THURSDAY, MARCH 28, 1907.

ULTRAMICROSCOPES.

Les Ultramicroscopes. Les Objets ultramicroscopiques. By MM. A. Cotton and H. Mouton. Pp. 232. (Paris: Masson et Cie., 1906.)

THE magnitude of an object which can be rendered visible by the ordinary use of the microscope has a lower limit which is well understood and can be succinctly expressed. It depends not merely upon the construction of the instrument, but also upon the character of the light employed and upon the liquid used for immersion. The instrument should possess a large numerical aperture, which is again increased by immersion in the ratio represented by the index of the immersing liquid, the result being the scientific expression for the power of the instrument, with a given magnifying power, to resolve close lines or points. As regards the light itself, the limit of resolution is proportional to the wave-length, so that shorter wave-length implies greater power of resolution. When special light is not selected for employment, the mean value of the wave-length is 0.55 μ, where μ signifies 0.001 of a millimetre.

Taking full advantage of these principles and of the high index, 1.66, of monobromonaphthalin as an immersion liquid, it may be said that the smallest visible objects have a magnitude not less than 0.17 μ. Bodies smaller than this are called ultramicroscopic. Some plan other than the usual microscope method must be adopted in order to make their existence appreciable, and it is upon this subject that MM. Cotton and Mouton have written the very valuable and learned book before us. In it will be found accounts, not merely of their own work, which is far-reaching and in practical points highly ingenious, but also of that of other investigators in the same field.

There are two methods at present in existence, which may be called respectively that of ultra-violet light and that of diffraction in a dark field. The first method aims at taking advantage of the short length of ultra-violet wave-lengths. The sources of light are electric sparks formed between wires, which may be of magnesium, producing wave-lengths of 0.280 μ, or of cadmium, producing those of 0.275 μ, the former being more intense, the latter more homogeneous. Such waves produce no effect upon the eye, though much upon fluorescent screens and photographic plates. But they are readily absorbed by glass. Hence the media (excepting air and immersing liquids) through which they pass on their way to the fluorescent screen or photographic plate, as the case may be, must be of quartz, and those above the stage of the microscope must, to avoid effects of double refraction, be of fused quartz. Thus the whole apparatus is highly specialised. On the other hand, the rays employed being homogeneous, there is no chromatic aberration to be considered in the design of the lenses.

The image formed by the objective is again magnified by the ocular, employed in such a way as to form a second real image at the place where finally is placed the fluorescent screen or photographic plate. With such an apparatus the limit of magnitude of the objects detected would be reduced to 0.09 μ.

The second and more recent method of detecting ultramicroscopic bodies is to employ their power of diffracting the light which falls upon them. They thus become mere point sources of light, but diffraction discs are formed upon the retina of the eye, as in the case of stars the dimensions of which are far too small to subtend an appreciable angle, even with the most powerful telescopic aid.

In the microscope, then, the illuminated ultramicroscopic object merely appears as a star of light. The form of the object is entirely unobserved, its presence only being appreciable when certain conditions are fulfilled. These are that the illumination shall be intense, that the field shall be profoundly dark, and that the objects themselves shall be sufficiently sparsely distributed in the field. It is advantageous, too, to employ those rays which make as small an angle with the illuminating beam as is consistent with other conditions.

To ensure the dark field it is strictly necessary that none of the illuminating light shall, except by diffraction, pass into the objective.

First, we have described in detail the apparatus of Siedentopf and Zsigmondy. In this the light from a narrow slit is focussed in such a way as to pass horizontally through the transparent medium under observation, forming a much diminished image of the slit exactly in the point of view of the microscope. In this image the width of the tape of light producing it corresponds to the length of the slit, and the depth to the width of the slit. The depth of the illuminated region thus becomes, with a knowledge of the diminishing power of the train of lenses, strictly calculable, this being of importance in estimating the number of particles rendered visible in a cubic millimetre. No part of the illuminating beam can, except when diffracted by small particles, pass into the objective. The mean direction of the rays which do so pass will be at right angles to the illuminating beam. The plan has the great advantage that an immersing liquid can be employed in the examination of solids, such as glasses tinted with metals, or of liquids beneath a covering glass. The adjustments must, however, be extremely nice, and require that the whole apparatus should be mounted upon one bank.

The authors have devised a simpler plan of illuminating the subsurface regions of a medium by taking care that incidence with the surface shall be at an angle exceeding the critical angle. To this end a small but intense beam of light is brought from a small arc downwards at an angle of 51° to the vertical. This passes at vertical incidence through the bevelled edge of a glass plate about 1 cm. thick upon the microscope stage. It is then totally reflected upwards by the lower surface towards the upper one.

Upon this is placed the microscope slide, with an intervening drop of cedar-wood oil, so that total reflection does not occur again until the upper surface of the cover glass is reached, when the ray is again sent downwards and passes away through another bevelled edge. It will be understood that the preparation does not contain air. On this plan no immersion liquid can be employed in the usual place between the cover glass and the objective, but, on the other hand, the rays diffracted by small particles come off from the main beam at angles considerably smaller than a right angle.

Several chapters of the book are devoted to the investigations which have been or can be carried out by these ultramicroscopes, of high interest to many. As examples, we may cite the distribution of silver, gold, and other metal particles in the coloured glasses containing them, and in the hydrosols of such metals; the Brownian movements of ultramicroscopic bodies in colloids, and the translation of such bodies by electric current. Especially interesting is the description given of the motions of silver particles in the hydrosol of that metal prepared by the Bredig process of forming a submerged electric arc between silver wires. The particles, below certain dimensions, remain in stable suspension. They are quite ultramicroscopic, but still are capable of diffracting light. When an electric current is passed through the liquid contained in a layer, not too thin, between top and bottom planes of glass, quartz, mica, &c., the microscope being focussed at the middle of the layer, at a point about equally removed from either electrode, the points of light seen move equably in a direction from the kathode to the anode, the speed being proportional to the potential gradient. For one volt per centimetre the speed is about 3·78 μ per second. Above and below this central region, *i.e.* in beds adjoining the top and bottom boundaries, the motion is in the opposite direction, somewhat slower and less equable, and variable with the size of the particles.

If the boundary surfaces are of glass, these inverse beds are each about 25 μ in depth, and if the thickness of the whole layer is diminished until it is only 50 μ, it is these inverse beds which survive, the central one being gradually extinguished. The motion will then be entirely from anode to kathode.

The material of the boundaries affects the depth of the inverse beds, which with quartz is rather less than 2·5 μ, and seems to disappear with gypsum. Mica has much the same effect as glass in this particular.

The particles have such exceedingly small mass that their ultimate velocities in the central region are acquired instantaneously, and if the electrodes are connected with an alternating source of electromotive force, the points of light move backwards and forwards in harmony with the stress through a distance proportional to its mean value and to the period, the constant being sensibly consistent with the speed under uniform stress quoted above. If a three-phase machine is connected with three electrodes, the particles describe closed curves.

THOMAS H. BLAKESLEY.

ANCIENT AND MODERN SHIPS.

Ancient and Modern Ships. By Sir George C. V. Holmes, K.C.V.O. Part i., Wooden Sailing-ships. Pp. xv+168. Part ii., The Era of Steam, Iron, and Steel. Pp. xii+219. (London: Printed for His Majesty's Stationery Office by Wyman and Sons, 1906.) Two vols, cloth-bound, price 2*s*. 3*d*. each.

THESE volumes belong to the series of science handbooks issued by the authorities of the Victoria and Albert Museum at South Kensington. The author was for a long period secretary of the Institution of Naval Architects; he is well qualified for the task he has undertaken. Within extremely narrow limits of space (about 400 pages) he has produced a readable account of ancient and modern ships, in which a large amount of trustworthy information has been summarised and admirably illustrated. Although the original intention of these handbooks may have been the assistance and instruction of visitors to the collection of naval models in the museum, they will undoubtedly prove of interest as books of reference to all who are interested in the history of shipbuilding. Their moderate price ought to secure a large circulation.

In the first volume wooden sailing-ships are described. This part of the work was published in 1900, but has been revised and re-issued in company with the larger second part, in which the history of the era of steam, iron, and steel is traced, so far as mercantile ships are concerned. War-ships, considered as fighting machines, are not dealt with, but the influence of peculiarities in their construction upon the development of mercantile shipbuilding is illustrated. Formerly, the naval models at South Kensington included those of war-ships; when the Royal School of Naval Architecture was transferred to Greenwich (more than thirty years ago) the Admiralty also concentrated there its collection of war-ship models. South Kensington retained the mercantile models, and the present collection includes loans from private firms, as well as models which are national property. It is much to be desired that the collection should be made complete and should illustrate adequately the development of the British mercantile marine. If Sir George Holmes's handbooks should increase public interest in the collection and lead to its proper development, a good purpose will have been served. At all events, he has produced a work which will enable laymen to reach an intelligent understanding of the history of shipbuilding and the principles governing the structural arrangements of ships.

Beginning with an admirable account of ancient Egyptian vessels, the author describes boats still existing and to be seen in the Cairo Museum, although they were built nearly 5000 years ago. Ships of the Mediterranean and Red Seas—Phœnician, Greek, Roman, and Venetian—are next dealt with. Another chapter is devoted to the ancient ships of northern Europe, of which specimens have been discovered in Scandinavia in recent years.

Mediæval ships are briefly described and excellently illustrated, this section ending with an account of the famous *Sovereign of the Seas*, built about the middle of the seventeenth century. A long chapter on modern wooden sailing-ships concludes this volume, and brings the history up to the construction of the great sailing three-deckers in the Royal Navy, which formed our most powerful war-ships until the middle of the nineteenth century. On the mercantile side the gradual development of sailing-ships is traced, and the famous "clippers" are described.

In the second volume steam navigation and the use of iron and steel for shipbuilding form the main topics. An interesting account is given of early wooden steamers. It is worth note in passing that this year is the centenary of the completion of the *Clermont* by Robert Fulton, and her trials on the Hudson River. The development of types of mercantile steamers is described, and numerous examples are included, amongst them being the *Great Eastern* and many vessels now employed on ocean or cross-channel service. Tables of dimensions and particulars for Transatlantic steamers are given in an appendix. On the structural side the book is valuable; it traces the influence of the use of iron and steel on dimensions and strengths of ships, and the differences between mercantile and Admiralty methods of construction. A brief discussion of the external forces acting upon a ship at sea, and the resultant stresses on the structure, is given in one appendix; in another the puzzling subject of tonnage measurement is made as clear as it can be made to general readers. This necessarily brief notice leaves many points unmentioned; the volumes should be read by all interested in the history of shipbuilding.

W. H. W.

FREQUENCY CURVES AND CORRELATION.

Frequency-curves and Correlation. By W. Palin Elderton. Pp. xiii+172. (London: Published for the Institute of Actuaries by C. and E. Layton, n.d.) Price 7*s*. 6*d*.

AS stated in a short preface by the president of the Institute of Actuaries, the object of this little volume is "to give a detailed description of the basis and practical application of those modern statistical methods that are associated with the name of Prof. Karl Pearson." The work was undertaken, we understand, by Mr. Elderton, at the invitation of the council of the institute, and we not only concur with the president in his commendation of the "public-spirited manner" in which Mr. Elderton acceded to their request, but think that the action of the council of a professional society in thus endeavouring to place the results of recent research before the members in a convenient form for consideration is well worthy of note.

In view of its purpose, the illustrations introduced are, of course, mainly of an actuarial character, but we have no hesitation in saying that the volume will be of great service to statisticians in other fields. Much of Prof. Pearson's work has been given in the Philosophical Transactions of the Royal Society, the *Philosophical Magazine*, and other publications which are not readily accessible to the ordinary statistician, and Mr. Elderton's work will be most useful to the student by providing a short and handy summary of some of the more important results.

After a brief introductory chapter, the author passes at once to the subject of frequency distributions, and the mean and standard deviation are defined (chapter ii.). The method of moments is then treated in some detail, including the calculation of moments by the direct and the summation methods (iii.). The deduction of Prof. Pearson's curves from the hypergeometrical series is then given (iv.), and their fitting by moments (v.).

The subject of correlation is introduced in chapter vi.; this is treated mainly from the standpoint of the normal distribution, but it is also shown that the formulæ may be regarded as obtained by the fitting of straight lines to the points in a "dot diagram," using the method of moments. In chapter vii. Prof. Pearson's method of calculating the coefficient of correlation from any fourfold table, for measured or unmeasured characters, is described, and there follow two short chapters on probable errors (viii.), and on Pearson's test for goodness of fit (ix.) respectively. The concluding chapter gives briefly the theory of the coefficient of contingency. A few appendices deal with frequency curves other than Pearson's, with the integrals of the normal function and other matters.

The exposition is careful and lucid, but some of the actuarial illustrations will prove rather a stumbling block to the non-actuarial reader. Proofs are given which assume a fair mathematical knowledge, necessarily including the integral calculus, but the more lengthy and difficult proofs are omitted. In some respects the work strikes one as a little limited in scope, but this arises naturally enough from the fact of its being addressed to a special public.

There are only one or two points we have noted in reading that seem to call for mention. In connection with the summation method of calculating moments, we would direct attention to the work of G. F. Lipps (Wundt's Phil. Studien, xvii., 538 *et seq.*, 1901), and to the chapters on "die Summenmethode" in the Wahrscheinlichkeitsrechnung of Bruns (1906). Even if the *name* "method of least squares" be avoided, we would submit that this is no reason for omitting the short and simple proof that $\Sigma(x-by)^2$ is a minimum if $b=r\sigma_1/\sigma_2$. Without this proof the meaning of the coefficients of regression remains, in the general case, vague and indefinite. In the chapter dealing with the coefficient of contingency, it might be as well to point out that the coefficient cannot attain the value unity unless the number of classes be indefinitely great; it cannot, in fact, exceed $\sqrt{(t-1)/t}$ for a $t\times t$-fold classification, at the best.

We cordially commend the volume to the attention of all students of statistics.

G. U. Y.

CAVES AND WATERWAYS.

La Spéléologie au XX^e Siècle. By E. A. Martel. Tome vi. of *Spelunca.* (Paris: Société de Spéléologie, 1906.)

THE completion of this volume deserves separate mention. Its 800 pages contain a critical review by M. Martel of practically all papers bearing on caves published in the last six years. Since these papers, in their turn, refer to a large amount of earlier work, we have here a complete exposition of what is at present known of 'spelæology." We pointed out, when noticing one of the separate parts, how the editor's comments render the abstracts readable and illuminating. The papers have been classified, for the most part geographically, and the volume becomes practically an unconventional text-book of the lore of caves. The range of subject permitted may here and there raise a smile; but it dies away in admiration of M. Martel's energy. Marcellin Boule, for instance, is cited on p. 694 as describing a lava-flow in Auvergne intermediate in age between the epoch of the mammoth and that of the reindeer. On p. 727, again, we read how a cave near Sévérac-le-Château —and memories of causse and cañon are recalled by the very name—was discovered in 1902 to contain a chapel, with accessories brought there during the persecution of the Catholic priests in 1793. A moment's reflection shows us that both references may prove of value. Traces of man among French volcanic deposits need not be regarded as of Pliocene age. The occurrence of religious emblems in caves may be due as much to a desire for secrecy as to the association of the cave itself with any form of ceremony. It is thus hard to think of any worker in anthropology or natural history who would not gain information from M. Martel's aid. The alleged glacial deepening of Alpine valleys, and the formation of *cluses,* are discussed on p. 526. Even writers on radio-activity may learn something from the notes on subterranean waters on pp. 610–612. To most readers, the gradual growth of our knowledge regarding the incised drawings and paintings on the roofs and walls of caves (pp. 654-705) will prove of surpassing interest. M. Martel presses home his contention that the bold representations of animals, sometimes amazingly faithful, are records or trophies of the chase.

Three photographic illustrations are given of paintings in the cave of Altamira, near Santander, which Martel himself has visited. Cartailhac (p. 703) records how the discovery of these was made by a child, in the company of less observant scientific excavators. Alcalde del Rio (p. 704), in a paper published in 1906, mentions, in the cave of Hornos de la Peña, "a figure in a human attitude, but apparently an ape." M. Martel adds that it has a tail; but why does he suggest, on p. 706, that M. Piette's "être de caractère simiesque," engraved on a bone, is "probablement imaginaire"? Surely the Neolithic or even earlier artists, who saw so much that was wonderful and worth reproducing in the animal world around them, had hardly yet risen, or descended, to the consciously imaginary and grotesque?

M. Piette has himself sent us a paper on "Fibules pléistocènes" (*Revue préhistorique,* 1906, p. 1), in which he writes confidently as to his anthropoid from Mas-d'Azil. He describes also a pendant ornament of incised reindeer-horn from Gourdan, on which a similar erect anthropoid, this time tailless, is clearly shown. The figures which he publishes are of immense interest; and M. Martel will doubtless note them in a future volume of *Spelunca.* Though "spelæologists" cannot be allowed to found a science of their own, geologists, zoologists, anthropologists, and historians may well hope to link a friendly arm in theirs.

GRENVILLE A. J. COLE.

OUR BOOK SHELF.

Die chemische Energie der lebenden Zellen. By Prof. Oscar Loew. Second edition. Pp. viii+133. (Stuttgart: Fr. Grub, 1906.) Price 3 marks.

THE great part played by the proteins in building up living cells has resulted in the ascription by physiologists to these substances of an indispensable *rôle* in vital processes. If, however, protoplasm be regarded as a protein molecule, the difficulty at once arises how to account for the great differences in stability between the living and the dead protein. This difficulty Pflüger, as well as Loew, attempts to get over by assuming a different constitution for the protein in the living body from that which is familiar to us in the dead protein as analysed in the laboratory. Whereas, however, Pflüger ascribed the lability of the living protein to the presence of cyanogen groups, which underwent transformation to amino-groups, Loew explains the difference by assuming the simultaneous presence in the plasma protein of aldehyde and amino-groups, basing his hypothesis largely on the fact that the cells of certain vegetable organisms give a black reaction with dilute ammoniacal silver only so long as they are alive, the reaction failing when the cells have been killed by heat, acids, or alcohol.

