have shown with considerable probability that the velocity of the ejected electron varies with the wave-length of the light; the shorter the wave-length, the swifter the electron. Moreover, there are lines of reasoning, worked out in great detail by Planck, Einstein, and others, which lead to the thought that light energy is contained in separate quanta; the shorter the wave-length, the more energy in the quantum. This is one of the most remarkable developments of modern physics.

It seems as if there was a strong invitation to consider radiation from this point of view. We ought not to think that in doing so we abandon the wave theory or its electro-magnetic development. Rather we might say that the radiation problem is too great to be seen all at once from any point to which we have hitherto attained, and that it is to our advantage to look at it from every side.

It would be quite fair, moreover, to say that there is something after all in the corpuscular theory of light. There is a very great deal of evidence, as I have already indicated briefly, for a corpuscular theory of X-rays; and it is widely held that the two forms of radiation are akin to each other. How can we hold a corpuscular and a wave theory of light at the same time?

If we say that radiation consists in the emission of quanta, each of which traverses space without spreading or altering in any way, and label this a corpuscular theory; and if, on the other hand, we suppose light to consist of wave-motions, and that we can resolve such wave-motions at any one time into elements each of which might exist alone and would then spread through space like a ripple on a pond; and if we say that the quantum in the one theory is to be matched with the element in the other, then, of course, the two theories are inconsistent.

But such inconsistencies are difficulties of our own making. If one hypothesis links together a number of observed facts, and a second hypothesis a somewhat different number; and if we think the two are inconsistent, the fault must be ours. We must be stretching one or other hypothesis to breaking-point, and we must work in the hope of finding a new hypothesis of greater compass. Until we do so, we are right to use those which are more limited; it is the way of scientific advance. So the great men of the past have done, as we may see readily.

Let us go back to the discussions of the close of the seventeenth century, the time when Newton, Huygens, Hooke, Pardie, and others debated the nature and form of light. A very important discovery had recently been made by Romer, who had shown by astronomical observations that light, which brought the news of the events taking place in space, took time to bring it; in others words, that light had a velocity. Romer had even succeeded in measuring the velocity with fair accuracy. Now Descartes had supposed the propagation of light to be instantaneous. He had considered it to be a pressure transmitted across a plenum between the luminous object and the eye; according to a well-known image, vision resembled the process by which objects are made manifest to a blind man, who feels for them with his stick and receives pressures transmitted thereby. Apart from the direct proof by Romer that this view was wrong, a very interesting objection to it is given by Huygens, who, after stating the Cartesian theory, remarks that "it is impossible so to understand what I have been saying about two persons mutually seeing one another's eyes, or how two torches can illuminate each other." That is to say, it is impossible to explain on a simple pressure theory the perfect facility with which rays of light traverse each other without injury. This mutual traverse of light rays interested Huygens exceedingly, and, as we shall see, influenced materially his choice of the hypothesis in terms of which he expressed the facts known to him.

Thus Newton and Huygens were led to introduce the idea of motion of some sort of matter as a fundamental point in their theories. They did so in different ways; and the distinction grew to be a cleavage between two schools of thought. It was not a very deep distinction at first; it would have been easy to have stepped from one side to the other of the dividing line. Only in later times did the corpuscular and wave theories stand immovable in hostile antagonism. It is not at all impossible that modern research will once more draw the two theories together.

The difference may be put in this way:—Newton imagined light corpuscles which moved in straight lines from the source of light to the recipient. thought that the "light" had the same carrier from beginning to end of its path. We should now express his idea by saying that the "energy" of the light had the same carrier; but Newton did not, of course, conceive of light-energy as a quantity to be measured and discussed. How far he was from this more modern idea is instanced by his supposition that the radiating power of the sun was conserved by the mutual radiation of its parts.