This blackening Loew and Bokorny assumed to be due to the presence of a reserve protein of special character, allied in the grouping of its constituent molecules to that which obtains in the living protoplasm.

In the present book, the first edition of which appeared in 1898, the author examines the behaviour of living cells, the nature of their work, and the assimilation of food-stuffs in the light of his theory. The great amount of work which has been carried out of late years by Kossel, Fischer, and their pupils on the constitution of the protein molecule, which has resulted in the separation of a large number of approximate principles, all distinguished by the possession of amino-groups, Loew dismisses with the airy suggestion that, during the action of the hydrolytic agents, acids or trypsin, a shifting of the intramolecular groups has taken place, with the result that the amino-acids, &c., obtained at the end of the hydrolysis cannot be assumed to throw any light on the structure of the protein molecule itself. Since in the plant organism it is probable that protein is formed from formaldehyde and ammonia by a process of polymerisation, the author imagines that the resulting product, in consequence of the presence of numerous aldehyde and amino-groups, must form a molecule of extraordinary lability. The first product of such polymerisation, which might be, as the author suggests, the aldehyde of aspartic acid, would further condense so as to form a body having the formula ascribed by Liberkuhn to the simplest protein. This substance, "primitive peptone," by polymerisation of two molecules might form albumoses, and by the union of three molecules might form albumen.

Although the facts brought together by the author are interesting, and although we must grant the possibility of aldehyde groups existing in some parts of the protein molecule, and perhaps being responsible for some of the chemical interactions which occur in the living cell, the new facts brought forward are too trivial effectively to modify our opinion on the structure of the protein molecule, which is based on the solid work of Fischer and his pupils.

La Découverte de l'Anneau de Saturne par Huygens. By Jean Mascart. Pp. 58. (Paris: Gauthier-Villars, 1907). Price 2 francs.

IN this small volume of 58 pages M. Mascart tells the history of the discovery of Saturn's rings from the time of Galileo's dramatic anagram concerning the *altissimam planetam*, and his subsequent tragic disappointment and despair, to the time when, after many questionings and discussions, Huygens finally established his accepted theory. This history is most interesting, and includes a number of extracts from Huygens's corespondence on the subject, showing us how he had to fight for the acceptance of his theory and then had to fight again for the vindication of his priority in the matter. The numerous reproductions of original drawings by Gassendi, Hélvétius, Riccioli, Huygens, Wallis, and others give an additional interest to the work, which is concluded by a lucid recapitulation of the later theories, such as that of Otto Struve, and discoveries concerning Saturn's unique appendage. W. E. R.

German Science Reader. Part i. Mathematics, Physics, and Chemistry. Compiled by C. R. Dow. Pp. 85. (London: J. M. Dent and Co., 1906.) Price 2s.

TWENTY pages of this book are devoted to mathematics, twenty-three to physics, nineteen to chemistry, and the remainder to a vocabulary of words not usually found in elementary class-books of German. The mathematical portion is a synopsis of principles of mathematics with enunciations of problems, while the two remaining sections consist of definitions and descriptions of some physical and chemical properties of matter. Any student of science who has an elementary knowledge of the German language should be able to read the book with the aid of the vocabulary, and the task would be more to his taste than reading or translating Grimm's or Andersen's fairy-tales. No grammatical rules are given, as instruction in these is assumed to have been obtained in an earlier course.

Céruse et Blanc de Zinc. By M. G. Petit. Pp. 154. *Préparation mécanique des Minerais. Résumé pratique.* By F. Rigaud. (Paris: Gauthier-Villars and Masson et Cie., n.d.)

BOTH these volumes are publications in the now well-known "Encyclopédie Scientifique des Aide-Mémoire." The first deals with the preparation and use in painting of white lead and zinc white respectively. The second book provides a practical account of the various processes in use for the mechanical preparation of ores by separating them from their stony matrix.

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 Ballot-Box.

IN reference to the weight-judging competition, Mr. Galton says that "the average competitor was probably as well fitted for making a just estimate of the dressed weight of the ox as an average voter is of judging the merits of most political issues on which he votes." These competitions are very popular in Cornwall; but I do not think that Mr. Galton at all realises how large a percentage of the voters—the great majority, I should suspect—are butchers, farmers, or men otherwise occupied with cattle. To these men the ability to estimate the meat-equivalent weight of a living animal is an essential part of their business; and, as an instance of their training, I may mention that one of the butchers here has a son under thirteen years of age who is an adept at this work, and is already, I am told, one of the best weight-judges in the district. This boy has been trained to it by his father, and already surpasses his instructor. Moreover, many of the competitors doubtlessly compete frequently, compare notes afterwards, and correct future estimates by past experience. Now the point of all this is that, in so far as this state of things prevails, we have to deal with, not a *vox populi*, but a *vox expertorum*. I am afraid that the majority of such competitors know far more of their business, are far better trained, and are better fitted to form a judgment, than are the majority of voters of any party, and of either the uneducated or the so-called "educated" classes. I heartily wish that the case were otherwise.

F. H. PERRY-COSTE.

Polperro, Cornwall, March 21.

I INFERRED that many non-experts were among the competitors, (1) because they were too numerous (about 800) to be mostly experts; (2) because of the abnormally wide vagaries of judgment at either end of the scale; (3) because of the prevalence of a sporting instinct, such as leads persons who know little about horses to bet on races. But I have no facts whereby to test the truth of my inference. It would be of service in future competitions if a line headed "Occupation" were inserted in the cards, after those for the address. FRANCIS GALTON.

MR. HOOKER, in NATURE of March 21, seems not to have quite appreciated my principal contention in the letters "One Vote, One Value" and "Vox Populi" of February 28 and March 7 respectively. It was to show that the verdict given by the ballot-box *must be* the Median estimate, because every other estimate is condemned in advance by a majority of the voters. *This being the case*, I examined the votes in a particular instance according to the most appropriate method for dealing with medians, quartiles, &c. I had no intention of trespassing into the technical and much-discussed question of the relative merits of the Median and of the several kinds of Mean, and beg to be excused from not doing so now except in two particulars. First, that it may not be sufficiently realised that the suppression of any one value in a series can only make the difference of one half-place to the median, whereas if the series be small it may make a great difference to the mean; consequently, I think my proposal that juries should openly adopt the median when estimating damages, and councils when estimating money grants, has independent merits of its own, besides being in strict accordance with the true theory of the ballot-box. Secondly, Mr. Hooker's approximate calculation from my scanty list of figures, of what the mean would be of all the figures, proves to be singularly correct; he makes it 1196 lb. (which is the mean of the deviates at 5°, 15°, 95°), whereas it should have been 1197 lb. This shows well that a small *orderly* sample is as useful for calculating means as a very much larger *random* sample, and that the compactness of a table of centiles is no hindrance to their wider use. I regret to be unable to learn the proportion of the competitors who were farmers, butchers, or non-experts. It would be well in future competitions to have a line on the cards for "occupation." Certainly many non-experts competed, like those clerks and others who have no expert knowledge of horses, but who bet on races, guided by newspapers, friends, and their own fancies.

Francis Galton.

Ketene.

While engaged in a research on the polymerisation of unsaturated compounds, we were led to try the action of a strongly heated platinum wire on various organic substances. It is unnecessary at this stage to discuss our general results, and we will therefore deal at once with the action of the wire on acetic anhydride. This substance when treated with the hot wire yielded a compound boiling about $-65°$ and freezing about $-130°$, which on standing at ordinary temperatures condensed fairly rapidly, yielding a brownish-yellow oil which, like the gas, has an extremely pungent smell. We have not yet succeeded in obtaining the new body in a completely pure state, but as our work has been interrupted for some time, we venture to give the following preliminary data.

On exploding one volume of the gas with excess of oxygen, there was a contraction of 1·01 volumes, and 1·85 volumes of carbon dioxide were formed, while 1·86 volumes of oxygen had disappeared. The corresponding numbers for the reaction $CH_2:CO+2O_2=2CO_2+H_2O$ are 1 : 1 : 2 : 2.

Another sample gave a density of 39·9 ($H_2=2$), while that calculated for $CH_2:CO$ is 42. This sample was, however, far from pure.

The gas is absorbed by all the ordinary reagents, including water. It combines with bromine, and appears to give a crystalline compound with bisulphites. It chars when treated with phosphorus pentoxide or concentrated sulphuric acid. These two reagents themselves produce traces of the gas when they are allowed to act on acetic anhydride. We would add that we have also obtained the substance from acetone, and it seems probable that it can be obtained by our method from all substances containing the group $—CH_2—CO—$.

We would suggest that the body is the parent substance of Staudinger's ketenes. We hope to be able to publish a fuller communication shortly.

N. T. M. Wilsmore.
A. W. Stewart.

University College, London, March 25.

Technical Terminology.

The writer on engineering terms in Nature of March 21 (p. 490) says that a single word is required to denote a central electric generating station.

Perhaps *megadyne* would be acceptable, signifying "great power," and suggestive of the dynamo equipment of the station. As a convenient abbreviation, *mega* would readily enter into common use.

J. T. Richards.

67 Thurleigh Road, Balham, S.W., March 23.

HIGHER EDUCATION IN THE UNITED STATES.

The most recent report issued from the United States Bureau of Education at Washington gives detailed information respecting recent developments of the various grades of education in the States down to June 30, 1904, and in it the Commissioner of Education gives a prominent place to the work of universities and colleges. The statistics now provided make it possible to supplement the article published in these columns (vol. lxviii., p. 25) dealing with university education in the United States, and to give some indication of the progress which has been made in American institutions of higher education during recent years.

There has been, in the first place, a large increase in the number of students attending universities and colleges in the United States. Whereas in the year 1899–1900 the total number of men students was, roughly, 61,800, and of women students 25,300, the numbers in 1903–4 had become, for men, nearly 72,000, and for women nearly 31,000.

The number of professors and instructors has increased in a similar manner. In 1899–1900 the number of such teachers in institutions for men and for both sexes was 12,664 men and 1816 women; in 1903–4 these numbers had become 15,342 men and 2272 women. In institutions for women alone the increase is not so decided. The number of men teaching in these institutions was in the former year 697, and in 1903–4 only 631. The number of women, however, shows a marked increase from 1744 to 1834.

It is interesting and instructive, too, to study the rise and fall in the popularity of the various subjects taken up by students. At the two periods under comparison there were some remarkable differences. In 1899–1900 the number of students studying classics and other subjects of general culture (as the report calls it) was roughly 57,000, but in 1903–4 the number had reached 65,000. In the earlier year the number of students in classes of pure or applied science was well on towards 26,000; in 1903–4 this number had increased to 32,000. The relative popularities of humanistic and practical studies may be said to have undergone little change at institutions of the rank under consideration. But in this connection it must be remembered that at the great technological institutions, which are not included in these statistics, large numbers of men are engaged entirely in studying branches of applied science.

The total value of property possessed by the institutions for higher education in the United States amounted in 1899–1900 to about 72,120,000*l.*, and in 1903–4 this large sum had increased to 93,043,000*l.* The endowment funds in the former year were valued at 33,240,000*l.*, while in the latter year this provision for future contingencies had grown to 41,313,000*l.*

The value of gifts and bequests received by institutions for higher education during 1899–1900 was 2,399,000*l.*; in 1903–4 the amount had increased to 2,740,000*l.*; and last year as much as 5,000,000*l.* was raised in this way. Twenty-five institutions in the former year received from private donors gifts of as much as 20,000*l.*, and in 1903–4 as many as twenty-nine institutions were equally fortunate.

For the first of the years with which we are concerned in this comparison, the total income, excluding benefactions, amounted to 5,712,000*l.*, of which about 2,234,000*l.* was received in the form of tuition and other fees. In 1903–4 the total income had reached 8,066,000*l.* In connection with this sum, the Commissioner for Education remarks:—"It is a well-known fact that the income derived from fees received from students forms only about one-third of the total income, the remainder necessary to meet the expenses of the institutions being derived from endowment funds, State aid, and miscellaneous sources."

In 1903–4 the State and municipal aid to higher education amounted to 1,984,600*l.*, as compared with 893,000*l.* in 1899–1900.

It is thus seen that the striking disparity between public and private efforts in behalf of higher education in the United States and Great Britain, pointed out in the article to which reference has already been made, has, in the interval of four years with which we are here dealing, become more accentuated; and, instead of having made up leeway, we appear to have fallen even further behind.

The annual amount raised by private munificence for American universities and colleges has in a few years been doubled; and, as recent notes in these columns have shown, there is no sign of any decline in the generosity of the men of wealth in the States. The amount of money raised in this way in the United Kingdom during the period 1871–1901 was only one-eighth of that contributed in the United States in the same time; and if the present scale of American gifts be continued, the comparison at the end of 1931 will be such as to leave us at a still more hopeless disadvantage.

All the statistics here brought together tell the same story; alike as regards number of students, number of university teachers, total value of university property and total annual income, from whatever point of view looked at, there is evidence of a strong and healthy growth in the system of higher education in the United States; and, though it can by no means be suggested that similar work in this country has remained stagnant, the most optimistic student of British affairs will hardly maintain that our universities and colleges can show progress and development at all commensurate with that the report of the Commissioner of Education reveals as true of the United States. It is clear that patriotic men of science among us cannot afford to relax their efforts to increase the efficiency of our universities and colleges, and to supplement their number. Students of science do not need to be reminded of the intimate connection between cause and effect, but it behoves them to take every opportunity to convince statesmen and the public that industrial supremacy is, in the long run, one of the effects of an adequately equipped and generously endowed system of higher education. A. T. S.

THE ASIATIC SOCIETY OF BENGAL.

THE Asiatic Society of Bengal, since its foundation in 1784 by that pioneer of oriental studies, Sir W. Jones, has played a leading part in the exploration of the natural history, philology, antiquities, and other branches of scientific inquiry connected with the East. Its Journal has been enriched by contributions from many eminent authorities, among whom may be named, in addition to its founder and older scholars such as H. H. Wilson, Prinsep, Sir A. Cunningham, Jerdon, Blyth, and Ball, men like Drs. Hoernle, Grierson and Annandale, Messrs. T. H. Holland and V. A. Smith, who are happily still at work. Like all scientific organisations in the East, it has suffered vicissitudes. The short and broken residence of Europeans in the country, pressure of official work, lack of native co-workers, want of libraries of reference, and last, not least, the indifference of the Indian Government, which prefers that its servants should devote their spare time to the judgments of the High Courts or the circulars of the Board of Revenue rather than to the science and literature of the country, have at times interrupted its progress. But under its present managers it seems to be inspired by a new spirit of enthusiasm. Its membership has increased within the last year by more than 50 per cent.; the Indian Government has at last begun to regard it seriously, and through the Lieutenant-Governor of Bengal, who now acts as president, has suggested a scheme for bringing its work into closer relation with that of European officials.

These gratifying signs of progress are reflected in its new publications. Besides its well-known Journal, it has commenced the issue of a series of monographs prepared by competent writers, well illustrated, and sold to the public at a very moderate price. These memoirs cover a wide range in the fields of natural science, philology, and anthropology. Among the most energetic naturalists is Dr. N. Annandale, the author of "Fasciculi Malayenses" and a study of primitive life in the Hebrides and Orkneys, who has now found a fresh field of activity as curator of the fine Calcutta collections. It is one of the ironies of fate that his name will survive in the scientific literature of the future linked with that of a new species of earwig, *Anisolabis annandalei*. He has recently contributed to the Journal a valuable series of papers on the fresh-water fauna of India, special monographs on Malaysian barnacles and the common Hydra of Bengal, and has opened an almost new field of study in his monograph on the "Fauna of a Desert Tract in South India," Rāmanād, in the Madura district, a region which might naturally, for zoological purposes, be regarded as worked out, but where his trained eye has discovered much new and interesting material.

In anthropology the society is judiciously working in connection with the Ethnographical Survey recently revived and extended by Lord Curzon, and has received from it several valuable communications. Mr. Sherring, who recently published an account of explorations in western Tibet, gives a further account of the Bhotiyas, and Mr. A. H. Francke of the Dards of the same region; the late Father Dehon, S.J., describes the religion of the Uraons of Bengal, and Mr. E. H. C. Walsh discusses the remarkable cup-mark records in the Chumbi Valley. Here, again, Dr. Annandale has made a new departure in the first of a series of notes dealing with the arts, industries, and implements of the more primitive tribes, which describes the blow-gun, which seems to have been imported into southern India by the Malays. Studies such as these will, we trust, lead to the foundation of an Indian Pitt-Rivers museum, the ample materials for which at present in existence will soon disappear unless their collection is taken up in earnest.

In another direction the society has started a valuable work by establishing a medical section, which proposes to organise the workers now engaged in the study of tropical disease. In this connection the monograph by Messrs. Hooper and Mann on earth-eating, already described in NATURE (vol. lxxiv., p. 543, September 27, 1906), is full of interest. This remarkable craze appears to be spreading rapidly among the coolies in tea-gardens in Assam, and the dangers resulting from the practice are attracting serious attention. It is not a racial characteristic, but is found in all parts of the country; it appears to depend on the purely mechanical effect of various kinds of earth in relieving gastric or intestinal irritation. When once indulged in, the craving becomes uncontrollable, and leads to serious disease of the digestive canal.

All classes of students will accept these new publications as a record of excellent scientific work, and will congratulate this historic society on its recent satisfactory progress.

ROBERT WARINGTON, F.R.S.

WE regret to learn of the death of Mr. Robert Warington, F.R.S., at Harpenden on March 20. Mr. Warington was the son of Robert Warington, F.R.S., for a long time chemist for the Society of Apothecaries, and was born in 1838. Being of delicate health, he was educated entirely at home, and learnt his first chemistry from his father. In 1859 he worked for some time as a voluntary assistant in the Rothamsted Laboratory, and in 1862 went to the Royal Agricultural College at Cirencester as assistant, first to the late Dr. Augustus Voelcker, and then to Prof. A. H. Church. In the next nine years Warington was chemist at Sir John Lawes's tartaric acid works, but in 1876, being desirous of devoting himself entirely to research, he came again to the Rothamsted Laboratory, where he remained until 1890.

Although Warington's chief interest was in agricultural chemistry, he published a number of papers dealing with inorganic chemistry, and a detailed account of the various salts of tartaric and citric acids as they occur in their natural sources and in the manufacture of these substances.

On his return to the Rothamsted Laboratory in 1876, Warington introduced several improved methods of analysis to save time or ensure greater accuracy in the routine determinations; there also he carried out the investigations on nitrification by which he made his name. In 1877 appeared the paper of Schloesing and Müntz which showed that the production of nitrates in the soil must be due to living organisms; this work was repeated by Warington, who continued to investigate the conditions favourable to the process. He showed that light would inhibit the change, and that the drying of the soil was sufficient to destroy the organism; he also investigated the distribution of the organism, and showed that it was confined to the surface layers of ordinary soil, being only present in any quantity in the portion usually stirred by the plough. Observing that the oxidation of the ammonia or urea employed sometimes stopped at the stage of nitrite, he succeeded in demonstrating that the process in ordinary soils takes place in two stages due to different organisms, one oxidising ammonia to nitrous acid, the other completing the oxidation to nitric acid. Warington had actually accomplished the final step in the isolation of the two organisms, though he had not brought his work to the stage which satisfied himself, when his researches were unfortunately interrupted, and before he could resume Winogradsky published his elegant method of isolating the nitrous and nitric organisms by the use of a nutrient silica jelly.

The circumstances which led to Warington thus missing the credit of the crowning point of his long researches on nitrification undoubtedly caused him bitter disappointment; he continued to live in Harpenden, but took no further part in research. In the course of his investigations on nitrification Warington also observed and studied that other process of denitrification, by which previously formed nitrates are reduced again, often with loss of the nitrogen as gas. In later years this subject became very prominent for a time, but the essential conditions of the action had been laid down before in Warington's papers. He also investigated the method of estimating small quantities of nitrates by means of indigo, and devised a standard process which, in a simplified form, is now used by most water analysts.

Warington gave a course of lectures in America for the Lawes Agricultural Trust in 1891; these were afterwards published by the United States Department of Agriculture; he was also Sibthorpian professor of rural economy at Oxford, 1894–7.

His "Chemistry of the Farm" was published in 1881, and has since gone through fifteen editions; though only a small book, it is noteworthy for its lucidity and compactness in the handling of a mass of experimental data: it is a model text-book which has no rival in any language, and on it the present generation of agricultural chemists in this country has been educated.

Warington was elected to the Royal Society in 1886; his connection with the Chemical Society, of which his father was one of the founders, dates back to 1863; he was vice-president from 1889 to 1893, and in its Transactions appeared nearly all his original work.

Warington's scientific work is distinguished by clearness and precision; the range is not wide, but everywhere it shows the minute care and the regard for accuracy with which he worked; in these respects his work only reflected his personal character.

A. D. H.

M. P. E. BERTHELOT.

THE death of M. Berthelot was briefly recorded in the columns of NATURE last week. The writer has been asked, as a former pupil of the great master, to give some account of his life and work.

Marcelin Pierre Eugène Berthelot was born in Paris on October 25, 1827. He was the son of a medical man, Dr. Jacques Martin Berthelot, and was educated at the Lycée Henri IV. In 1846 he obtained the prix d'honneur de philosophie at the concours-général, open to the best students of the highest classes of the lycées of Paris. In February, 1851, he became assistant (préparateur) to Balard, the discoverer of bromine, who held the chair of chemistry at the Collège de France. He kept this minor position until December, 1859, when he was appointed professor of organic chemistry at the École supérieure de Pharmacie. In 1865 a chair of organic chemistry was created for him at the Collège de France, which he held until his death. In 1870–1 he acted as president of the Comité scientifique de défense during the siege of Paris. In 1873 he was elected member of the Academy of Sciences, of which he afterwards became perpetual secretary. In 1876 he was appointed inspector-general of higher education; in 1881, senator for life. He was Minister of Public Instruction from December, 1886, to May, 1887, and Minister of Foreign Affairs in 1895–6. In 1900 he was elected a member of the French Academy.

The French nation has from the time of the Revolution turned more than once to its scientific men for help in the conduct of national affairs. The names of Lavoisier, of Lazare Carnot, mathematician and organiser of victory, of Fourcroy, of Dumas, and of Paul Bert recur to the memory. But if Berthelot took an untiring part in public affairs, and especially, as member of the Conseil supérieur de l'Instruction publique, in educational affairs, it is not as an administrator or as a minister that he will be remembered, but as a chemist, and perhaps the greatest, as he was the most prolific, chemist of his age.

Of his first studies in chemistry I have found no account, but we know that Claude Bernard in 1848 asked him for chemical assistance in his early work on glycogen.

It was in 1850 that he published his first paper, on a method of liquefying gases. Between that date and 1883 the Royal Society's catalogue records against his name the titles of between 600 and 700 papers; it is probable that their total number falls little, if anything, short of a thousand, and to these must be added eighteen or twenty books, some of them, it is true, being only the summaries of published papers, but others, and especially his works on the history of chemistry, in a large measure independent publications. To estimate justly the value and influence of this colossal contribution to science would be the work of months rather than of a few hours, and, indeed, the very mass of the work has perhaps hidden something of its significance and of the importance of the underlying ideas.

Berthelot first gave his measure in his doctoral thesis on glycerin and the fats, published in 1854. Chevreul had compared the fats to compound ethers, or esters, as we should now call them. Berthelot showed that the relation of glycerin to ordinary alcohol was comparable to that of phosphoric acid to nitric acid, thus introducing the important notion of polyatomic alcohols into chemistry. By a curious slip, inconsistent with the facts he had discovered, Berthelot compared the three series of glycerin esters to the orthophosphates, pyrophosphates, and metaphosphates, instead of to the neutral and "acid" salts of orthophosphoric acid. It was reserved to Wurtz, his great rival, to give the fullest interpretation and extension to his discovery.

The next question to which Berthelot devoted himself was a larger one. Gerhardt, who in the 'forties had contrasted the analyses of the chemist with the organic syntheses of nature, effected by the help of "vital force," already in 1853, in the introduction to his "Traité de Chimie organique," described as the object of chemistry:—"la connaissance des moyens de composer tous les corps, la connaissance des moyens de décomposition n'en étant que le préliminaire obligé." But at that time the only organic compounds that had been synthesised from their elements were urea, by Wöhler, and acetic acid, by Kolbe. Berthelot set himself the great task of synthesising from their compounds the fundamental organic compounds, marsh-gas, formic acid, methyl and ethyl alcohol, acetylene, benzene—and succeeded. His work overthrew the "vital force" theory as applied, not, indeed, to living matter, but to its non-living products. It forms the basis of those syntheses which have perhaps given to the chemistry of the nineteenth century its greatest prestige in the eyes of the world.

In his work on the fats, Berthelot had shown that they could be produced by the direct action of glycerin on the fatty acids, provided that time were given; it was characteristic of the man to generalise from this single discovery. In his work with his pupil, Péan de St. Gilles, on chemical affinity, published in 1862–3, he first introduced into chemistry the study of rates of reaction and of reversible reactions. Few single researches in the history of chemistry have been more fruitful of results.

He next set himself a task comparable to the work on organic synthesis. C. L. Berthollet in the early years of the nineteenth century had written a famous treatise on chemical statics; it was Berthelot's ambition to lay the foundation of chemical mechanics as a whole by a systematic study of the heat-changes involved in chemical reactions. Andrews, Hess, Favre and Silbermann, and others had carried out isolated investigations in this domain, but Berthelot, and almost simultaneously Thomsen, the Danish chemist, set out to investigate the whole field of thermochemistry systematically. In his "Mécanique Chimique fondée sur la Thermochimie," published in 1879, Berthelot gives the result of fifteen years' assiduous work. Full of brilliant discoveries of detail, of ingenious methods of experiment and calculation, the work cannot be said to have realised to the full the ambitions of its author. The "principle of maximum work," which he regarded as his greatest generalisation, is incomplete. But his work is, nevertheless, monumental in extent, and forms the necessary starting point for all fresh researches on the subject. In 1897 he published a vast collection of thermochemical data under the title "Thermochimie, Données et Lois numériques."

In one branch of thermochemistry, that of explosions, Berthelot's discoveries are as novel as they are fundamental. Working mainly with his pupil Vieille, he found that when an explosive mixture or compound is fired, the flame proceeds through the mixture at a gradually increasing rate until a maximum rate is attained of which the value depends on the chemical composition of the explosive. This is the phenomenon of the "onde explosive," or explosion wave, especially familiar in this country through the remarkable work of Dixon, carried out subsequently. It was in the course of his work on explosive mixtures that Berthelot invented the well-known calorimetric bomb, an extremely simple and accurate instrument for determining the heats of combustion of organic compounds.

The problems of vegetable chemistry began to interest Berthelot in 1876, when he showed that nitrogen could be made to combine directly with carbohydrates under the influence of the silent electric discharge. Later he found that the microbes of the soil played an important part in the fixation of nitrogen in the vegetable tissues—a discovery to which the work of Hellriegel and Wilfarth on leguminous plants gave the most brilliant confirmation.

In 1884 a fine laboratory was built for him on the heights of Meudon, and here, with the devoted and able collaboration of M. G. André, he carried out the vast series of researches on vegetable chemistry recorded in the four volumes on "La Chimie végétale et agricole," published in 1899.

Berthelot's work in the history of chemistry is on the same kind of scale as his experimental work. In a first book, "Les Origines de l'Alchimie," he traces alchemy to its origin in a combination of the ideas of Egyptian metal-workers (who from the practice of making alloys naturally desired to economise the use of the precious metals in their production) and of the Greek ideas of the transmutation of elements current in the school of Alexandria. In 1887–8 he published a more comprehensive work, in collaboration with C. E. Ruelle, the "Collection des Alchimistes grecs." This was followed in 1893 by a similar work, "La Chimie au Moyen-âge," which deals with the Syriac and Arabic alchemists, translated by MM. Rubens Duval and Houdas. The author showed that the Latin works previously attributed to Geber (or Djaber, as he should be called) were late forgeries, and published authentic texts of the famous alchemist. These he supplemented in his last work, "Archéologie et Histoire des Sciences" (published in 1906), by printing the Latin translation of another work of Geber, the "Liber de Septuaginta," of which the Arabic original has been lost, together with a number of fresh memoirs on mediæval chemistry and on the composition of metallic specimens of Egyptian, Chaldaic, Persian, and Roman origin. On the more modern history of chemistry he published a book on Lavoisier, "La Révolution chimique" (1890), containing extracts from Lavoisier's note-books, and "La Synthèse chimique" (1875).

Besides these works and practical treatises on calorimetry and gas analysis, he published a number of volumes of essays—"Science et Philosophie" (1886), "Science et Morale" (1897), "Science et Éducation" (1901), "Science et Libre-Pensée" (second edition, 1905); and the correspondence with Ernest Renan, who in his "Souvenirs d'Enfance" has left so interesting an account of the beginnings of the life-long friendship of the two men, was issued in 1898.

The "Cinquentenaire scientifique de M. Berthelot" gives an account of the jubilee celebration held at the Sorbonne on November 24, 1901, when, in the presence of the President of the French Republic and the great officials of State and of the learned bodies of France, M. Berthelot received the congratulations of the academies of the world. "Dès que vous abordez une question," said Moissan in addressing him on behalf of the French Academy of Sciences, "vous l'étendez en la généralisant." But few men have united with the power to generalise such marvellous quickness and tenacity in working out detail. That quickness and tenacity may be estimated by the volume of his work. In his later life he had, of course, much help, but in his earlier years, when he often passed the night in the laboratory, he worked single-handed. Berthelot rejected until well into the 'nineties (as Bunsen did until his death) the use of the atomic notation, chiefly perhaps from a horror of the enthusiastic and somewhat uncritical faith of contemporaneous exponents of the atomic theory.

In person Berthelot was short and slight, and with the stoop of the student. In lecturing he spoke rapidly and in a low voice, with no attempt at oratorical effect. But his fine, regular features and brilliant blue eyes left an impression not easily to be forgotten. Reserved and almost cold in manner, he cared for two things supremely, his work and his family. He survived the shock of his wife's death, which took place on March 18, only by a few minutes.

The French Parliament voted a public funeral; it took place on Monday in the Panthéon, where the remains of his wife rest beside his own.

M. Berthelot left a daughter and four sons, of whom one, M. Daniel Berthelot, is well known for his researches in physical chemistry, and occupies a chair at the Ecole supérieure de pharmacie.

P. J. HARTOG.

NOTES.

MEN of science in this country will probably have to wait a long time before they will see the Government and the nation pay such a tribute to the greatness of one of their number as was witnessed in Paris on Monday, when the national funeral of M. and Mme. Berthelot took place at the Panthéon. Here politicians and people have little sympathy with intellectual greatness; and if M. Berthelot had lived in Great Britain instead of France his death would have been mourned by the world of science, but the Government would certainly not have hastened to secure for him the honour of a national funeral, because our statesmen do not know the influence of scientific work on national character and progress; and to them men of science live in a world, far beyond the range of practical politics, where virtue finds its own reward. To understand the right spirit of appreciation of a great man of science we have to cross the Channel, and be present at a funeral like that of M. and Mme. Berthelot; for on such an occasion the French manifest incomparable qualities of organisation and tact. From the report of the Paris correspondent of the *Times* we learn that not since the funeral of Ernest Renan have the population of the capital been invited to join the authorities in such a solemn demonstration of mourning for one of their great compatriots. Amid impressive surroundings all that is representative of the dignity of the State was assembled, from the President of the Republic to the members of the several academies, the council of the Legion of Honour, the Ministers, the members of Parliament, and a host of the most eminent personalities of France. After a portion of Beethoven's Symphony in C minor had been rendered, the Minister of Education, M. Briand, ascended a small platform erected near the academicians and read a funeral oration in which he worthily honoured the illustrious dead. Berthelot's attitude towards the religious sentiment he accurately summarised in the terms of a formula borrowed from Renan—"The real way of adoring God is to know and love what exists." Respecting Berthelot as a *savant*, he dwelt particularly on his *rôle* as a creator, the forerunner of more startling syntheses still. The great moral quality of the man, the natural consequence of his philosophical ideas, was tolerance. After the oration, the two coffins were carried to the peristyle of the Panthéon, where a monumental catafalque had been raised. A splendid military pageant followed, the troops defiling past the coffins to the strains of the "Chant du Départ" and "Les Girondins," while flags were lowered and swords raised in salutation of the dead. In the afternoon the public was allowed to visit the Panthéon, and in the evening the bodies were taken to the Panthéon vaults, where they occupy provisionally a place next to the remains of Victor Hugo.

SCIENTIFIC men will do well to watch the course of events connected with the subject of Mr. Haffkine's prophylactic and the Mulkowal accident, referred to by Prof. Ross in last week's NATURE, as it is important that laboratories engaged in making prophylactics and sera shall not be lightly discredited on inadequate evidence—important not only for the laboratories, but for the public, which in its alarm is led to reject these valuable agents. In the House of Commons on March 20, Mr. Morley gave a cautious written reply to a question by Sir W. Collins on the subject. He stated that Mr. Haffkine is still in the employment of the Government of India, and has been offered "employment in that country on research work at a salary equal to that of which he was in receipt when he left India." But it is understood that Mr. Haffkine is holding out, not for the loaves and fishes of office, but for the vindication of himself, his laboratory, and his science from what appears to have been at least a very doubtful verdict. Mr. Morley also stated, somewhat too cautiously, that "Dr. Haffkine's prophylactic continues to be one of the precautions which are recommended by Government to the general populations against outbreaks of plague." But this is quite an inadequate description of it. Mr. Morley appears to have overlooked the facts that in official statements other measures, such as segregation, disinfection, and evacuation, have been declared to be unavailing; that in the epidemic now raging in the United Province of Agra and Oudh, the Government of the province reported only last month (*Bombay Gazette*, February 18) to the effect that the prophylactic was the only measure affording real and substantial protection; and that in the Punjab alone, up to October, 1903, 1,327,075 people had been inoculated, with a declared reduction of mortality to about one-twelfth that occurring in the uninoculated (report on plague and inoculation in the Punjab by the chief plague medical officer, Lahore, 1904). But Mr. Morley may be trusted to see that justice (and, let us hope, something more) is done in this case.

LORD KELVIN, O.M., has been nominated as president-elect of the Institution of Electrical Engineers for the session 1907–8, his term of office as president to begin next November. Prof. J. J. Thomson has been elected an honorary member of the institution.

LORD AVEBURY will preside at the annual soirée of the Selborne Society, which will be held at the Civil Service Commission (Old London University), Burlington Gardens, on Friday, April 26. Illustrated addresses will be given, and there will be a display of microscopes and objects of interest.

A *Times* correspondent at Kingston, Jamaica, reports that earthquake shocks are recurring with alarming frequency, the latest being at 1.30 a.m. on March 25. All the shocks have been sharp, though short, and accompanied by loud subterranean rumblings.

THE *Pall Mall Gazette* states that Mr. Franz Herger, director of the Meteorological Observatory of the St. Gothard, was caught by a snowstorm while returning from the observation tower, and his dead body was found a few days ago, almost completely covered with snow, near the Lucendro Bridge.