On the other hand, Huygens imagined the light to be passed on from particle to particle of the æther; that is to say, the energy was not carried by one particle all the way, but by relays. It must be remembered that he thought of the æther as a collection of particles resembling the particles of luminous bodies, but of smaller dimensions. The latter particles he supposed to float in a subtle medium which agitated them and made them strike against the particles of the æther, which thus became the seat of spreading impulses. We might compare the difference between the ideas of Newton and Huygens with the difference between the despatch of a message by a special runner and the spreading of a rumour.

Huygens has given two reasons for his choice of hypothesis: one, the extreme speed of light, which Romer had recently found; the other, the ease with which rays of light traverse each other. These induced him to reject the idea of the movement of matter through the whole of the distance from source to receiver, since he could not imagine how matter could move with so great a speed, nor could he conceive how material rays could pass through each other. He arranged æther corpuscles in a row between source and receiver, and supposed light to move along the row in the same way that a disturbance would move along a row of glass spheres placed so as to touch each other. Indeed, he filled all space with æther particles in contact so as to allow of the transmission of disturbances from any one point to any other. In such a plenum two disturbances might easily be imagined to cross each other without hindrance. To use an illustration which he gives himself, "If against this row (B C in Fig. 10) there are pushed from two

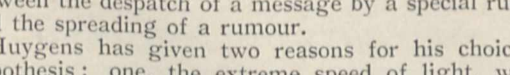

FIG. 10.

opposite sides at the same time two similar spheres A and D, one will see each of them rebound with the same velocity which it had in striking; yet the whole row will remain in its place, although the movement has passed along its whole length twice over." It is, of course, the movements, not the spheres, which traverse each other. Or we may arrange the experiment as in Fig. 11. If the balls A_1 and B_1 are pushed in the directions of the arrows so as to strike the rows they are shown approaching, the spheres A_3 and B_3 will spring forward and continue the lines of motion of A_1 and B_1, and the movements will have crossed each other without any injury. He conceived such a result to be beyond explanation on a theory like Newton's.

His hypothesis met also, as he thought, the other of the two fundamental requirements. The disturbance might be supposed to move as fast as was desired, even with the extreme velocity which light, according to Romer, possessed. For, as he says, "there is nothing to hinder us from supposing the particles of the æther to be of a substance as nearly approaching to perfect hardness and possessing a springiness as prompt as we choose." And another very important property of light was illustrated at the same time, viz., that the velocity in free æther was independent of the intensity.

It is to be observed that Huygens takes the ideas of hardness and impenetrability of matter which he has drawn from the behaviour of glass spheres and applies them to the molecules of the æther.

From what we have seen of the properties of the new rays we cannot allow Huygens any justification of the reasons which he gives for his preference for the wave theory. There were two, you will remember. In the first place, he supposed that matter could not move with so great a speed as light; yet you see that the α particles move practically as fast as he conceived light to move, and they are as material as anything else. Secondly, he argued that streams of matter could not interpenetrate each other; yet we see that atoms can pass through each other easily. Indeed, the more we consider the behaviour of the rays from radio-active substances, the more impossible appears the view that "particles" of any sort have boundaries which are limits to interpenetration. We see no reason for supposing that there is anything in the known universe which can retain a portion of space to its own exclusive use and forbid all strangers to enter therein.

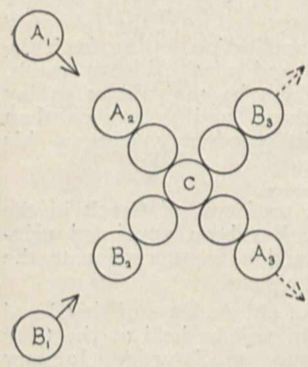

FIG. 11.