THE seventy-ninth meeting of the German Association of Naturalists and Physicians will be held at Dresden on September 15–21. General meetings will be held on Monday, September 16, and Friday, September 20, at which lectures will be given by Profs. Hempel (Dresden), Hergesell (Strassburg), Hoche (Freiburg-im-Baden), and Strassen (Leipzig). The sections will meet on September 16, 17, and 18. There will be a section of geophysics, meteorology and terrestrial magnetism, and anyone desiring to give a short lecture or demonstration to the section should communicate before May 25 with Prof. Paul Schreiber, Direktor des K. Met. Instituts, Dresden-N. 6, grosse Meissner Strasse 15.

WE regret to see the announcement that Prof. E. von Bergmann, professor of surgery in the University of Berlin since 1882, died at Wiesbaden on Monday, March 25, in his seventy-first year. For a few years before his appointment to his Berlin chair and to the directorship of the University Clinical Hospital he was professor of surgery at Würzburg. An obituary notice in the *Times* records that in Berlin von Bergmann devoted himself to the development of Lord Lister's antiseptic methods, and became one of the leading exponents of the purely aseptic treatment which dispensed with the carbolic spray, and relied upon the prevention of infection by means of perfect cleanliness. His success was especially remarkable in operations upon the skull and the brain, and surgery owes to him considerable advances in this particular department of its labours. After the death of Prof. Virchow, von Bergmann became the most eminent representative of the German medical world, and he was a present or a past president of the leading medical and chirurgical societies. Last year he was made a life member of the Upper House of the Prussian Diet. German and foreign universities honoured him by the bestowal of their academic degrees, and only last December he celebrated his seventieth birthday, and received tributes of admiration and esteem from the leading members of his profession at home and abroad.

THE motion for the second reading of the Weights and Measures (Metric System) Bill was defeated in the House of Commons on March 23 by a majority of 32, 118 voting for the second reading and 150 against. The Bill proposed that from April 1, 1910, or at a later date to be fixed by Order in Council, the standard metre and kilogram should be established, and that sales and contracts should thenceforth be made according to the metric system. Mr. Strauss, in moving the second reading, said that resolutions in favour of the Bill have been passed by the London County Council, large numbers of chambers of commerce, and many local authorities, and it is supported by the heads of many trade and engineering firms and numbers of trade unions. He asked the House to give the Bill a second reading for three reasons:—the loss of time and money in business and trade involved in the present system; the most serious waste of time in the education of children; and the loss of commerce with other countries owing to our dealing in weights and measures which to them are incomprehensible. The incongruities and absurdities of the cumbersome British units of weights and measures were exhibited by Mr. Strauss and Sir H. Norman, who seconded the motion, while the latter gave a convincing exposition of the simplicity and interdependence of the metric weights and measures.

THE opposition made out a strong case against the Metric System Bill referred to above. Mr. Haworth urged that 80 per cent. to 90 per cent. of the engineers of this country are against the Bill, and that it had been estimated that in engineering alone the cost of the change would be 100 million pounds. In shipping, measurements of draught, displacement, and tonnage, which are nearly universal on the British standard, would have to be altered throughout the world. The cotton trade, again, is carried on all over the world on the English measure. Similar cases were quoted by subsequent speakers, and it was also maintained that the greater part of our trade is with non-metric countries, and that unless the colonies and the United States adopted the change with us, few of the advantages offered by the metric system could be reaped. The metric system was legalised in Great Britain several years ago, and the manufacturers of the country can adopt it when they find it to their interest to do so. In commerce, as in science, it is desirable to secure international standards so far as possible, and the metric system has been adopted by many countries, and has become the basis of scientific measurements, because it provides simple and satisfactory standards. An international system of weights and measures may be as impracticable as an international language, but the advantages of either of these common means of expression are obvious. When traders and manufacturers find that the metric system must be adopted in order to have commercial relations with other countries, they will no doubt adapt themselves to the new circumstances. Until some common agreement has been arrived at among leading business men, it can scarcely be urged that Parliament should make compulsory a system which would involve an industrial revolution.

THE anniversary dinner of the Chemical Society was held on March 22, Prof. Meldola, president of the society, being in the chair. Lord Rayleigh proposed the toast of "The Chemical Society," and he is reported to have said, in the course of his remarks, that an ardent student, if he is so disposed, can become the parent of a new substance. Others of maturer age look upon this increase of the chemical population as rather an embarrassment. No doubt there is a multitude of details, and one can only hope that in the course of time generalisation may arise and be established which will supersede much of that detail, link it together, and so render it no longer so serious a burden upon the memory. In replying to the toast, Prof. Meldola said in its intimate relations with other branches of science chemistry is as far-reaching, as cosmopolitan, has as many points of contact with all branches of science, organic or inorganic, as any branch of science that is being cultivated at the present time. He expressed regret at the enormous wastage of chemical talent and faculty going on all over this country, and said the society could do very much if it had larger resources to fall back upon. The research fund should be in such a position that the society could afford to give personal grants to workers to enable them to secure the services of competent men to cooperate with them in their work. The toast of "Scientific Societies" was proposed by Sir

William Ramsay, and responded to by Lord Kelvin and Prof. Ray Lankester. Prof. Lankester agrees that there is a need for great endowments for furthering chemical science, and, indeed, the various departments of the whole scientific field, and that if learned societies make it known that they will administer those funds, the money will be forthcoming. He considers it would be better to give money in this way than that it should be given, say, to universities, which Prof. Lankester is unable to regard as promoters of scientific knowledge in this country. Sir A. Rücker, however, in responding to a later toast, said that he has cherished as part of his creed that the business of a university is not only to teach, but to add to knowledge. The Foreign Office and the Royal Society asked the University of London to undertake the establishment of a chair of protozoology, and it was done. As Prof. Lankester acted as the adviser of the Royal Society in this matter, Sir Arthur Rücker thought the action was proof enough that he really believed in research by a university.

In an article on the evolution of the horse family, published in the March number of the *American Journal of Science*, Mr. R. S. Lull gives a series of diagrams illustrating the differences in relative size and form of the various generic types. When referring to the suggestion that the one-toed Siwalik hipparion may be the ancestor of the zebras, the author is oblivious of the view that the latter form a mixed group, one of the members of which is closely allied to the wild ass. A paper by Mr. C. W. Gilmore, on a new species of the ichthyosaurian genus Baptanodon from Wyoming, is also included in the same issue.

The fifth annual report of the Philippine Bureau of Science (published at Manila in 1906) shows that the society did excellent work during the twelvemonth under review, although its efforts were considerably hampered for lack of sufficient accommodation. Special attention was directed to the prevention of cholera by means of cholera vaccine. Although eradication of the disease seems impracticable, it appears to be a fact that the vaccine confers a blood-immunity greater than that resulting in the case of typhoid by the use of typhoid vaccine, and it is considered that vaccination will prove of even greater value in the case of cholera than it is in that of typhoid.

A MODEL of the restored skeleton of the horned dinosaur *Triceratops prorsus*, duplicated from one in the U.S. National Museum at Washington, has just been set up in the reptile gallery in the Natural History Museum. The original bones upon which the restoration is based were obtained from the Laramie beds (Upper Cretaceous) of Converse County, Wyoming. Another addition to the collection of very considerable interest is a specimen of the slughi (or gazelle-hound) of the eastern deserts, the gift of the Hon. Florence Amherst. The special interest attaching to these dogs (also known as Syrian or Persian greyhounds) is that they belong to the same type as one represented in the tombs of Beni Hasan, and are thus the oldest breed in existence. The best strains are in the possession of the Bedouin chiefs, from one of whom the specimen presented by Miss Amherst was obtained.

CONSIDERABLE interest attaches to the exhibition in the entrance hall of the Natural History Museum of a specimen of the tile-fish, *Lopholatilus chamaeleonticeps*, a species remarkable, not only for its brilliant coloration—perhaps unequalled by any other non-tropical fish—but for its curious history. The species first made its appearance off No Man's Land, Massachusetts, in 1879, when a specimen was taken in deep water on a cod-line. Soon after it could be taken in abundance with the same kind of apparatus, a catch of some 250 lb. of fish (ranging individually from 10 lb. to 40 lb.) in the course of a couple of hours or less being not uncommon. This raised the hopes of fishermen, and in the U.S. Fishing Report for 1881 it was stated that "there is every reason to believe that the tile-fish will rank among the most important food-fishes of the United States." About the time (1882) that New English fishermen were getting into the swing of the fishing the tile-fish, owing to ice in the Atlantic, disappeared as suddenly as it came, and it is only during the last fifteen years that it has re-visited the American Atlantic coast, where it can now be taken at a depth of about seventy fathoms.

THE commission appointed for the investigation of Mediterranean fever has issued part v. of its report. Staff-Surgeon E. A. Shaw, R.N., shows by experiments on monkeys that infection is possible through the eyes, nose, and digestive tract by means of infected dust and food, and through scratches and wounds by the urine of patients. The possibility of infection by unlimited contact is also demonstrated. The same investigator shows that the *M. melitensis* produces little toxin, and he has failed to obtain a curative serum of much potency, and experiments by Dr. Eyre confirm the latter. A preventive vaccine was prepared which seemed to possess considerable immunising powers. Major Horrocks, R.A.M.C., discusses the occurrence of Mediterranean fever in Gibraltar, and shows that its incidence there, as in Malta, is probably largely dependent on goats. Dr. Eyre contributes a bibliography of the disease from 1897 to 1907.

AMONG the botanical papers included in the Proceedings of the Indiana Academy of Science, 1905, Mr. W. J. Young communicates an account of the embryology of *Melilotus alba*, stating that the megaspore mother-cell forms the embryo sac without undergoing division, and that a portion of the endosperm functions as a haustorium. Mr. G. W. Wilson enumerates the rust fungi with host plants recorded from Hamilton and Marion counties; species of Dicæoma attacking cereals, and *Gymnoconia interstitialis* infesting the blackberry bushes, were the most injurious. A description of the Leesburg Swamp and the plant associations occurring there is furnished by Mr. W. Scott.

AN account of experiments to determine the effect of stimulating organisms with different light rays is communicated by Prof. E. Hertel to *Naturwissenschaftliche Wochenschrift* (February 10). Two contingencies have to be taken into account; first, allowance must be made for the disparity in the intensity of the rays, and, secondly, the effect of stimulation will vary with the absorbent capacity of the organism for rays of varying wave-length. When a method was applied for equalising the intensity of the different rays, the physiological effect was found to decrease from the red to the blue rays, but since the absorption of the rays by living tissue also varied in the same way, the conclusion is evolved that the effect of light does not vary with the wave-length.

A SECOND paper on *Termes gestroi*, the white ant that is becoming a pest of considerable importance to the Hevea rubber trees in Tenasserim, is contributed by Mr. E. P. Stebbing to the *Indian Forester* (January). The curious accumulations of rubber in the nests have given rise to some discussion. The explanation put forward by the discoverer, that the termites are concerned with these accumulations, has not received acceptance, and it has been suggested that they are due to natural exudation. Meantime, analysis has shown that the rubber is purer than the best ordinary latex, and thus the matter stands. On the subject of fire in teak forests, Mr. H. Rodger presents a note accompanied by illustrations representing probable stages in the destruction of the teak trees.

THE fifth supplement to the first volume of the *Philippine Journal of Science* is appropriated to an enumeration of the Philippine grasses. The author has revised the lists of Blanco, F. Villar, and other previous compilers to exclude doubtful species; he has also drawn up short keys for the identification of tribes, genera, and species. With regard to geographical distribution, one-fifth of the species is endemic, including the monotypic genus *Garnotiella philippinensis*; there is a pronounced affinity with the grasses of the Malayan and Indo-Malayan regions, and a fair sprinkling of Australian types. The determination of the bamboos is uncertain, but the author records a new species of Gigantochloa.

DISCUSSING the mechanical development of the German iron industry in a copiously illustrated article in the *Engineering Magazine* (vol. xxxii., No. 6), Mr. J. H. Cuntz shows that the three important factors which now make for economy are by-product coking, the utilisation of furnace gases in the gas engine, and advanced practice in electric driving of winding and rolling-mill engines.

THE bridge at the Victoria Falls of the River Zambezi was described in detail by Mr. G. A. Hobson in a paper read before the Institution of Civil Engineers on March 19. Several types of bridges were considered, but the nature of the situation made it obvious that a two-hinged spandrel-braced arch was the one that most completely answered the requirements of the case. The bridge consists of three spans. The end span, on the left bank, is 62½ feet and the other 87½ feet, while the central span is 500 feet between the centres of the bearings, with a rise of 90 feet. The entire bridge, with the exception of the main bearings, weighs 1500 tons. The engineering interest which attaches to the execution of this work is due in a large measure to the remoteness of the site. The question of erection was considered of primary importance, and every detail was devised to simplify the procedure.

THE admirable work that is being done by the corps of mining engineers in investigating the mineral resources of Peru is clearly shown in the numbers of the *Boletin* of that body recently received. In No. 41 Mr. M. A. Denegri gives a report on the mineral production of Peru in 1905. The production included 75,338 tons of coal, 49,700 tons of petroleum, and considerable quantities of gold, silver, copper, lead, bismuth, nickel, mercury, salt, and borates. Excellently reproduced photographs accompanying the report indicate that in many cases the mines are well equipped. In No. 44 Mr. Carlos E. Velarde describes the mineral district of Huancavelica. The copper and silver veins are of considerable importance, and the Santo Domingo colliery furnishes an ample supply of coal for steam raising, whilst coke for smelting purposes can be abundantly obtained from the coal of the Oyon collieries, thirty miles distant from Huancavelica. In No. 45 Mr. G. I. Adams deals at length with the water supply of the provinces of Arequipa, Moquegua, and Tacna. Lastly, in No. 46 Mr. F. M. Santolalla describes the mineral resources of the province of Santiago de Chuco. The district is one of the richest in Peru, and its mining industry has a great future in store when better means of transport are provided by the projected extension of the railway from Menocucho to Salpo. The deposits existing in the province may be divided into the metalliferous veins in eruptive rocks, veins in sedimentary rocks, and the coal seams of Callacuyan, Chasamuday, Llaray, Hospital, and Angasmarca, all of which form part of the same coalfield.

THE admirable paper on petrol motor-omnibuses, read by Mr. W. Worby Beaumont before the Institution of Mechanical Engineers on March 15, forms a valuable contribution to the history of engineering, for there are few examples of rapid growth from the experimental stage to that of widespread practical importance so remarkable as that of the motor-omnibus. There is no example so instructive in possibilities as the adaptation of the high-speed, high-power, light-weight petrol prime-mover to the heavy work of the operation of the motor-omnibus on common roads. Barely four years have passed since the first petrol-propelled motor-omnibus may be said to have been regularly worked in public service in England, and within the last two years the number in London has increased from a few small vehicles to 795 in actual commission. These are carrying about 185 million passengers per year, and run from 90 to 120 miles per day, or 30,000 to 40,000 miles a year. There is great similarity in external design, but in the details of the mechanism and in the arrangement of the underframes there are considerable differences, which are clearly described by Mr. Beaumont and elucidated by the numerous excellent drawings to scale accompanying his paper. No standardisation in motor-omnibus construction can be expected for some time. The extraordinary mileage has accumulated much experience in a short time, but it has been very costly; and it must be admitted that, even with the finest material ever placed in the hands of the engineer, larger dimensions and greater surfaces are required to contend with the severe work of the present double-deck omnibus. Improvement may be looked for in the introduction of twenty-six-passenger in place of the present thirty-four-passenger vehicles. Then the weight of an omnibus may be materially reduced, and fuel and oil consumption and wear and tear also reduced, which, with a general observance of the legal speed-limit, will together add to the life and commercial efficiency of an omnibus. It is interesting to note that the cost of working a petrol motor-omnibus running 100 miles per day for 280 days per year may now be put as 9·56*d*. per mile, including depreciation at 20 per cent., while the average receipts per motor-omnibus mile in London exceed 13*d*.

WE have received from Washington a copy of the annual report of the Board of Regents of the Smithsonian Institution for the year ending June 30, 1905, together with a report of Mr. Richard Rathbun, the then acting secretary of the institution, for the year ending on June 30 last. Mr. Rathbun gives an account of the numerous activities of the institution during the year under review, and is able to record satisfactory progress. The general appendix of the regents' report contains, as usual, an admirable selection of papers by men of science of many nationalities, designed to furnish brief accounts of scientific discovery in particular directions. Among these papers we notice Sir William White's Friday evening address to the Royal Institution, on submarine navigation; Mr. G. T. Beilby's presidential address to the chemical section of the British Association at its South African meeting, on gold in science and industry; Sir Harry Johnston's paper to the Royal Geographical Society, on Liberia; as well as other contributions by British workers in science. The fine illustrations add greatly to the interest of the volume.

A third edition of "A Text-book of Plant Diseases caused by Cryptogamic Parasites," by Mr. George Massee, principal assistant in the department dealing with cryptogams of the Royal Herbarium, Kew, has been published by Messrs. Duckworth and Co.

Vol. iv. of the Proceedings of the London Mathematical Society, second series, is now available. The volume is published by Mr. Francis Hodgson. Among its contents may be mentioned the records of proceedings at meetings of the society; obituary notices of the late Astronomer Royal of Ireland, Mr. C. J. Joly, F.R.S., and the late Mr. Robert Rawson, sometime headmaster of the Dockyard School, Portsmouth; papers published in the Proceedings from November, 1905, to November, 1906; and several useful indexes. Abstracts of papers brought before the society appear regularly among our reports of scientific societies and academies.

OUR ASTRONOMICAL COLUMN.

Astronomical Occurrences in April:—

April 3. 5h. 48m. to 8h. 55m. Transit of Jupiter's Sat. III. (Ganymede).
7. 16h. 18m. to 17h. 1m. Moon occults γ Capricorni (mag. 3·8).
10. 9h. 55m. to 13h. 2m. Transit of Jupiter's Sat. III. (Ganymede).
13. 11h. 0m. Vesta in conjunction with the Moon (Vesta 0° 24′ N.).
,, 12h. 0m. Minimum of Algol (β Persei).
14. 16h. 0m. Mercury at greatest elongation (27° 36′ W.).
16. 8h. 49m. Minimum of Algol (β Persei).
18. 6h. 57m. Jupiter in conjunction with the Moon.
20–22. Epoch of Lyrid meteor-shower. Radiant 271° + 33°.
21. 2h. 41m. Venus and Saturn in conjunction (Venus 0° 38′ N.).
,, Venus. Illuminated portion of disc = 0·773.
30. 15h. 38m. to 16h. 50m. Moon occults ξ Ophiuchi (mag. 4·5).

Comet 1907*a* (Giacobini).—No further observations of this comet have yet been received, but the elements and daily ephemeris computed by Herr M. Ebell appear in No. 4161 of the *Astronomische Nachrichten* (March 13), the latter extending to March 31. An extract is given below:—

Ephemeris 12h. (M.T. Berlin).

1907	α (true) h. m.	δ (true) ° ′	log r	log Δ	Brightness
March 27	6 27·4	−3 34·3	0·3119	0·2474	0·67
29	6 24·9	−2 16·4			
31	6 22·7	−1 2·3	0·3122	0·2682	0·61

Observation of Comet 1905 IV.—A telegram from the Kiel Centralstelle announces a further observation of comet 1905 IV. by Dr. Kopff at the Königstuhl Observatory on March 21. The position of the comet at 14h. 45·8m. (Königstuhl M.T.) was

R.A. = 14h. 58·6m., dec. = 21° 18′ S.,

and the magnitude was estimated to be 13·8.

The above position lies in the constellation Libra, and is above the horizon from about 11 p.m. to 6 a.m.

This comet was first discovered, as 1906*b*, by Dr. Kopff at Heidelberg on March 3, 1906, and was observed until June, 1906; the perihelion passage occurred on October 18, 1905. The orbit is remarkable for its great perihelion distance (3·3 R.), which has only been exceeded by that of the comet of 1729. The motion is probably parabolic, although an elliptic orbit, having a period of 1153 years, has been suggested.

Standard Stellar Magnitudes.—In order that astronomers may have a ready means of reducing their magnitude observations to a uniform scale, Prof. Pickering publishes, in Circular No. 125 of the Harvard College Observatory, the positions and carefully determined photometric magnitudes of a selected sequence of stars in the region of the North Pole. To determine the magnitudes of other stars the following method is suggested:—Two photographs are taken, one of the polar region, the other of the region to be investigated, and on the former the standard stars, on the latter the stars the magnitudes of which are to be determined, are marked. Then on a night when the atmospheric conditions are good and constant, and at a time when the second region is at about the same altitude as the pole, a third plate is successively exposed for exactly the same time on each of the two regions.

Thus on the third plate the observer has the standard and unknown star-images on the same plate taken under exactly the same conditions, and may recognise them by superposing, in turn, the two negatives first secured and marking off the required images. These may then be compared for magnitude, and the results reduced to a standard scale by means of Prof. Pickering's standard list.

The Spectrum and Radial Velocity of Mira.—In No. 1, vol. i., of the Journal of the Royal Astronomical Society of Canada, Mr. J. S. Plaskett, of the Dominion Observatory, publishes the results of a spectrographic investigation of Mira during the most recent maximum. The spectra were obtained with a three-prism Brashear universal spectroscope giving a linear dispersion at Hγ of 18·6 tenth-metres per millimetre, and having a resolving power of 40,000. The results obtained by measuring two plates are in good agreement with one another and with the results obtained by Prof. Campbell and Mr. Stebbins. For the absorption lines a radial velocity of +65·6 km., reduced to the sun, was obtained, and as this is practically the value obtained by the other two observers mentioned, in 1897 and 1902, it appears that the receding motion of Mira in the line of sight is constant. The velocity, as determined from the bright hydrogen lines, is some 15 km. less, and Mr. Plaskett suggests that this difference is probably due to some abnormal conditions of pressure, temperature, or electrical state in the atmosphere of the star.

The present spectrograms show that titanium is undoubtedly represented in the spectrum of Mira, a point considered doubtful by Stebbins in 1902, and that the magnesium line at λ 4571, bright in 1902, is now represented by a normal absorption line; Hβ is fairly strong as a bright line, but Hϵ cannot be seen on these spectra.

Two Rapidly-changing Variable Stars.—In No. 5 of the *Comptes rendus* M. J. Baillaud announced the discovery of two new variable stars of which the light changes were so rapid as to be shown on plates taken at the Paris Observatory with three successive exposures at intervals of half an hour. During the period of observation one of these stars changed from magnitude 14·5 to magnitude 12·7; the other changed from 14·5 to 13·6. As there are not likely to be many photographic images of these faint objects, they have been looked for on the Harvard photographs, and in Circular No. 126 Prof. Pickering publishes the information that has been gathered from thirteen plates.

A New Astronomical Journal.—We are pleased to be able to record that, with an increased grant from the Dominion Government, the Royal Astronomical Society of Canada has commenced the publication of a bi-monthly journal recording the proceedings of the society. The first number (January and February, 1907) contains information regarding the society and several very interesting papers. Among the latter may be mentioned two papers by Mr. Stupart on magnetic storms and auroræ, the president's address on the astronomical work of 1906, and a paper by Mr. Plaskett on the spectrum of Mira, referred to above.

MODERN VIEWS OF THE ETHER.

Introduction.

IN putting into print once more the book called "Modern Views of Electricity," my object is to recall attention to the ethereal aspect of affairs, and to assist in the combination of those ideas with the comparatively recent notion of electrons on the strength of which such great advances have been made. There are several additions to the book, and especially there is a concluding chapter which, since the other portions of the original book appeared in the columns of NATURE, may likewise be allowed so to appear. It will be observed that, on the basis of a consistent working hypothesis therein, an attempt is made to estimate the absolute value of the two ethereal constants—a thing which I have for many years sought to do. It will also be seen that, from the point of view adopted, the density of the ether comes out, not merely greater than platinum, as had several times been surmised, but very much greater: in fact, something comparable to a billion times the density of water, and its intrinsic constitutional energy is correspondingly enormous.

There is nothing paradoxical, nor, so far as I can see, improbable, about these figures. Matter is an excessively porous or gossamer-like structure, and the inertia of matter must be a mere residual fraction of the inertia of the continuous incompressible complex fluid, of which it is hypothetically composed, and in which it moves.

The following is the chapter referred to:—

CONCLUDING CHAPTER OR SUMMARY.

Structure of the Ether.

What, then, is the conclusion of the whole matter, so far as a conclusion is possible at present?

The material universe seems to consist of a perfectly continuous incompressible and inextensible medium, filling all space without interstices or breach of continuity;—not of a molecular or discrete structure, and as a whole completely at rest: as frictionless moreover, and unresisting to all ordinary motion of what we call matter through it, as is the mathematical conception—a perfect fluid. But in spite of immobility as a whole, it possesses that property of "rigidity," or elastic resilience to "shear," which is characteristic of what we ordinarily call a solid; wherefore it would appear that it must be, throughout, in such a state of excessively fine-grained turbulent motion as would confer this property upon it. And the resilience is so complete and instantaneous, without any delay or permanent set, that the elasticity must be described as "perfect." It is the gyrostatic kind of elasticity, discovered dynamically and applied ethereally by Lord Kelvin, whereby a perfect fluid can kinetically acquire some of the properties of a perfect solid.

It is well known that every solid possesses two kinds of elasticity—elasticity of bulk and elasticity of shape. The first or volume elasticity may also be called "the incompressibility," and is common to all forms of matter—fluid as well as solid. In the case of the ether, however, the value of this quantity appears to be infinite: it is, at any rate, greater than we have as yet been able to appreciate by specially directed experiments—meaning especially the Cavendish experiment referred to in §§ 4 and 14A. The elasticity of figure, or shape-elasticity, is only possessed by solids, and is technically called "rigidity"; it is small in the case of india-rubber, great in the case of steel or glass; it is the property on which spiral springs and torsion-balances depend. The two kinds of elasticity are quite independent of each other—quite independent also of anything akin to viscosity, which in the case of the ether appears to be zero.

Now something analogous to shape-elasticity the ether possesses. It does not possess ordinary mechanical rigidity, because that is an affair of molecules; but it possesses something which may be called an electric rigidity, or electromotive elasticity. It is identical with the electromotive elasticity of a dielectric,—it is the property which causes recoil after charge; and it has been denoted by $4\pi/\kappa$, where κ is the absolute Faraday's dielectric constant, or specific inductive capacity, for free space.

The property thus analogous to rigidity, or shape-elasticity, is accompanied by another property, akin to inertia. This is the property to which magnetism is due; it is a magnetic inertia, to pair with electric rigidity, and it has been denoted throughout by $4\pi\mu$, where μ is the absolute magnetic permeability of free space. The self-induction of quasi-inertia associated with every electric current, of which $4\pi\mu$ is the non-geometrical and essential factor, is explicable, up to a point, as due to the magnetic field excited by electric motion; but it would seem as if ultimately it must necessarily be dependent on an unexplained and fundamental kind of inertia possessed by the ether itself; so that the ether may be said to have a certain density, or mass per unit volume,—something at least so like ordinary material specific-gravity or density that we have to call it by the same name.

By reason of these two properties—electric elasticity and magnetic density—transverse electromagnetic waves are transmitted through and by the ether, at a perfectly definite and known speed. This speed of wave propagation is far greater than any we are accustomed to in connection with matter; and if ever the motion of matter can be made to approach this speed, it must encounter a reaction or impedance or opposition to further acceleration, which ultimately, in the limit, amounts to a practically infinite obstruction, at the actual critical speed.

This obstruction is not of the nature of friction,—it is not resistance proportional to the velocity, or in any way dependent on the velocity: it solely opposes acceleration, and is of the nature of impedance or inertia.

The fact of inertia enables an oscillatory wave-process to go on in the ether, and endows those oscillations with a particular kind of alternating kinetic, as well as with potential, energy.

The energy of strained or distorted ether is always potential energy, and is all the potential energy there is; but accessible or convertible kinetic energy is usually only possessed by those individualised and discriminated regions, or ethereal structures, which possess the power of locomotion, and which in their aggregate appeal to our senses as "matter."

During the passage of waves, the ethereal structure is sheared to and fro; not with any movement as a whole, but with equal opposite movement of two aspects, or elements, or conditions, of its structure: such shear being equivalent to what is called an electric displacement, and being subject to a restoring force accurately proportional to that displacement.

This elasticity is "perfect" in free space, apart from matter, until a critical shear, of unknown value, is reached. If strained beyond that, it may be supposed that a separation, or dislocation, or decomposition, of the ether into two components or constituents would occur;—constituents generated, as it were, by means of the shear, and probably not existing, as such, in the unperturbed ether. One of these components we call positive, and the other negative, electricity. Once formed they do not disappear again: they may combine—or approach each other so closely that they neutralise each other's effects at a distance; but they are still readily separable by electromotive force. They do not combine in the sense of destroying each other,—they do not re-form the original substance out of which they were produced.

The negative electricity, when separated, is freely mobile and easily isolated: it is what we experience as an electron. The positive constituent does not appear thus in an isolated manner, but is only known to exist in a mass, as if matted together and associated with an indistinguishable and inseparable aggregate of charges—opposite charges apparently in combination, going about as a whole. Some of these aggregates may unite into larger ones; others, when too large, may split up into smaller ones; and so finally a set of sub-permanent stable aggregates are formed, which we recognise as the atoms of the so-called "elements" of matter: each with its appropriate degree of stability.

These masses or aggregates may temporarily acquire, or may lose, one or more of the free electrons; and by thus becoming amenable to electrical or chemical attractions and repulsions, constitute what we call "ions," so long as the unbalanced or electrified condition lasts.

Massiveness of the Ether.

Each electron, moving like a sphere through a fluid, has a certain mass associated with it; dependent on its size, and, at very high speeds, on its velocity also.

Now how shall that mass be treated?

Shall we deal with it on the analogy of a sphere moving through a perfect irrotational liquid, without examining into details any further?

Or shall we consider it as generating circular lines of magnetic induction by its movement, by reason of the rotational properties of the ether, and attribute all its inertia to the magnetic whirl thus caused round its path: treating the whirl as an actual circulation of fluid excited by the locomotion?

Both methods may be adopted, to see whether they will agree.

Now treating it by the first method, and considering the electron merely as a sphere moving through a perfect liquid, its behaviour is exactly as if its mass were increased by half that of the fluid displaced and the surrounding fluid were annihilated. It has been argued in the book, from the result of the Cavendish surface-charge experiment, and from the phenomena of gravitation, that the ether is incompressible, to a high degree of exactness; and accordingly the density of fluid inside and outside an electron must be the same. So that, treating it in this simplest fashion, the resultant inertia is half as great again as that of the volume of fluid corresponding to the electron: that is to say, is $2\pi\rho a^3$, where ρ is the uniform density. If it is of some other shape than a sphere, then the numerical part is modified, but remains of the same order of magnitude.

Now treat it by the other, or magnetic whirl, method.

Let a spherical electron e of radius a be flying at speed u, so that the magnetic field at any point $r\theta$, outside, is

$$H=\frac{eu\sin\theta}{r^2},$$

and the energy per unit volume everywhere is $\mu H^2/8\pi$.

It has been shown by Lord Kelvin, Mr. Heaviside, G. F. FitzGerald, and Prof. Larmor, that a magnetic field may be thought of, hypothetically, as a circulation of fluid along the lines of magnetic induction—which are always closed curves—at some unknown velocity w.

Consider the energy per unit volume anywhere, it can be represented by the equivalent expressions

$$\tfrac{1}{2}\rho w^2=\frac{\mu H^2}{8\pi}=\frac{\mu}{8\pi}\frac{e^2u^2\sin^2\theta}{r^4},$$

wherefore

$$\frac{w}{u}=\sqrt{\left(\frac{\mu}{4\pi\rho}\right)}\cdot\frac{e\sin\theta}{r^2};$$

On the cog-wheel analogy the highest velocity will be that in contact with the moving charge, and there is some reason to suppose that the maximum velocity w at the equator of the moving sphere may be equal to the speed u. Elsewhere it will decrease with the inverse square of the distance just as H decreases.

But without any hypothesis, if there be a circulation at all, its velocity must be a maximum at the equator of the sphere, where $r=a$ and $\theta=90$; so, calling this w_0,

$$\frac{w_0}{u}=\sqrt{\frac{\mu}{4\pi\rho}}\cdot\frac{e}{a^2},$$

and

$$\frac{w}{w_0}=\frac{a^2\sin\theta}{r^2},$$

and therefore the major part of the circulation is limited to a region not far removed from the surface of the electron.

The energy of this motion is

$$\tfrac{1}{2}\rho\int_0^\pi\int_a^\infty w^2\,.\,2\pi r\sin\theta\;\;rd\theta\,.\,dr,$$

or substituting the above value of w the energy comes out equal to $\frac{4}{3}\pi\rho a^3 w_0^2$.

Comparing this with a mass moving with speed u,

$$m=\frac{8}{3}\pi\rho a^3\left(\frac{w_0}{u}\right)^2.$$

This agrees with the simple hydrodynamic estimate of effective inertia, if $w_0=\frac{1}{2}\sqrt{3}u$; that is to say, if the whirl in contact with the equator of the sphere is of the same order of magnitude as the longitudinal rack-motion or cog-wheel spin at the same place.

Now for the real relation between w_0 and u we must make a hypothesis. If the two are considered equal, the effectively disturbed mass comes out as twice that of the bulk of the electron. If w_0 is much smaller than u, then the mass of the effectively disturbed fluid is much less even than the bulk of an electron; and in that case the estimate of the fluid-density ρ must be exaggerated enormously, in order to supply the required energy. It is difficult to suppose the equatorial circulation w_0 *greater* than u, since it is generated by it; and it is not unreasonable to treat them both as of the same order of magnitude. So, taking them as equal,

$$e=a^2\sqrt{\frac{4\pi\rho}{\mu}}$$

and m = twice the spherical mass.

Hence all the estimates of the effective inertia of an electron are of the same order of magnitude, being all comparable with that of a mass of ether equal to the electron in bulk.

This would also be the conclusion drawn, if, instead of integrating the magnetic energy from a to infinity, we integrated from a to a larger radius b, or say na; the inertia would then come out

$$\tfrac{2}{3}\mu e^2\left(\frac{1}{b}-\frac{1}{a}\right)\quad\text{or}\quad\frac{2(n-1)}{3n}\frac{\mu e^2}{a},$$

and be still of the same order of magnitude for all reasonable values of n; the reason being that all the effective disturbance is concentrated in the neighbourhood of the charge.

Now the linear dimension of an electron is 10^{-13} centimetre diameter, and its mass is of the order 10^{-27} gram, being about the 1/700th part of the atom of hydrogen. Consequently, if its mass were due to its contents, the density of its material must be of the order

$$10^{-27}\div10^{-39}=10^{12}\text{ grams per cubic centimetre.}$$

This, truly, is enormous, but any reduction in the estimate of the circulation speed, below that of an electron, would only go to increase it; and since electrons move sometimes at a speed not far below that of light we cannot be accused of underestimating the probable velocity of magnetic spin by treating it as of the same order of magnitude, at the bounding surface of the electron: a relation suggested, though not enforced, by the cog-wheel and gyrostat analogy.

Incidentally, we may notice how enormous is the magnetic field surrounding the equator of an electron moving along an axis with, say, one-thirtieth the speed of light: it amounts to 10^{15} C.G.S. lines per sq. centimetre. And the magnetic energy there is correspondingly enormous, being 4×10^{28} ergs per c.c. At the velocity of light it would equal the constitutional energy of the ether itself.