So the reasons which Huygens gives for his choice of a hypothesis are both mistaken; and we might think that this was a bad beginning for the structure which he built. But his true foundation was laid otherwise. The spreading-pulse theory suggested to him his famous construction of the wave front, which has been of such immense importance in the development of our knowledge of radiation. His construction gave a correct account of the phenomena of reflection and refraction, and, what was most wonderful, he found himself able to explain by its means the complicated motion of light in Iceland spar. In this way he began the marvellous development of the relations between light and crystalline structure which has roused the interest and admiration of the subsequent centuries. It is true that he had no idea of a regular succession of waves; in fact, he expressly states that he does not wish us to think of his pulses as following each other at regular distances. He did not explain colours, and he failed altogether to account for polarisation. But his hypothesis linked certain facts together, and was useful so far as it went.

It was Newton with his corpuscular theory who introduced the idea of periodicity in order to explain the colours of the soap film and other "thin plates"; who ascribed differences in colour to differences of frequency, and correctly described the phenomena of polarisation as due to the rays of light having sides, a description which could not be applied to the conception of Huygens. Newton was able to express many of the facts known to him in terms of vibrations of an all-pervading æther; he saw that in such case the longer vibrations would excite the sensation of red, and the shorter—the more refrangible—the sensation of violet. He actually supposed that such vibrations travelled along the optic nerves and carried the sensations to the brain, and he directed attention to persistence of vision as evidence of the "vibratory nature of the motions at the bottom of the eye." Heat he supposed to be conveyed by æther vibrations. He could express the behaviour of a soap film in respect to colour in terms of the wave theory with formal correctness, showing its dependence on the ratio between the thickness of the film and the wave length of light. But he preferred to express his ideas on a corpuscular model, because he could not otherwise explain the formation of sharp shadows, and deemed it impossible for a pulse on rounding a corner to spread so little as light. It was for this reason he rejected the theory of Huygens, and he was perfectly right. If we take Huygens's own model, if we project a billiard ball against a group of other balls in contact, as we might, somewhat inefficiently, start a game of pyramids, the energy of motion is scattered every way, and balls fly in all directions. Huygens never met this objection; it was not answered until the time of Fresnel, more than a hundred years afterwards. Newton was also impressed with the impossibility of varying the nature of light by transmission, reflection, or refraction, and ascribed all apparent changes of colour to sorting processes. As he says, "very small bodies conserve their properties unchanged in passing through several mediums, which is a condition of the rays of light." He was thinking of contemporaries who supposed that the colour of light was readily changed in deviation or transmission.

The essence of Newton's idea was the travel of light as an entity which did not spread or change as it went. He implied by the term "corporeity of light" no more than "something or other propagated every way in straight lines from luminous bodies without determining what that thing is, whether a confused mixture of difform qualities or modes of bodies, or of bodies themselves; or of any virtues, powers, or beings whatsoever." He strongly opposed a tendency to read more into his hypothesis than it was intended to hold. In these respects the X-ray resembles very closely the corpuscle which Newton conceived, so long at least as it remains untransformed. But if transformation occurs the electron generally loses energy, and a retransformed X-ray will have less energy than the original, a well-known process. It may be compared with the phenomenon of fluorescence, of which Newton knew nothing.

Now if X-rays are to be classed with light, as there are reasons for supposing, and as many do suppose with more or less conviction, then it must be acknowledged that Newton's conception has more value in it than the last century has been accustomed to grant. But we shall not therefore adopt Newton's theory as he left it. It is too obviously defective. It cannot explain diffraction, and his main reason for rejecting the wave theory was wrong. He gave no satisfactory explanation of the uniformity of the velocity of light in space. Even his explanation of the colours of thin films is defective. Moreover, he was hopelessly at sea, and, it may be observed, so was Huygens, in attempting to explain the absorption of light. Neither of them had at his command any mechanism but that of the collisions between particles of æther, particles of matter, and light corpuscles, and they could but juggle with the relative sizes of these things. Newton was very hard put to it to explain the difference between a perfectly transparent body and a perfectly black one, and was compelled to suppose it due to a small difference in the sizes of the particles of matter. Huygens would have liked to ascribe internal reflections at the surface of a piece of glass to collisions between the æther corpuscles and the particles of air outside, and was disconcerted by the fact that reflection took place equally well when there was no air at all. But it is quite unnecessary to follow the subject further, and discuss the contributions of Young and Fresnel, and the other men of famous names to whom the modern theories of radiation are due.