Value of the Ethereal Constants.

It has been argued throughout the book that the ethereal density is what we know in magnetism as $4\pi\mu$; wherefore an approximate estimate of the absolute value of the magnetic constant μ for free space, on this view, is 10^{11} grams per c.c.

Using the value $4\pi\mu=\rho$, we get for the charge of an electron

$$e=4\pi a^2,$$

or comparable to its superficies.

The speed with which waves travel through the medium is the square root of 10^{21} C.G.S.; consequently the elasticity of the ether must be of the order 10^{33} dynes per square centimetre, which is what in static electricity we denote by $4\pi/\kappa$. Wherefore an approximate estimate of the absolute value of Faraday's dielectric constant κ, for free space, is 10^{-33} cubic centimetre per erg.

In other words, the intrinsic energy of constitutional motion of the ether, to which its rigidity is due, is of the order 10^{33} ergs or 10^{26} Joules per cubic centimetre—about a hundred foot lbs. per atomic volume; which is equivalent to the output of a million horse-power working for forty million years, in every cubic millimetre of space. It can otherwise be expressed as the energy of a thousand tons per cubic millimetre, moving with the velocity of light; but of course the motion really contemplated is all internal and circulatory.

Transmission of Waves.

Wherever electrons and atoms exist, they modify the ether in their immediate neighbourhood, so that waves passing through a portion of space containing them are affected by their presence, as if the ether were more or less loaded by them; because the electric displacements which go on in the unseparated and still perfectly united constituents of free ether are also shared to some extent by the separated peculiarities, especially by those of the electrons which are not too embedded in or surrounded by a positive charge—for instance, like a nucleus in a shell. These might be inert, and without influence on the light, except as small fixed mechanical obstructions; but all those charges which possess externally-reaching lines of force must share in the motion of the waves, without having the requisite amount of resilience to compensate for their inertia; consequently they, to that extent, constitute a retarding, and either an absorbing or a reflecting, agency.

Furthermore, their motions of vibration and rotation during the epochs of acceleration, however caused, encounter the inertia of the medium, and thereby excite waves in it—waves of oscillatory electric displacement with magnetic concomitant—and this electromagnetic radiation is transmitted out into space; but it is insignificant in amount unless the acceleration is violent. It is proportional to the square of the acceleration.

The positive and negative constituents, when they combine or cohere, do not destroy each other and revert into plain ether again; on the contrary, they retain their individuality and persist, in either a combined or separate state. We do not know how to produce or to destroy these peculiarities; and though atoms of matter are composed of them, and though all electrical phenomena and the excitation of radiation are due to their presence and behaviour, it is no more and perhaps not much less correct to say that the main bulk of the ether is composed of them than it is to say that actual sodium and chlorine exist in undissociated common salt. These elements only make their appearance when the original substance is decomposed. But certainly matter can be dissociated with extreme ease, whereas the dissociation of ether is unknown and hypothetical, save as represented by its apparent results.

Nevertheless, it must be the case that the slight, almost infinitesimal, shear, which goes on in a light wave, is of the nature of incipient and temporary electric separation; and all electromotive force *tends* to drive one constituent in one direction and the other in the other; thus beginning that individualisation or separate manifestation of the two ingredients, without a knowledge of which the original fluid would have appeared to be of a perfectly uniform and homogeneous character.

It is quite possible that the actually double aspect of ether is not only manifested, but really generated, by an electromotive force applied to it, just as the elastic recoil is so generated. It appears possible that a sufficiently violent E.M.F. applied to the ether, by some method unknown to us at present, must be the kind of influence necessary to shear it beyond the critical value and leave its components permanently distinct; such constituents being opposite electric charges, which, when once thoroughly separated, only combine to form matter, and do not recoil into ordinary ether again.

Hypothetical Longitudinal Stress.

Every attempt at separation of this kind, even if no stronger than exists in ordinary light, seems to be accompanied by a slight longitudinal force at right angles both to the displacement and to the orbital axis of the excursion—a force which is known as the normal pressure of light, or Maxwell's pressure, perpendicular to an advancing wave-front: the inertia of the constantly encroached upon region of free ether having the effect of momentum.

If the disturbance could be made so extreme as to result in permanent dislocation, this pressure might leave behind it, as permanent residue, a longitudinal pressure, extending throughout space inversely as the distance; whereby all the dislocated material would thereafter be urged together with a force which we know as gravitation, proportional in any piece of matter to the number of dislocated centres which go to compose it, and therefore proportional to its mass, irrespective of secondary accidents of a physical or chemical constitution.

Amplitude of Light Wave.

If a is the amplitude of shear during the passage of a wave of light, and if u is the maximum velocity of recovery, then

$$\frac{u}{v}=2\pi\frac{a}{\lambda},$$

where v is the velocity of light and λ the wave-length. The total energy per unit volume is $\frac{1}{2}\rho u^2$, where ρ is the density of the medium; for this represents twice the average kinetic energy, and of this quantity one-half is really kinetic, the other half potential.

Now direct thermal measurements, such as those conducted by Pouillet, give as the energy of sunlight near the earth 4×10^{-5} erg per c.c.; and consequently, in the region of intense light near the solar surface, the energy of radiation must be about 2 ergs per cubic centimetre. There may be more intense light than this, but this is the most intense we know of, so it is instructive to consider the amplitude of the shear corresponding to such violent illumination. Let us therefore put $\frac{1}{2}\rho u^2=2$, whence

$$u^2=4\times10^{-12}.$$

It follows, therefore, that

$$u/v=\tfrac{2}{3}\times10^{-16},$$

and accordingly the amplitude, of the most intense visible light we are acquainted with, is only 10^{-17} of a wave-length. The maximum strain is 2π times this fraction; and so the tangential stress thus called out in the medium, its rigidity being 10^{33}, may be estimated as comparable with 10^{17} dynes per square centimetre, or 10^{11} atmospheres.

The ordinary electrostatic unit of charge, on this estimate of ethereal elasticity, becomes 10^{-16} square centimetre, or the superficial dimension of an atom. This also corresponds with the estimate above, that the electronic charge is equal to the superficies of an electron; since one should be 10^{10} times the other.

The pressure of light has been represented by Prof. Poynting as a travelling momentum, like that of a jet of water, resulting in a pressure ρcv, where c is the velocity of longitudinal motion or circulation in the light beam, and v is the velocity of light. Taking the pressure of intensest light as 2 dynes per square centimetre, this gives $c=\tfrac{2}{3}10^{-22}$ centimetre per second: excessively small, therefore, even in that extreme case.

Hypothetical Flow along Lines of Magnetic Induction.

It has long been a working hypothesis with some mathematical physicists (see, for instance, the ensuing April number of the *Philosophical Magazine*) that there was probably something of the nature of a flow—an ethereal flow—along lines of magnetic induction; and the fact that these are always closed curves, in all known circumstances, is in favour of such an idea. The energy of the field would then be attributable to the energy of this flow; and though it is possible that the flow might be of the nature of components moving in opposite directions, the movement is hardly likely to be of this nature, since that would correspond with merely an electric current.

Fourteen years ago, in 1893, having rather perfect appliances for examining the effect of drift on the velocity of light, I carefully looked for some longitudinal flow along lines of magnetic force; repeating the experiments still more anxiously when I learnt that something of the kind was seriously suspected by Dr. Larmor.

Applying a field of 1400 C.G.S. units over a length of light path of about 14 metres in the aggregate, things were so arranged that a drift of 1 foot a second, or about 10^{-9}th of the velocity of light, would have been observed by a fractional shift of micrometrically viewed interference bands, if it had occurred. But no effect whatever on the interference bands could be detected, nor was anything observed when—with less perfect vision, in that case, owing to increased difficulties—the air along the field and path of light was replaced by bisulphide of carbon; except that, of course, if plane-polarised light was used, the plane was then rotated by a very large amount. Sufficient details of this series of negative experiments will be given in the forthcoming April issue of the *Philosophical Magazine*.

The result was to show that if the magnetic energy were to be accounted for in the assumed kinetic fashion, the density of the ether must be very considerable—in fact about 180 times that of water—in order to give the actual energy with a velocity below what could be observed in this way.

I have now, however, as described above, made a theoretical estimate of the density of the ether—arriving at the tentative conclusion that it is of the order 10^{12}—and we can therefore proceed to calculate what velocity of hypothetical ethereal drift is to be expected in any given magnetic field. It will come out, of course, exceedingly slow; for, on this view, the electromagnetic unit of field is $\mu^{-\frac{1}{2}}$, which equals 3×10^{-6} centimetre per second, and the velocity to be expected is the 2πth of that.

So, for instance, the field inside a solenoid, surrounded by a current of 100 amperes circulating 100 times round every centimetre of it, being $4\pi n_1 C$, will equal 12,000 C.G.S.; which corresponds with a velocity of 0·003 centimetre per second, or about 4 inches an hour. In fact, the ampere turns per inch, in any solenoid, measures the speed of magnetic circulation along its axis, no matter what the material of the core may be, in millimicrons per second.

When iron is substituted for air, the speed is the same; but the ethereal density is virtually increased, by the loading due to the molecular whirls in the iron.

It may seem difficult to reconcile this very slow velocity, in any ordinary field, with the great velocity, of the very same character, already postulated in the immediate neighbourhood of an electron; where it is supposed that the magnetic circulation is equal to, or at any rate of the same order of magnitude as, the locomotion speed—which it is well known may easily be 1/30th of the velocity of light, without departing appreciably from the simply calculated inertia. But that great speed, in the immediate neighbourhood of an electron, can be fully admitted; and there is nothing really inconsistent in that with the slow speed observed at any ordinary distance. For instance, if, close to the equator of a flying electron, the ethereal magnetic speed is 1/30th of the velocity of light, or 10^9 centimetres per second; then, at a distance of 1 millimetre away, the speed is reduced to 10^{-24}th of that value, and is, therefore, even at that small distance, only 10^{-15} centimetre per second, or 3 millimicrons per thousand years.

The speed at the axis of a solenoid is, of course, far greater than that, because of the immense number of electrons in any ordinary current surrounding it; but, in order to get up a drift-velocity of 1 centimetre per second in a solenoid, a thousand amperes would have to circulate three thousand times round every centimetre of it; which seems hardly practicable.

The optical arrangements, in my experiment above spoken of, could doubtless be improved sufficiently to show an ether drift of 1 centimetre per second; but I do not see how to produce a field of the required intensity to give even this leisurely flow. Such a field would have to be about four million C.G.S. units, and must exist throughout a great length of air.

The experimental verification of the above theoretical estimate of ethereal density seems therefore to be beyond the reach of this form of experiment. Nevertheless, I feel reasonably convinced that there is a justification for assuming the ether to have properties such as can only for the present be represented, in analogy with the properties of matter, by saying that its behaviour consistently indicates something typified by its possession of an immense elasticity or rigidity, 10^{33} dynes per square centimetre, caused by its intrinsic constitutional energy; combined with a property analogous to, and resulting in, material inertia, and typified by attributing to it a density of the order 10^{12} grams per cubic centimetre. The ethereal property, here called elasticity, is certainly the source and origin of every kind of material elasticity and potential energy; for the only real static effect producible in the particles of matter is a change in their arrangement or configuration. All stress must exist really in the ether.

Although the experimental methods so far suggested have proved themselves unable to test the magnitudes involved in these high values, some other method of inquiry may be suggested, and the theory may yet be brought to the test of experiment. OLIVER LODGE.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE annual spring meeting of the Institution of Naval Architects was held last week at the Society of Arts, commencing Wednesday, March 20, and being continued over the two following days. Fourteen papers were read and discussed, some of them at considerable length, while Lord Glasgow's presidential address, the report of the council, and other necessary business received due attention.

The first paper taken was a contribution by Mr. James McKechnie, of Barrow, the subject being the influence of machinery on the gun-power of the modern warship. This paper was full of information, but perhaps the most interesting part was that in which the author compared the elements of design of three imaginary battleships, propelled respectively by steam, gas, or oil engines. It is somewhat startling to find the chief engineer of one of our most powerful shipbuilding and engineering companies—and one, too, so largely engaged in the production of war material—should think gas or oil engines, as propulsive agents for the largest warships, sufficiently within the possibilities of the near future as to make it the subject of a paper before this important institution; it is prophetic of still vaster changes in store than even the transition from shell boilers to water-tube boilers, and from reciprocating engines to the steam turbine. Mr. McKechnie, however, intimated during the discussion on his paper that his company, Vickers, Sons and Maxim, was quite prepared to build a warship with gas-producers in place of boilers, and gas engines in place of steam engines, if any Government had the courage to give them an order. It would seem almost that steam's unconquerable arm is likely to have its supremacy challenged even in that field where we have hitherto held it to be most secure.

Mr. McKechnie takes for his comparison the designs of three battleships, each of 16,000 horse-power. The one propelled by steam would have machinery that would develop 10·1 horse-power per ton weight of machinery; the gas-driven machinery would give 14·48 horse-power per ton, whilst the oil engines and machinery would give off 21·33 horse-power per ton. Probably an oil-engined battleship may be considered outside the bounds of practical engineering application until oil fuel becomes far more plentiful than there appears to be any prospect of it being at present, waiting, of course, that gloomy but undefined era when the coal supplies of the world are exhausted. If, however, we confine ourselves to coal fuel, it is certainly a tempting offer which the engineer offers to the naval architect, this increase of nearly 50 per cent. in the power developed on a given weight. There are, however, other inducements. With the steam engine the area occupied by machinery per unit of power is 0·453 square foot, whilst of the gas engine but 0·336 square foot is needed for each horse-power developed. That also is a very substantial gain in a battleship, where every inch of space is so costly to produce and so urgently needed.

The third chief consideration Mr. McKechnie brings forward is fuel economy. Steaming at full power, the coal burnt would be 1·6 lb. per indicated horse-power with one ship, whilst the sister vessel would be "gassing" (we shall have to become reconciled to the objectionable term) with a consumption of 1 lb. of coal per indicated horse-power per hour. Here is a saving of more than 50 per cent. in weight of coal carried, bunker space, time of coaling, and other subsidiary matters, amongst them money cost. At lower powers the figures bear approximately the same ratio.

These are enormous strategical advantages, but the tactical benefits offered are hardly less pronounced. By means of profile views the author showed the gun emplacements of the two ships. With the usual two-chimney arrangement of the steam ship, there are four 12-inch guns placed in pairs in two barbettes at the ends of the battery, as is usual. These have arcs of training, a few degrees before or abaft the beam respectively, whilst the weapons of a lighter nature can only fire on their respective broadsides. When we turn to the ship without boilers—the gas-engine ship—we find the space that would be taken in the other vessel by funnels, uptakes, &c., occupied by three additional barbettes placed *en echelon*, and each containing two 12-inch guns. There are also the two end barbettes with their four guns, as in the steam ship. These six centrally placed guns can be, moreover, trained on either broadside, so that, in an encounter between the steam ship and the gas ship the latter could bring ten 12-inch guns into action as against four of the former vessel, supposing the encounter to be broadside on; or, to put the case another way, the gas ship could fight a steam ship on each broadside, and have a superiority over her enemies of two 12-inch guns. With secondary armament the problem is more complicated, and could hardly be explained without diagrams.

What, it will be asked, are the defects of these qualities? and an answer can only be given by the light of experience—an experience only likely to be gathered by steps. The marine steam engine has been brought to such a state of efficiency that its performance can be practically depended upon; this is not the case with the producer gas engine. There are many things to find out yet, the problem being more complex from the combination of mechanical and chemical sciences that have to be applied. With gas engines afloat—a very different thing from gas engines ashore supplied from a central source—one hears of the explosive mixture failing, from unexplained causes, and the engines stopping without warning, and there are details of working connected with ignition and other points which have yet to be perfected. For much the same reason that many naval engineers prefer hydraulics to electricity for working armaments, steam is likely to be preferred to gas for propelling battleships. Which will ultimately survive time will show; in the meantime, it may be said Mr. McKechnie has worked out a very strong case for gas.

The remaining paper taken on this day was by Mr. Simon Lake, who dealt with the subject of submarine boats. The type of vessel the author advocates is fairly well known, its most striking characteristic being that it is fitted with wheels so that it can travel along the bottom of the sea. The paper gave an interesting account of some of Mr. Lake's adventures in his ingeniously devised craft.

On the second day of the meeting Mr. W. J. Luke, of Clydebank, read a paper in which details of certain points in the construction of the new big Cunard ship *Lusitania* were set forth. The chief point was the application of high tensile steel in the upper part of the hull structure, a detail of shipbuilding design which possesses definite advantages, seeing that the hogging stresses are more serious than the sagging stresses, and therefore tension is of high importance for the upper member of the girder formed by the hull structure. The evolution of the modern cargo steamer was the subject of a paper by Mr. S. J. P. Thearle, of Lloyd's. It was a contribution that will be of value in the Transactions of the institution for future students of the history of shipbuilding. Cranes for shipbuilding afforded a subject of practical interest for Signor C. Piaggo.

The two papers that were read at the evening meeting of the same day were both of interest and importance. They described two forms of instrument for measuring the power given off by turbines. The author of the first paper was Mr. A. Denny, and of the second Mr. J. H. Gibson. As is well known, the ordinary steam-engine indicator, by which horse-power has been measured since the days of James Watt, is useless for application to turbines, because there is no reciprocating motion with the latter. This has been a serious obstacle in the path of ship designers, but it appears to have been overcome by taking indicators of the torsion of the shafting through which power is conveyed from the turbine to the propeller. In both the instruments described by the authors of the two papers recourse is had to this means, but the method of recording is different. In the Denny and Johnstone torsiometer is an electrical method in which a telephone is used, whilst in Mr. Gibson's instrument recourse is had to a flash of light deflected by a mirror. The details by which these processes are made practical have been worked out in each case with great ingenuity, but it would be difficult to make them clear without illustrations. It may be pointed out, as Lord Glasgow stated at the meeting, that the successful application of these instruments will solve a problem that the elder Froude worked out with much enthusiasm during the later years of his life, though with very partial success. A paper on propeller struts, by Mr. G. Simpson, was of purely professional interest.

One of the most interesting papers of the meeting was Sir William White's contribution on experiments with Dr. Schlick's gyroscopic steadying apparatus. This paper is of such interest that we propose to deal with it separately. Its full comprehension, however, involves a knowledge of the principles set forth in a paper read by Dr. Schlick a few years ago, Sir William having thought it unnecessary to go over the same ground again.

The other papers read were on the approximate formulæ for determining the resistance of ships, by A. W. Johns; on the application of the integraph to ship calculations, by J. G. Johnstone; on the prevention of fire at sea, by Prof. Vivian B. Lewes; on modern floating docks, by Lyonel Clark; and on some phases of the fuel question, by Prof. Vivian B. Lewes.

The institution will hold a summer meeting in Bordeaux towards the end of June.

TICKS AS TRANSMITTERS OF DISEASE.[1]

MANY statements are found in medical works as to the local poisonous effects of tick bites, but these are of small importance compared with the diseases inoculated by ticks. Until a year or so ago ticks were only known to transmit one kind of disease, and this was confined to the lower animals. Of these diseases, "Texas" fever in cattle may be regarded as the type. These diseases, which are met with in cattle, horses, asses, sheep, and dogs, are due to parasites which attack the red cells of the blood. The parasites are characterised by their pear shape, and hence were originally called Pyrosoma; but this name has now generally been replaced by Piroplasma, and the infection by these parasites is known as piroplasmosis.

Smith and Kilborne in America, by their classical researches, first established the fact that Texas fever in cattle was transmitted by ticks. We may consider the mode of transmission somewhat more closely. Ticks in their life-history go through the stages of eggs, larva, nymph, and adult. In the case of transmission of malaria by certain Anophelines, we know that the adult mosquito when it has fed on the blood of a malarial patient can transmit the disease again after the lapse of ten days, more or less, to a healthy person. Very different, however, is the mode of transmission of piroplasmosis by ticks. Smith and Kilborne showed that Texas fever was transmitted from the sick to the healthy animal, not by adult ticks, but that it was young ticks hatched from the eggs

[1] "Scientific Memoirs by Officers of the Medical and Sanitary Departments of the Government of India." New series, No. 23. "The Anatomy and Histology of Ticks." By Capt. S. R. Christophers. Pp. 55+plates. (Calcutta: Office of the Superintendent of Government Printing, 1906.) Price 4s. 6d.

Memoir xxi. of the Liverpool School of Tropical Medicine, September, 1906. Pp. xiv+118+plates. (London: Williams and Norgate.) Price 7s. 6d. net.

of ticks found on diseased animals that transmitted the infection. The transmission is thus hereditary, and of a transmission of this kind we have no evidence at all in the case of malaria, though it has been stated that this mode of transmission occurs in yellow fever.

The transmission of Piroplasma by ticks is thus peculiar, and when we come to examine the known facts closely the peculiarity increases. Smith and Kilborne, as we have stated, showed that the infection of Texas fever due to *P. bigeminum* was carried by ticks in their larval stage. In the case of *P. canis* producing malignant jaundice in dogs the mode is different. In this case it is not the larva, but the adult tick of the second generation that transmits the disease. This also is the case for red-water of sheep due to *P. ovis*. In the case of piroplasmosis of the horse, the mode has not yet been definitely established. Finally, in the case of "African coast fever" in cattle, a disease resembling in some respects "Texas" fever, but due to a different Piroplasma, viz. *P. parvum*, we appear to have a still more complex state of things. The transmission, according to Lounsbury, in the case of the tick (*R. appendiculatus*) is not hereditary, but is transmitted by nymphs which in the larval stage have fed on infected animals, and also by adults which in the nymphal stage have fed on infected animals. Hence it is clear that analogy as a guide is almost useless, and it must be determined by actual experiment how in each case the transmission is brought about. Of the actual changes undergone by the Piroplasma in the tick, egg, larva, nymph, as the case may be, we know but little.

Recently, however, Koch described peculiar forms in the stomach of the tick which he considers to represent a cycle of development. Other forms have also been found in the egg, but not, so far, in the larva or nymph. No doubt research will be in the future directed to these points.

Piroplasmosis is, then, an important set of diseases transmitted by ticks, but, further, they have been recently shown to play a part in the transmission of those minute, slender, corkscrew-like parasites known as Spirochætes. These parasites give rise in man to a dangerous and often fatal fever, a marked character of which is the tendency to relapse. Hence it is known as recurrent or relapsing fever. The cause of relapsing fever has been long known to be a Spirochæte, viz. *S. obermeieri*, but it is only recently that the nature of "African tick fever" has been elucidated. This is also due to a Spirochæte, and as it is different from the former it has been named *S. duttoni*, after the late Dr. Dutton, who with Todd was the first to elucidate the mode of transmission of the disease. The memoir of the Liverpool School of Tropical Medicine contains an elaborate study, clinical and experimental, of the characters of this Spirochæte. Perhaps the most convincing proof brought that these two Spirochætes are different lies in the fact that an animal that has recovered from an attack of the one is still susceptible to inoculation with the other, and *vice versâ*. How the ordinary relapsing fever is transmitted is still uncertain; it may be by bugs, though the numerous experiments recorded in this memoir to transmit *S. duttoni* in this way have all failed; but ticks are the transmitters of *S. duttoni*, and in Africa the particular tick implicated is *Ornithodoros moubata* (Murray). This tick, long of evil reputation, can transmit the disease in the following ways:—(1) directly, *i.e.* by means of adults that have sucked the blood of infected patients; and (2) by the nymphal descendants of these adults. Spirochætes have also been found by Koch in the eggs of ticks, but whether or no they undergo any development is at present unknown.

From what we have said it will be evident that to the medical man a knowledge of ticks is of the utmost importance, and every medical man will welcome this memoir of Captain Christophers on the anatomy and histology of ticks. The histological portion will be especially useful, as the systematic treatises, *e.g.* Neumann's memoirs, deal solely with the external characters on which their classification is founded. The internal anatomy of ticks has until quite recently been described in a very meagre fashion, and it is evident that such a knowledge is absolutely necessary in the search for developmental forms of Piroplasma and Spirochæta in the various tissues.

Those who are acquainted with Captain Christophers's previous work on the anatomy and histology of the mosquito will know what to expect in this memoir.

The clear descriptions, illustrated by numerous diagrams and six photogravure plates, might with advantage be imitated by other recent writers on the same subject.

With regard to the plates, unfortunately in passing through the press the lettering of many of the figures has not appeared. We may note also that the secretion from the coxal glands was observed by Dutton and Todd in the Congo.

The Liverpool memoir, besides the study of *S. duttoni*, contains a description of various attempts made to cultivate this Spirochæte, but all in vain. A new Spirochæte in the mouse, *S. laverani*, is also described. Two papers on Trypanosomes, and a number of pictures of the research laboratories at Runcorn of the Liverpool Tropical School, complete a very interesting memoir.

J. W. W. Stephens.

TROPICAL BOTANY.

An interesting number of the Annals of the Royal Botanic Gardens, Peradeniya (London: Dulau and Co.), has just appeared. In the first paper Mr. R. H. Lock gives the third instalment of his work on plant-breeding in the tropics, dealing with maize. Unlike some Mendelian experiments, the results have been obtained with large numbers, and on a total, for instance, of 111,697 seeds, the result was 50·17 against an expectation of 50·11. The second paper is by Mr. T. Petch, on the fungi of the nests of the common termites, or white ants, of Ceylon, a worthy successor of Möller's classical paper on the fungi of the leaf-cutting ants of South America. He has worked out in detail the entire life-histories of the fungi, and shows that while the "regular" fungus is a Volvaria (already described elsewhere, as are so many of the tropical fungi that have only been worked at in Europe, under at least six genera), the garden also contains "weeds," one of which, at least, a Xylaria, is impossible of eradication by the ants. Incidentally, grave doubt is thrown on Möller's theory of selection of the fungus by the ants, for the "Kohl-rabi heads" occur in the termite nests in an even more perfect and complex form than in the leaf-cutters' nests, and yet the same form appears on an allied outside fungus not cultivated by the ants. The paper is well illustrated.

The third paper is by Dr. Willis, on the flora of Ritigala. This is an isolated mountain in the "dry" zone of Ceylon, forty miles from any other, and high enough to condense much moisture on the top, where are found 103 species not otherwise known in the dry zone. These, being species of the lower zone of the southern mountains, must have leapt the whole forty miles in one operation. Among them are twenty-four bird-carried things, with one very slightly marked endemic variety among them; forty-nine wind-carried things (including twenty-four ferns), with two endemic species and one variety; and thirty plants the mode of distribution of which may be called doubtful or accidental. Six of these are low-country plants which might come by easy stages, and of the remaining twenty-four no less than nine are endemic to Ceylon and to the couple of acres of the summit of Ritigala. One of these nine has been found in South India, but the other eight are confined to Ritigala. This goes to show, therefore, that endemism goes with difficulty of distribution and rare arrival in one spot.

The final paper is by Mr. A. M. Smith, who has followed up Blackman's already almost classical paper on optima and limiting factors by a careful study of growth under different conditions in Ceylon—where it is rapid, and can be easily measured—and finds that Blackman's theory explains matters well. In Dendrocalamus (giant bamboo) at Peradeniya the limiting factor is humidity, while at night at Hakgala, where it is cold, the temperature is limiting and humidity has no effect. This work explains, but renders practically valueless, the enormous mass of observations on growth made by physiologists from Sachs onwards, and no one interested in physiology can afford to leave this paper unread. It also helps to show what an opening there is for really good physiological work in the tropics. The whole number is one of considerable interest and importance, and cannot be neglected by botanists.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. J. E. S. MOORE has been elected to the chair of experimental and pathological cytology, recently established in the University of Liverpool by the Liverpool Cancer Research Committee.

A SERVICE for members of the University of London will be held in Westminster Abbey on Wednesday, May 8, presentation day, at 6 p.m. The Dean of Westminster has consented to preach the sermon.

PROF. M. D'OCAGNE, of the École des Ponts et Chaussées, will deliver in April, at the University of Paris, a free course of lectures on graphic calculus and nomography. In the second part he will give for the first time in a public lecture a complete account of his own methods on the subject.

MR. BIRRELL announced in the House of Commons on March 23 that the Treasury has agreed to place at the disposal of Ireland a sum of 40,000*l.* a year for a period of three years to assist to remedy the present disgraceful condition of Irish school buildings. There is no intention of stopping the grant at the end of three years, but it is felt, Mr. Birrell said, that 40,000*l.* is as much as can be spent profitably and usefully in a year.

WE have received an interesting description of the central electric power station of the Victoria Jubilee Technical Institute, Byculla, Bombay, which was opened by the Governor of Bombay on February 20. The installation, the first of its kind in India, is thoroughly up to date, and it is interesting to note that the erection of the boiler, engines, dynamo and motors, as well as all piping and wiring work, was carried out by the institute students.

IN the *Engineering Magazine* (vol. xxxii., No. 6) Commander W. F. Worthington discusses the United States Naval Academy as an engineering school. With the aid of numerous excellent photographs he shows the number, variety, and interesting character of the practical exercises, and expresses the opinion that the academy graduate at the end of a term of years after graduation should rank high among engineers of his own age from other schools, no matter what branch of the work he might take up.

A CIRCULATING library from which the most recent scientific and technical books may be obtained without trouble and at a moderate expense is a great convenience alike to teachers and students of science. Mr. H. K. Lewis, of Gower Street, London, W.C., has realised this fact, and his recently published list of medical and scientific books issued during the last quarter of 1906 shows that he makes every effort to keep his library up to date, and that the conditions under which books may be borrowed have been made as simple as possible.

IN connection with the Federal Educational Conference which the League of the Empire has arranged for May 24, the nature-study section intends to make (for the benefit of the colonial representatives) an exhibit typical of nature-study work in this country. The section will also meet during the week devoted to the conference, in order to discuss matters connected with the promotion of nature-study. Suggestions as to topics that might be considered should be sent to Mr. Wilfred Mark Webb (honorary secretary of the nature-study section), at Caxton Hall, Westminster.

THE organising committee of the International Congress for Hygiene and Demography, which is to be held in Berlin on September 23–29, is making arrangements to render it possible for members of the congress to visit the numerous hygienic institutions in and near Berlin. The meetings of sections will not be extended later than 2 o'clock, so as to leave the afternoons free for visiting. More than a hundred institutions will be thrown open to visitors, and a "Hygienic Guide" giving a short description of each of them in three languages is to be published, so that members of the congress will be assisted in choosing which institutions they will inspect. A local committee composed of representatives of interested Imperial and State offices, the Berlin Council, and other bodies and societies, is actively engaged in preparing for the congress.

THE President of the Board of Agriculture and Fisheries has appointed a departmental committee to inquire as to the provision which has now been made for affording scientific and technical instruction in agriculture in England and Wales, and to report whether, in view of the practical results which have already been obtained, the existing facilities for the purpose are satisfactory and sufficient, and, if not, in what manner they may with advantage be modified or extended. The committee will be constituted as follows, viz.:—Lord Reay (chairman), the Lord Barnard, Lord Moreton, Mr. F. D. Acland, M.P., Mr. D. Davies, M.P., Mr. N. Lamont, M.P., Mr. T. Latham, Mr. J. C. Medd, Prof. T. H. Middleton, Prof. W. Somerville, and Mr. H. Staveley-Hill, M.P. Mr. A. E. Brooke-Hunt, of the Board of Agriculture and Fisheries, will act as secretary, and Mr. H. L. French, of the Board of Agriculture and Fisheries, as assistant secretary to the committee.

THE general committee responsible for the arrangements in connection with the second International Congress on School Hygiene, to be held under the presidency of Sir Lauder Brunton in London next August, is sparing no pains to make the congress a complete success. A meeting to promote the interests of the congress was held on March 20 at the Mansion House, and was well attended. Sir Lauder Brunton explained the objects in view, and gave a detailed description of the groups of subjects to be considered by the congress. There will be eleven sections, as follows:—the physiology and psychology of educational methods and work; medical and hygienic inspection in school; the hygiene of the teaching profession; instruction in hygiene for teachers and scholars; physical education and training in personal hygiene; out-of-school hygiene and the relations of home and school; contagious diseases, ill-health, and other conditions affecting attendance; special schools for the feeble-minded; special schools for blind, deaf, dumb, crippled, and invalid; hygiene of residential schools; the school building and its equipment. Already the donations promised and received reach 927*l.* Further subscriptions are solicited, and should be sent to the treasurer, Sir Richard B. Martin, Bart., at the Congress Office, Royal Sanitary Institute, Margaret Street, London, W.

MR. MCKENNA, M.P., President of the Board of Education, was present at the annual dinner of old students of the Royal School of Mines on Tuesday, and in the course of a speech he made the announcement that the school is to retain its name and individuality in the Royal Technical Institute to be established at South Kensington. Mr. D. A. Louis presided at the dinner, and in proposing the toast of the evening, "Prosperity to the School of Mines," he said it is of vital importance that there should be a well-equipped national institution for the training of mining engineers, and that the institution should grant a distinctive diploma. The Royal School of Mines is such an institution; yet it has been proposed to relegate it to some hole-and-corner place in a big jumble of institutions which have nothing in common with it, excellent though they are in their own way. Mr. McKenna, in the course of his remarks, said that the school needs more and better equipment in order to provide it with the means of coping with rival institutions in various parts of the world. He hopes that in future the failure to make this provision will be remedied. In a memorial from past students of the Royal School of Mines to a departmental committee which inquired into the formation of the new technological college three requests were made, namely:—"(1) that the title be retained as 'The Royal School of Mines'; (2) that the diploma of 'Associate of the Royal School of Mines' be retained as heretofore; (3) that the school, even though it may be affiliated to some central institution, be preserved as a separate entity as regards mining and metallurgical training with its own special staff and organisation." As an answer to these requests, Mr. McKenna read a paragraph from a draft of a charter, which may be issued hereafter. The clause states that "One of the departments of instruction of the new institution shall provide specialised courses in mining and metallurgy, and that department shall be called and known by the name of 'The Royal School of Mines,' and the governing body shall award the diploma of 'Associate of the Royal School of Mines' to any student who completes such courses to the satisfaction of the governing body." The individuality and history of the school will thus be preserved, and will not be sacrificed in what the chairman called a jumble. In conclusion, Mr. McKenna expressed the hope that though, in joining a larger association, the school necessarily will sacrifice a certain amount of individuality as a governing body, nevertheless by retaining the name and the diploma it will be compensated for any respect in which it may suffer by the advantages which will accrue from the fuller and more complete equipment. The name and the fame of the Royal School of Mines must be kept bright as a star in the firmament of the new institution, which is to be a pioneer even to Germany in the work of scientific training.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 13, 1906.—"An Examination of the Lighter Constituents of Air." By J. E. **Coates**. Communicated by Sir William Ramsay, F.R.S.

About 73,000 litres of air were systematically fractionated in order to ascertain whether any constituent lighter than hydrogen (*e.g.* coronium) were present. A preliminary concentration of the lighter portions was effected by collecting the gas which had passed repeatedly through an air-liquefying plant, precautions being taken to avoid contamination of the gas with hydrogen. By fractionation of the liquefied gas, a light portion having a volume of about 4700 c.c. was obtained, which was further fractionated by absorption in charcoal at about −205° C. The lightest fractions thus obtained were examined spectroscopically, but no lines were detected which could not be attributed to hydrogen, helium, and neon. The volume of hydrogen amounted to 0·778 c.c., while the total volume of neon and helium obtained was 46 c.c. Assuming that 60,000 volumes of air contain one volume of mixed neon and helium, it appears that hydrogen is present in the air to the extent of one part in about a million and a half. This estimate has been subjected to a correction for the solubility of hydrogen in liquid air, an approximate correcting factor being obtained by performing the fractionations on a sample of air to which a known small quantity of hydrogen had been added. This is much smaller than previous estimates; it seems probable that hydrogen is a variable constituent of the atmosphere.