The point is simply this, that each of these great workers constructed for himself a hypothesis or model, which represented correctly certain facts known to him, and by its aid was able to use what he knew as a means to learn more. The results of his work depended upon the construction of his model, and his choice of the known facts he had made it to represent to a greater or less degree. For no one could construct a hypothesis which represented correctly all that was known. But if it was correct so far as it went it led to good results in a limited field.

Therefore it happens that hypotheses must always be diversified, and it is well for the possibilities of advance that they should be. If now we have a number of new facts regarding new radiations, if it turns out that they are to be carried over to the older radiations which have been studied for so long, and if the wave theory cannot absorb them at once, this means no rejection of the work of the past, no retracing of steps. It means rather the enriching of our opportunities of advance, in which all the good work which has been done in the past will tell as well as that which we may hope to do in the future.

If my observations are well-worn sayings, you will perhaps forgive the fact in the newness, and I should like to add, if I might, the appropriateness, of the illustration. It does, after all, make for our encouragement and efficiency if we remember that we are free to make any hypothesis we please, and that we are not to be judged directly for the choice we make, but indirectly for the use we make of it. Our reasons for choosing a scientific creed will probably be wrong; we cannot hope to do better always than Newton and Huygens. But perhaps we can do something with it which will be good and will last. It may contribute also to the general peace if we remember that our hypotheses are made, in the first instance, for our own personal use, and that we have no justification for demanding that others shall adopt the means which we find most convenient in the modelling of our own ideas.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The professor of anatomy has reappointed Dr. W. L. H. Duckworth to be senior demonstrator of human anatomy for five years from January 1, 1913, and Mr. D. G. Reid to be an additional demonstrator of human anatomy for the same period.

The Quick professor of biology has reappointed Mr. C. Warburton to be demonstrator in medical entomology as from October 1, 1912, to September 30, 1915.

The managers of the Balfour Memorial Fund give notice that the Balfour studentship will be vacant March 25. The names of applicants, together with such information as they may think desirable, should be sent on or before January 31 to the secretary, Prof. J. Stanley Gardiner, Zoological Laboratory, Cambridge.

OXFORD.—The master and fellows of University College intend to proceed, in the course of the Hilary Term, 1913, to the election of a fellow qualified to take part in the educational work of the college as prælector, with special reference to the chemistry schools, provided that a candidate suitable to the requirements of the college presents himself. Candidates must have taken a degree in a university of the United Kingdom or of the British Dominions beyond the Seas, and be unmarried. A stipend of at least 350*l*. per annum, including the emoluments of the fellowship, will be assigned to the fellow and prælector, so appointed, from the first, with prospective rise of salary proportionate to nature and length of service. The prælector in chemistry will not be precluded from undertaking further work in the University, outside the college, subject to the consent of the master and fellows from time to time. Candidates are requested to forward to the master of University College, on or before January 31, 1913, the following documents:—(1) A signed application setting forth the candidate's qualifications, and any evidence (such, *e.g.* as original work) which he may desire to lay before the electors; (2) three, and not more than three, testimonials from independent sources in his favour.

PROF. R. M. BURROWS, professor of Greek in the University of Manchester, has been appointed principal of King's College, London, in succession to the Rev. Dr. A. C. Headlam.