January 31.—"A Recording Calorimeter for Explosions." By Prof. Bertram **Hopkinson**. Communicated by Prof. H. L. Callendar, F.R.S.

This paper describes a method of recording the heat lost up to any instant after an explosion of coal-gas and air in a closed vessel. For this purpose the vessel, which was cylindrical, and about 1 foot in diameter and 1 foot long, was lined first with a wooden backing ½-inch thick and then with a continuous length of copper strip ¼-inch wide by 1/25-inch thick. The strip was wound helically on the cylindrical part of the vessel, and the two end-plates were covered with parallel pieces joined up at the ends so as to form an electrically continuous length.

The method consists in recording the rise of resistance of the whole length of copper strip when the explosion takes place. The rise of resistance is proportional to the rise of mean temperature of the strip. Hence, knowing the heat capacity of the copper, the total heat that has passed into it at any instant can be obtained from the record, after making certain corrections for the heat which has passed from the copper into the backing and into those parts of the walls which are not protected by the copper.

The record of resistance was obtained by passing a known current (about 8 amperes) through the strip, and recording the potential at the terminals of the strip by means of a reflecting galvanometer having a period of about 1/15th of a second. The galvanometer was placed in series with a constant source of E.M.F. of such magnitude as to balance the E.M.F. at the terminals of the strip when cold; the galvanometer deflection was then proportional to the rise of E.M.F. between the terminals of the strip, and so to the rise of resistance. The galvanometer mirror reflected an image of a fine hole illuminated by an arc lamp on to a photographic film carried on a revolving drum. A photographic record of the pressure in the vessel was obtained at the same time on the same film.

The mixture used consisted of one part of coal-gas and about seven parts of air at atmospheric pressure and temperature. It was fired by an electric spark at the centre of the vessel. To test the accuracy of the calorimeter, the heat which had passed into the walls at the end of one second from firing was calculated from the record, and was found to be 10,000 calories. The temperature of the gas at that moment was found from the pressure record to be 545° C. Using Holborn and Austin's values for the specific heats of the constituents up to that temperature, the heat remaining in the gas was calculated to be 3800 calories. The total heat accounted for by the calorimeter and pressure records is therefore 13,800 calories, and this should be equal to the heat of combustion of the coal-gas used. This was the case within 2 per cent.

The calorimeter record shows that during about two-fifths of a second after firing the rate of heat loss to the walls at any moment is approximately inversely proportional to the square root of the time. That is, the law of heat loss is initially the same as that of a solid at uniform temperature the boundary of which is suddenly cooled. It is pointed out that the rate of cooling is conditioned mainly by the state of the surface layer of gas in contact with the walls; at first heat is drawn from that layer, and the loss of heat is very rapid, but when the surface layer has been cooled down it acts as heat insulation for the remainder, and further cooling is relatively slow.

Linnean Society, February 21.—Prof. W. A. Herdman, F.R.S., president, in the chair.—The Percy Sladen Trust Expedition to the Indian Ocean in 1905 under Mr. J. Stanley Gardiner. (1) Description of the expedition. (i.) Introduction; (ii.) history and equipment of the expedition; (iii.) *résumé* of the voyage and work. Part i., Colombo to Mauritius: J. Stanley **Gardiner** and C. Foster **Cooper**.—(2) Land nemerteans, with a note on the distribution of the group: R. C. **Punnett**. A single land nemertean obtained by Mr. Stanley Gardiner in the Seychelles must be referred to a new species, and has accordingly been named *Geonemertes arboricola*. The specific name has reference to the peculiar habitat of the worm, which occurs, among other places, in the leaf-bases of the screw-pine, *Pandanus hornei*.—(3) Land Crustacea: L. A. **Borradaile**. The collection contained thirty species, belonging to eleven genera. None were new to science, and all had previously been reported from the Indian Ocean. The fauna revealed by the collection is richer than that of the Maldives and Laccadives, but otherwise closely resembles it.—(4) Hymenoptera: P. **Cameron**. Thirty-two species of the group were obtained, ants being excepted. Of these, seventeen are described as new, one, *Tolbia scaevola*, as the type of a new genus. Ten species were obtained from the Chagos, three being new; and twenty-three from the Seychelles, including Coetivy, eleven new, the fauna for this archipelago now consisting of twenty-four species. As regards the habits of the species, it is suggestive that so many of them belong to genera (Evania, Ampulex, Sphex, Notogonia, &c.) of which many, if not most, of the species prey on Orthoptera.—(5) Dragon-flies: F. F. **Laidlaw**. The collection contains fourteen species, none of which are new. All were obtained in the Seychelles, and four in the Chagos as well. It is suggested that the species peculiar to the Seychelles are a fragment of an endemic fauna which is being displaced throughout the whole Indo-African region by an invading fauna from the north.—(6) Fourmis des Seychelles, Amirantes, Farquhar et Chagos, déterminées par H. A. **Forel**. Nous avons pour les divers groupes d'îles en question 8 espèces cosmopolites, 8 espèces malgaches, 8 formes locales, qui ont toutes dans leur dérivation un caractère malgache; trois formes locales (sous-espèces ou variétés) dérivées d'espèces indomalaises; une espèce océanienne; une espèce américaine évidemment importée et ayant un peu varié; puis deux formes communes aux archipels mais l'une au moins décidément dérivée malgache. Enfin, une espèce (*Pheidole punctulata*) et une sous-espèce (*Camponotus grandidieri*) tout communes aux faunes africaine et malgache, probablement dérivées de la première.—(7) Pycnogonida: Prof. G. H. **Carpenter.** Only five species of the group were obtained, of which four are described as new. The most remarkable is a Colossendeis from 450 fathoms off the Saya de Malha Bank.—(8) Aves: Dr. H. F. **Gadow,** F.R.S., and J. Stanley **Gardiner.** The birds obtained were in no way remarkable, being mostly waders or regular sea-birds of wide distribution. The crab-plover (*Dromas ardeola*) was found everywhere. Of economic importance as guano-formers were breeding colonies of *Fregata ariel* on Nelson Island, Chagos, *Sula piscator* on St. Pierre, *Sterna fuliginosa* and *Anous leucocapillus* on Cargados Carajos, and *Pelecanus crispus* and *Puffinus tenuirostris* on St. Joseph, Amirante Islands.

Society of Chemical Industry, March 4.—Mr. R. J. Friswell in the chair.—Five years' experience in measuring and testing producer gas: R. **Threlfall,** F.R.S. The first part of the paper is devoted to a *résumé* of the principles and construction of the instruments employed in Pitot tube gas measurement. This is followed by a description of the "static" method of measuring gas density. An account is then given of the results of balancing the make and distribution of producer gas over a period of several years, this being illustrated by curves which show that an agreement within about 2 per cent. can be attained in practice. The next section of the paper is devoted to a discussion of the theory and practice of measuring pulsating streams of gas or air, such, for instance, as are produced by pumping by gas-engines or otherwise. As to the question of sulphur in producer gas, it is shown that the referee's test is less suitable for this purpose than a modification of Valentine's test. The discussion of this matter covers both the determination of sulphuretted hydrogen and of total sulphur, and it is shown that it is fatal to the sulphuretted hydrogen to employ a gas meter containing water—no matter how long it may have been in action. The best methods hitherto proposed and practised for the determination of the volume of gas produced per ton of coal, otherwise than by the author's meters, are considered critically, and some examples are given of the results of balancing on carbon and on ammonia. The paper ends with a note on the determination of producer temperatures by a system of thermocouples which are read by a potentiometer suitably divided to read direct, and fed by a very large Clark or cadmium cell.

Zoological Society, March 5.—Mr. F. Gillett, vice-president, in the chair.—The discovery, in cave deposits in Crete, of remains of elephants, some of which represent a new species: Miss D. M. A. **Bate.**—Report on the Polyzoa of the third Tanganyika expedition: C. F. **Rousselet.** Five species were represented in the collection, three of which were described as new. Of the five species, three belonged to the Phylactolæmata and two to the Gymnolæmata. Amongst the latter was *Arachnoidia raylankesteri,* Moore, which was found in some abundance on shells dredged from deep water.—Report on the Brachyurous Crustacea of the third Tanganyika expedition: Dr. W. A. **Cunnington.** The collection contained specimens from both Nyasa and Tanganyika. Including a few individuals which had hitherto passed without notice in the collection of the British Museum, there were now on record three species from Nyasa and five from Tanganyika. Of these species, three were described as new. The forms from Nyasa all belonged to the widely distributed subgenus Potamonautes; but while two species from Tanganyika also belonged to that subgenus, the lake contained three species belonging to the remarkable endemic genus Platythelphusa, A. Milne-Edwards. The suggested marine appearance of *P. armata* was considered to be only superficial, and the peculiar character of the Brachyuran fauna of Tanganyika could be explained on the grounds of a prolonged isolation of the lake.—Two new species of African oligochæte worms of the genus Microchætus belonging to the collection of the Christiania Museum: F. E. **Beddard.**

Physical Society, March 8.—Prof. J. Perry, F.R.S., president, in the chair.—The rate of recovery of residual charge in electric condensers: Prof. F. T. **Trouton** and S. **Russ.** The experiments described by the authors were undertaken in order to examine the rate of recovery of residual charge when the difference in potential of the plates is kept constant. Previous experimenters have always allowed the charge to accumulate on the plates while observing the rate of rise in potential. In that case the recovery meets with an ever-increasing opposition which complicates matters. The authors have employed two methods. In the first, which was used with mica condensers, the potential, observed by an electrometer, was kept constant by means of a variable resistance which was gradually increased as the recovery current diminished. The high resistance necessary was constructed of two horizontal metal plates with ionised air between them. A movable shutter could be introduced between the plates to diminish gradually the cross-section of the air resistance as required. The second method was used when the residual charge was great enough. In it the current was passed through a dead-beat galvanometer, and the value of the recovery current at each moment determined. In this case the difference of potential of the plates may be taken as constant since it was practically zero. The observations when plotted with current against time were found to lie on a hyperbola. This shows that in the circumstances of the experiments the quantity of electricity recovered up to any given time follows a law $Q = a \log (p+t)$ similar to that found by Rankine and others for the recovery of stress in overstrained elastic bodies when the strain is kept constant.

MANCHESTER.

Literary and Philosophical Society, February 12.—Mr. Francis Nicholson in the chair.—Some tables for explaining the nature of statistical correlation: A. D. **Darbishire.** The thirteen tables exhibited graphically the results of thirteen series of pairs of throws of dice in such a way that the effect of increasing the correlation between the first and second throws of the pair was clearly seen. The method is an application, to some new sets of throws, of Weldon's beautiful device for illustrating statistical correlation.

February 26.—Prof. H. B. Dixon, F.R.S., in the chair.—Report on the recent Foraminifera from the coast of the Island of Delos (Grecian Archipelago), part iv.: H. **Sidebottom.** Drawings of some of the more interesting species were exhibited, and mounted specimens were shown under the microscope.—The leaves of Passerina: Madeline **Carson.** The Passerinæ belong to the natural order Thymelæaceæ. These plants inhabit the warm dry regions of Egypt, South Africa, and the Mediterranean. They are common on the sand hills near the coast, and always live under conditions in which there is a difficulty of obtaining water. In order to combat against this, they are specially modified. The leaf surface is reduced, often the leaves are imbricating. They are provided with a very thick cuticle, have the edges inrolled, and the stomates are found only on the inner surface. They are further protected by a covering of hairs. The chief object of the study of these leaves was to discover whether the epidermal cells contained mucilage or not. In *Passerina filiformis* and in *P. hirsuta,* the author found that in many of the epidermal cells a portion was cut off from the rest by a cellulose wall. The upper portion contained tannin and probably mucilaginous sap, while the lower portion consisted of hard stratified mucilage. In the other species examined, *Passerina ericoides* and *P. rigida,* no trace was found of separation of the epidermal cells into a striated and non-striated portion. The whole epidermal cell stained with mucilage stains and tannin stains. Since mucilage and tannin both act in the same way towards methylene blue, and since it is impossible to separate tannin and mucilage, the evidence for the presence of mucilage in these species is not perfectly conclusive. As, however, mucilage is without doubt found in some Passerinæ, its absence is not characteristic of the group, and therefore its presence or absence can no longer be used as a basis for classification of the Thymelæaceæ.

PARIS.

Academy of Sciences, March 18.—M. A. Chauveau in the chair.—A property of platinum amalgam: H. **Moissan.** When platinum amalgam is shaken with water, a semi-solid mass of the consistency of butter is formed. This appears to be permanent, since the volume does not change after keeping for one year, and the mass can be heated to 100° C. without destroying it. Amalgams of copper, silver, or gold do not produce a similar emulsion, but separate in precisely the same fashion as pure mercury.—The wax from the palm *Raphia Ruffia*, of Madagascar, and on arachic alcohol: A. **Haller.** An alcohol possessing the formula $C_{26}H_{42}O$ was isolated from this wax. This is the same formula as that of an alcohol isolated by M. Étard from lucerne, but a comparison of the two showed that they were not identical. The acetic and benzoic esters of the new alcohol were prepared, and also a hydrocarbon by treating with anhydrous zinc chloride. Arachic alcohol was also prepared, and found to be not identical with the alcohol under examination.—The existence of parameters capable of characterising the magmas of a family of eruptive rocks: Michel **Lévy.** Having a set of fifty analyses of rocks of the Mont-Doré series, in which particular care had been given to the determination of the alumina and the separation of the alkalis, the author has worked out a set of the various parameters to characterise rocks, the most stable of all being that which represents the latent acidity,

$$\phi = \frac{S_{sal}}{2k + 3n},$$

where S_{sal} represents the silica of the white elements and $2k+3n$ a number sensibly proportional to the sum of the atomic weights of the alkalis.—The modifications introduced by the pathological state in the immediate destinations of the nitrogenous elements: A. **Chauveau.**—Observations of the Giacobini comet (1907*a*) made with the large equatorial of the Observatory of Bordeaux: Ernest **Esclangon.** The comet had the appearance of a feeble nebulosity with a clearly defined nucleus. The apparent positions of the comet and mean positions of the comparison stars are given for March 12 and 13.—Observations of the Giacobini comet (1907*a*) made at the Observatory of Algiers with the 31·8 cm. *coudé* equatorial: MM. **Rambaud** and **Sy.** Similar observations made on March 11, 13, and 14. The comet appeared to be circular, with a diameter of about one minute of arc. The central condensation was 5″ diameter, with a brightness corresponding to a star of the 11·5 magnitude.—Elements of the Giacobini comet (1907*a*): Paul **Brück.**—Observations of the Giacobini comet (1907*a*) made with the *coudé* equatorial at the Observatory of Besançon: P. **Chofardet.** Similar observations for March 12, 14, and 16.—The new Giacobini comet: M. **Giacobini.**—Orthogonal systems of functions: Frédéric **Riesz.**—Periodic solutions of linear differential equations: T. **Lalesco.**—The problem of Dirichlet: H. **Lebesgue.**—A surface of the sixth order related to Abelian functions of the third genus: L. **Remy.**—Helices considered as generators of a surface: G. **Barré.**—The method of isoperimeters: G. **Hilleret.** An application of the method of isoperimeters to the rapid approximation of π.—Aëroplanes: A. **Étévé.**—Waves of shock and of spherical combustion: M. **Jouguet.**—The origin of spectra in series: W. **Ritz.** It is known that the frequencies ν of the ordinary spectrum of hydrogen and of the new spectrum discovered by Pickering in certain stars are given very exactly by the formulæ

$$\nu = N\left(\frac{1}{4} - \frac{1}{m^2}\right), \quad \nu = N\left[\frac{1}{4} - \frac{1}{\left(m - \frac{1}{2}\right)^2}\right], \quad (m = 3, 4, 5, \ldots);$$

where N is a constant. An outline of a physical system is here given which it is shown would give rise to just such a system of vibrations.—The ionisation of the chromium sulphates: Albert **Colson.** In the chromium sulphates the lowering of the freezing point appears to be independent of the ionisation as measured by the electrical conductivity.—The alloys of nickel and tin: Em. **Vigouroux.** By directly heating together pure tin and nickel, alloys containing respectively 73·6, 83·6, and 92·7 per cent. of tin have been prepared. All three alloys are non-magnetic, and under the action of nitric acid leave a crystallised metallic residue.—The arsenites and arsenates of rubidium: A. **Bouchonnet.**—The action of *p*-*p*-tetramethyldiaminobenzylhydrol on some methylene derivatives: R. **Fosse.**—The inequality of the resistance of natural starch and artificial amylose towards extract of barley: J. **Wolff** and A. **Fernbach.** Amylose in its natural form is distinguished from artificial amylose by a much greater resistance to saccharification by extract of barley.—The influence of fertilisation on the characters of figs: Leclerc **du Sablon.** Fertilisation, which is not necessary in the varieties cultivated in France, is possible, and increases both the weight and the yield.—The development of the *pneumathodes* of the palm and on the true nature of these organs: C. L. **Gatin.**—The mode of action of tephrosin: M. **Hanriot.**—Some consequences of the interpolation of the principal experiments of M. Chauveau on muscular energetics: Charles **Henry.**—Morphological changes in the nerve cells surviving the transplantation of nerve ganglia: G. **Marinesco** and J. **Minea.**—Locomotion in the Gasteropods: Raphael **Dubois** and Fred **Vlès.**—A new subfossil Lemurian of Madagascar: G. **Grandidier.**—Some seismic constants deduced from the earthquake of April 4, 1904: E. **Oddone.**

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