THE fifth annual dinner of old students of the Royal College of Science, London, will be held at the Café Monico, Shaftesbury Avenue, on Saturday, January 25. The president of the Old Students' Association (Sir William Crookes, O.M., F.R.S.) will preside, and the guests will include Sir Alfred Keogh, K.C.B., Sir Henry Miers, F.R.S., Sir Robert Morant, K.C.B., Lieut.-Col. Sir David Prain, C.I.E., Sir Amherst Selby-Bigge, K.C.B., Dr. R. T. Glazebrook, F.R.S., and Dr. H. Frank Heath, C.B. Tickets may be obtained on application to Mr. T. Ll. Humberstone, secretary of the Old Students' Association, 3 Selwood Place, South Kensington, S.W.

THE recently established University of Hong Kong is making rapid strides in the development of its various faculties, and attention is at present being specially directed to the provision of facilities for the practical study of pure and applied science. In an address delivered to the Institution of Engineers and Shipbuilders of Hong Kong last November, Prof. C. A. M. Smith, professor of engineering in the new University, made an eloquent appeal to men of wealth to assist in the important work of training Chinese students in modern science. "In Hong Kong," he said, "we wish to train men who know the East to develop China's natural resources. For that development they must obtain machinery—if we do our work aright we shall secure a market for those who are at home, and provide greatly increased freightage for the shipping to this port." Later he continued:—"We require at once machines for demonstration and experimental purposes. We want to equip laboratories for testing the materials of construction, such as steel, concrete, copper, &c. We want oil, gas and steam engines, and refrigerators, as well as dynamos and all sorts of electrical apparatus." As an inducement to manufacturers and others to give generously, Prof. Smith said:—"We will house your gifts and keep your samples running and in good condition. We will show your present and future customers the merits of your machines, and we will advertise your goods in the centre of the greatest market of the near future." There seems every likelihood that Prof. Smith will be successful in his efforts to secure well-equipped laboratories of a modern type. Already, we understand, the Chloride Electrical Storage Co., Ltd., of Manchester, has decided to present to the University of Hong Kong a complete battery of their chloride accumulators for use in the electrical laboratory. It may be hoped that ere long each of the pieces of apparatus in the list needed at the new University, which has been circulated widely by Prof. Smith, will be secured.

SOCIETIES AND ACADEMIES.

LONDON.

Mathematical Society, January 9.—Prof. A. E. H. Love, president, and temporarily Sir Joseph Larmor, treasurer, in the chair.—J. C. **Fields**: Proofs of certain general theorems relating to orders of coincidence.—W. E. H. **Berwick**: The reduction of ideal numbers.—A. E. H. **Love**: Notes on the dynamical theory of the tides.—W. H. **Young**: Uniform oscillation of the first and second kind.—H. **Bateman**: Some definite integrals occurring in the harmonic analysis connected with a circular disc.

Royal Astronomical Society, January 10.—Dr. F. W. Dyson, F.R.S., president, in the chair.—Dr. S. S. **Hough**: The periodic errors in the right ascensions of standard catalogues. In giving an account of this paper, Sir D. Gill explained in detail the method adopted at the Cape Observatory for obtaining great accuracy in meridian observations, notwithstanding some instability in the foundations of the instruments.—Prof. **Douglass** spoke on the records of solar radiation made in Arizona.—H. E. **Wood**: Work at Union Observatory, Transvaal, and photographs of Gale's comet. The comet had two straight tails, one of them of considerable length.—Rev. A. L. **Cortie**: Sun-spots and terrestrial magnetic phenomena, 1898–1911. Second paper, the greater magnetic storms. It was concluded that while a general state of sunspot activity corresponds with a general state of terrestrial magnetic activity, it requires the advent of a large spot, the influence of which extends in all directions, or a spot favourably situated in heliographic latitude, to disturb the equilibrium by the precipitation of a magnetic storm.—Prof. H. C. **Plummer**: The motions and distances of the brighter stars of the type B–B5, being a continuation of previous researches on stellar motions. The whole of the stars of the first type appear to be at about 200 light-years' distance, and to be very uniformly distributed in a plane, their motions being parallel to the Milky Way. The author considered that there were two star streams.—Mr. Eddington pointed out that the motions of the B-type stars were very small, and that they might be moving in a direction perpendicular to the Milky Way.—C. **Martin** and H. C. **Plummer**: The short-period variable SU Cygni. Prof. Plummer showed a diagram of the interesting light-curve of the star.

PARIS.

Academy of Sciences, December 30, 1912.—M. Lippmann in the chair.—H. **Deslandres**: The general magnetic field of the upper layers of the solar atmosphere. New verifications. Regarding the upper solar layer as strongly ionised, the behaviour of the ions in a magnetic field offers a simple explanation of the phenomena hitherto observed. Further experimental proofs are given.—A. **Haller** and Édouard **Bauer**: The formation of dimethylstyrolene, starting with phenyldimethylethyl alcohol. The alcohol was obtained by the reduction of phenyldimethylacetamide with sodium and absolute alcohol. Various by-products of the reaction are described.—The secretary announced the death of Paul Gordan, correspondant for the section of geometry.—J. **Guillaume**: Observations of the sun made at the Observatory of Lyons during the third quarter of 1912. The results of observations made on seventy-two days are given in tabular form.—M. **Luizet**: Elements of the orbit of the variable star RR Lion (BD+24°2183°).—Ch. **Gallisot**: The influence of the colour and magnitude in sudden variations of brightness of a stellar image. An account of a repetition of some experiments of Broca and Sulzer, for the case of luminous points.—Georges **Rémoundos**: The theory of M. Picard and algebroïd functions.—J. **Taffanel** and H. **Dautriche**: The detonation of dynamite No. 1.—G. **Eiffel**: The resistance of spheres in air in motion. An experimental study of the causes of the divergence of the author's results and those obtained at the aërodynamical laboratory at Göttingen. In the expression, $R=KSV^2$, in which R is the total resistance, S the diametral surface, V the velocity of the air, and K a constant, K is only really constant after a certain critical value of V has been reached. In the Göttingen experiments V was below this critical value. The existence of this critical velocity is of practical importance, and must be taken into account in apparatus used to measure the velocity of the wind, or of aëroplanes.—René **Arnoux**: A new method of steering aëroplanes by means of the motor.—Gustave **Plaisant**: A mode of cycloidal attack of the air.—A. **Korn**: The potentials of an attracting volume the density of which satisfies the Laplace equation.—F. **Croze**: New observations relating to the Zeeman phenomenon in the hydrogen spectrum. The author's experimental results are not in accord with those recently published by Paschen and Back. An account is given of further experiments on the cause of these discrepancies.—Guillaume de **Fontenay**: The action of inks on the photographic plate. The action is complicated, and varies greatly with the method of working.—Ch. **Boulanger** and G. **Urbain**: The theory of efflorescence. The influence of the magnitude of the crystal. An expression is given for the rates of loss of moisture of two crystals of different masses of the same material, and this is submitted to experimental confirmation with a special form of microbalance.—André **Brochet**: The relation between the conductivity of acids and their absorption by hide powder. The acid absorption is a general phenomenon, and is due to a chemical combination, since whatever acid is employed the amount absorbed is sensibly proportional to the chemical equivalent.—Jean **Bielecki** and Victor **Henri**: The quantitative study of the absorption of the ultra-violet rays by fatty acids and their isomeric esters. The absorption of ultra-violet rays by acids and esters is not determined by their empirical formula. It depends on the constitution of the molecule.—H. **Labbé**: The influence of alkaline salts on the elimination of urinary ammonia in normal dogs.—Michel **Cohendy** and D. M. **Bertrand**: Living sensibilised antistaphylococcus vaccine.—A. **Trillat** and F. **Mallein**: Study of the action of the filtrate or distillate of a fresh culture of *B. proteus* on the evolution of the disease caused by pneumococcus in mice.—E. L. **Trouessart**: Migrating and sedentary forms in the ornithological fauna of Europe.—Louis **Besson**: A periodic element in the variations of the barometer.

BOOKS RECEIVED.

The Milk Question. By Prof. M. J. Rosenau. Pp. xiv+309. (London: Constable and Co., Ltd.) 7s. 6d. net.

Introduction to the Rarer Elements. By Dr. P. E. Browning. Third edition. Pp. xiii+232. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd.)

Willing's Press Guide, 1913. Pp. xii+487. (London: J. Willing, Ltd.) 1s.

Weather Bound. By R. T. Smith. Pp. 320. (Birmingham: Cornish Bros., Ltd.) 15s. net.

The Value and Destiny of the Individual. The Gifford Lectures for 1912, delivered in Edinburgh University. By Dr. B. Bosanquet. Pp. xxxii+331. (London: Macmillan and Co., Ltd.) 10s. net.

Handbuch der Entomologie. Edited by Dr. C. Schröder. Lief. 1 to 3. (Jena: G. Fischer.) 5 marks each.

Das Bodenwasser und die Abkühlung des Meeres. By F. Nansen. Pp. 42. (Leipzig: Dr. W. Klinkhardt.)

The Sea West of Spitsbergen. The Oceanographic Observations of the Isachsen Spitsbergen Expedition in 1910. By B. Helland-Hansen and F. Nansen. Pp. 89+plates vi. (Christiania: J. Dybwad.)

Finländische hydrographisch-biologische Untersuchungen No. 10 Jahrbuch, 1911, enthaltend hydrographische Beobachtungen in den Finland umgebenden Meeren. Edited by Dr. R. Witting. Pp. 129+4 plates. (Helsingfors.)

Plant Diseases. By Dr. W. F. Bruck. Translated by Prof. J. R. Ainsworth-Davis. Pp. 152. (London: Blackie and Son, Ltd.) 2s. net.

DIARY OF SOCIETIES.

THURSDAY, JANUARY 16.

ROYAL SOCIETY, at 4.30.—The Effect of Junctions on the Propagation of Electric Waves along Conductors: Lord Rayleigh.—The Influence of Chemical Constitution upon Interfacial Tension and upon the Formation of Composite Surfaces: W. B. Hardy.—Duration of Luminosity of Electric Discharge in Gases and Vapours: Hon. R. J. Strutt.—Some Electrical and Chemical Effects of the Explosion of Azoimide: Rev. P. J. Kirkby and J. E. Marsh.—Factors Affecting the Measurement of Absorption Bands: H. Hartridge.—The Refraction and Dispersion of the Halogens, Halogen Acids, Ozone, Steam Oxides of Nitrogen and Ammonia; and the Causes of the Failure of the Additive Law: Clive Cuthbertson and Maude Cuthbertson.—Liquid Measurement by Drops: R. Donald.—The New Theory of Integration: Prof. W. H. Young.—Negative After-images with Pure Spectral Colours: Dr. G. J. Burch.—A New Method of Measuring the Torque produced by a Beam of Light in Oblique Refraction through a Glass Plate: Dr. G. Barlow.—The Positive Ionisation produced by Platinum and by certain Salts when Heated: Dr. F. Horton.

ROYAL INSTITUTION, at 3.—Birds of the Hill Country: Seton Gordon.

LINNEAN SOCIETY, at 8.—A Visit to Madagascar in Search of Subfossil Lemuroids: The Hon. P. Methuen.—Les Caridines des Seychelles, avec des Observations sur leurs Variations: Prof. E. L. Bouvier.—Psychodidæ of the Seychelles; Ephemeridæ of the Seychelles: The Rev. A. E. Eaton.—Odonata of the Seychelles: H. Campion.—A New Land Leech from the Seychelles: W. A. Harding.—Some New British Plants: G. C. Druce.

ROYAL SOCIETY OF ARTS, at 4.30.—Agricultural Progress in Western India: G. F. Keatinge.

INSTITUTION OF MINING AND METALLURGY, at 8.—(1) Some Considerations on the Specification of Theodolites for Mines; (2) Specification of a Precision-Theodolite (for Workings on Lodes of Medium Inclination and Narrow or Medium Thickness): L. H. Cooke.—Description of a Modern Lead Concentrating Mill, Broken Mill Junction North Mine, N.S.W.: S. C. Bullock.—The Blast Roasting of Sulphide Ores: J. H. Levings.

FRIDAY, JANUARY 17.

ROYAL INSTITUTION, at 9.—Further Applications of the Method of Positive Rays: Sir J. J. Thomson.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Indicators: J. G. Stewart.

MONDAY, JANUARY 20.

ROYAL SOCIETY OF ARTS, at 8.—Liquid Fuel: Prof. Vivian B. Lewes.

VICTORIA INSTITUTE, at 4.30.—The Fact of Prediction: Rev. J. Urquhart.

TUESDAY, JANUARY 21.

ROYAL INSTITUTION, at 3.—The Heredity of Sex and Some Cognate Problems: Prof. W. Bateson.

ROYAL STATISTICAL SOCIETY, at 5.—The Population of England in the Eighteenth Century: Prof. E. C. K. Gonner.

MINERALOGICAL SOCIETY, at 5.30.—Optical Activity and Enantiomorphism of Molecular and Crystal Structure: T. V. Barker and J. E. Marsh.—Note on the Determination of the Optic Axial Angle of Crystals in Thin-section: H. Collingridge.—Graphical Determinations of Angles and Indices in Zones: Dr. G. F. Herbert Smith.—The Goldschmidt Apparatus for Cutting Models of Crystals: J. Drugman.—A Nodule of Iron Pyrites: Prof. H. L. Bowman.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The London and South-Western and Metropolitan District Railways' Widening between Acton Lane and Galena Road: E. A. Ogilvie.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.

WEDNESDAY, JANUARY 22.

GEOLOGICAL SOCIETY, at 8.—The Fossil Flora of the Marske Quarry (Yorkshire): H. Hamshaw Thomas. With Notes on the Stratigraphy: Rev. G. J. Lane.—The Derived Cephalopoda of the Holderness Drift: C. Thompson.

ROYAL SOCIETY OF ARTS, at 8.—Advertising: E. Street and L. Jackson.

THURSDAY, JANUARY 23.

ROYAL SOCIETY, at 4.30.—*Probable Papers:* The Relation of the Islets of Langerhans to the Pancreatic Acini under Various Conditions of Secretory Activity: Dr. J. Homans.—The Metabolism of Lactating Women: E. Mellanby.—(1) Colour Adaptation; (2) Trichromic Vision and Anomalous Trichromatism: Dr. F. W. Edridge-Green.—Transmission of Environmental Effects from Parent to Offspring in Simocephalus: W. E. Agar.—Contributions to the Histo-chemistry of Nerve; the Nature of Wallerian Degeneration: H. O. Feiss and W. Cramer.—Onychaster, a Carboniferous Brittle-star: I. B. J. Sollas.

ROYAL INSTITUTION, at 3.—Birds of the Hill Country: Seton Gordon.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—The Use of a Large Lighting Battery in connection with Central Station Supply: F. H. Whysall.

FRIDAY, JANUARY 24.

ROYAL INSTITUTION, at 9.—Recent Advances in Scientific Steel Metallurgy: Prof. J. O. Arnold.

PHYSICAL SOCIETY, at 5.

CONTENTS.

Editorial and Publishing Offices:

MACMILLAN & CO., LTD.,

ST. MARTIN'S STREET, LONDON, W.C.

Advertisements and business letters to be addressed to the Publishers.

Editorial Communications to the Editor.

Telegraphic Address: PHUSIS, LONDON.
Telephone Number: GERRARD 8830.